UNIVERSITY OF SOUTHAMPTON

Digital Disasters: A Novel Methodological Approach to Assess Social Media as a Tool for Disaster Management

by

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ABSTRACT

FACULTY OF ENGINEERING, SCIENCE AND MATHEMATICS
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In a rapidly globalising world the way in which crises are managed is changing. This thesis theorises that social media, as a prominent example of modern technological developments, hold paramount importance in reducing risk during disasters. Such developments now have a plethora of applications that are valuable for resilience, response, recovery and risk reduction during the life-cycle phases of an event. While many developments and new methods are employed during disasters, there remain a range of limitations which the scientific community must seek to address in order to lessen the impacts of future crises. This thesis seeks to address some of these limitations through three main academic contributions to the field of disaster management. Firstly, a novel methodological approach is designed and implemented. This creates a conceptual framework to ascertain the users and uses of social media in modern disasters, and to track how and why social media content may change over the course of an event. This has been applied to data collected from the platforms Facebook, YouTube and Twitter as well as to qualitative interviews. This forms a mixed-methods approach which provides a new paradigm on the use of sites during crises. Secondly, the methodological approach is employed on two high-magnitude and highly contrasting disaster case studies: the Kaikoura earthquake (New Zealand, 2016), and hurricane Irma (Antigua and Barbuda, 2017). By using social media as a lens for analysis the results have generated unique insight into each case, as well as highlighting the underlying geographical, demographical, political and economic factors which affect the complex outcomes of disaster. It has also demonstrated that variations in platforms utilisation are dependent on a plethora of issues, which may be conceptualised across the pre-disaster, during, post-disaster and throughout-all-stages phases of an event. Thirdly, from this analysis the current role that social media holds has been scoped in the context of a globalising world, and five proposed recommendations for its improvement have been formulated. These are (1.) the creation of a range of downloadable media content aimed at resiliency efforts; (2.) the integration of online and offline volunteer strategies targeted at response efforts; (3.) the incorporation of social media specialists into response strategies; (4.) developing a lessons learned method focused on improving recovery; and (5.) enhancing tailored communications protocols throughout all stages of an event. This thesis concludes by emphasising the importance of research in this field given the increasing severity and frequency of global hazards, especially in conjunction with rapid socio-technical progression which have the power the shape the outcome of future events.

Declaration of Authorship

I, Briony Jennifer Gray , declare that the thesis entitled "Digital Disasters: A Novel Methodological Approach to Assess Social Media as a Tool for Disaster Management" and the work presented in this thesis are both my own, and have been generated by me as the result of my own original research. I confirm that:

1. This work was done wholly while in candidature for a research degree at this University;
2. No part of this thesis has been previously submitted for a degree or any other qualification at this University or any other institution, this has been clearly stated;
3. Where I have consulted the published work of others, this is always clearly attributed;
4. Where I have quoted from the work of others, the source is always given. With the exception of such quotations, this thesis is entirely my own work;
5. I have acknowledged all main sources of help;
6. Where the thesis is based on work done by myself jointly with others, I have made clear exactly what was done by others and what I have contributed myself;
7. Parts of this work have been published in peer reviewed conference and journal proceedings under these details:

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Chapter 1

Introduction: Social Media, Disasters, and their Management in a Globalising World

> *"Disasters have become increasingly dependent on media in respect of how they become known and responded to"* - Simon Cottle, 2014.

Globally, natural hazards are becoming more severe, unpredictable, and frequent than previously thought (Kappes, Papathoma-Köhle, and Keiler, 2012; Guha-Sapir et al., 2004; Papalexiou et al., 2018). By definition, they are naturally occurring events which cause damages and mortality, with certain types prone to re-occurrence. Primarily, climate change is argued to be a significant driver of this, with global meteorological trends reaching extremes never before recorded (Mechler and Bouwer, 2015; Mal et al., 2018; Papalexiou et al., 2018). Subsequently, for human populations, the level of vulnerability and risk from natural disasters is rising also (Mal et al., 2018; Füssel, 2007; Joern Birkmann et al., 2015). Sea level rise is exposing coastal communities and ecosystems (Tompkins, 2005) as well as threatening tourism and economic stability (Schwarz et al., 2011). Hurricanes and storm systems have broken records for intensity and number throughout 2016 and 2017 (Zolnikov, 2018), causing unparalleled damages to island communities and forcing a shift in the way that annual seasons must be managed in the future (Shultz, Kossin, et al., 2018). Similarly record-breaking, earthquakes, seismic hazards and volcanic eruptions, too, have shaken populations globally (Alexander, 2017), affecting rural communities and those driven to live in more at-risk areas by social and environmental drivers such as poverty and war (Jigyasu, 2002). Although global figures show a rise in disaster related deaths and damages, there are further reasons to warrant research in this field. Firstly, almost all individuals, from all backgrounds and walks of life, will be affected by disaster in one way or another in their lifetimes (Alexander, 2017; Blaikie et al., 2014; Smith, 2013). Secondly, the more technologically complex society

becomes, the more diverse the risks and affects of disaster can be – but also the ways in which they can be managed (Cottle, 2014; C.-M. Huang, Chan, and Hyder, 2010; Crowe, 2012). Finally, it is often the most vulnerable populations, commonly in lesser-developed countries, which are subject to the worst outcomes of disasters (Mechler and Bouwer, 2015). This combination necessitates significant intervention and management in order to reduce global risk in inevitable future crises.

Globalisation has played an important role in both how natural disasters are managed and perceived (Cottle, 2014). The rapid creation and uptake of new technologies has been deemed by sociologists as the rise of the "networked society", originally termed by Castells (2011). Within the network society, there has been a revolution in communication technologies which have shaped what is achievable in the online world, as well as in our everyday interactions and uses of technology (Cottle, 2014).These progressions, naturally, have been applied to relevant research fields that have scope for the better integration of society and technology (Castells, 2011). Disaster management, as an example of such a field, has moved with technological evolution quickly (Luna and Pennock, 2018). Since the creation and uptake of the World Wide Web ("the Web")in the early 1990s there has been a debate as to the extent that new media could be utilised in disaster management efforts (Wellman et al., 1996). Pioneering case study applications and analyses fuelled this debate, presenting seemingly overwhelmingly positive evidence for the use of globalising trends throughout modern disasters (Luna and Pennock, 2018; C.-M. Huang, Chan, and Hyder, 2010; White, 2014). However, as time progressed, it became apparent that the availability of new media was not the only foundation for the development of modern methods in disaster management (Cottle, 2014; Luna and Pennock, 2018).

Globalisation has meant that the paradigm in which disasters are conceptualised has changed (Cottle, 2014). Now, disasters are global events where individuals, connected through media, may experience crises unlike any previous time in human history (Blaikie et al., 2014). Aspects of new media, by extension, have become equally vital to the effective management of disasters also (Luna and Pennock, 2018). The presence of digital divides – sociological and technological variations in populations – highlight that globalisation remains an unfolding process where some areas progress faster than others (Milio, 2001). This is a reminder that for individuals experiencing disasters through a global stage, the digital divide and its many complex factors may define the perception and parameters of a disaster (Milio, 2001). Online human behaviour, too, has the ability to shape the way disasters are perceived (Luna and Pennock, 2018). As a result, disaster management must now take into account the psychology and predictability of behaviours online, as well as offline, to ensure that management methods can effectively reduce risk during crises (Luna and Pennock, 2018). Similarly, political influences, sociological phenomenon and dynamics of power have extended into the online world (Cottle, 2014; Palen and Hughes, 2018). These may dictate the way in which an individual engages

with new media, and subsequently how they may do this during disasters (Palen and Hughes, 2018).

An example of new media that have in the past decade become a valuable resource for disaster management is that of "social media" (Luna and Pennock, 2018). Social media can be used as a lens through which disasters may be conceptualised, assessed, and understood in more detail compared to their traditional media counterparts alone (Palen and Hughes, 2018). Furthermore, they offer rapid access to time-critical information that is both free and situation-sensitive (St. Denis, K. M. Anderson, and Leysia Palen, 2014; Shklovski, Leysia Palen, and Sutton, 2008; Rudra et al., 2016). Information sourced from social media may help individuals to make complex safety-critical decisions during crises, as well as a range of other valuable applications (Carver and Turoff, 2007). Other notable examples include real-time monitoring and evaluation for targeted action purposes, demonstrated by Twitter data during the case of Hurricane Sandy (Ruggiero and Vos, 2014). Generalised monitoring and analysis may support policy-making, highlighted by national and international research councils assessing social media impacts (Sobkowicz, Kaschesky, and Bouchard, 2012). Situational awareness may be derived through content analysis, data mining and natural language processing, illustrated by micro-blogging platforms during the Nepal earthquake and other prominent disasters (Anderson, 2014; Rudra et al., 2016). Social media applications, too, can be used to provide warning systems, and be used as distributed sensing systems to identify and track potential hazards or problems (Imran, Castillo, et al., 2014; Crooks et al., 2013), and to improve human interaction, coordination and communications during crises (Lindsay, 2011).

The use of social media for disaster management purposes still however faces obstacles. Despite the rise in global connectivity through developments such as the Web, accessibility to social media remains a significant barrier to usage (Wentz et al., 2014). Factors such as social class, gender, ethnicity, income and geographical location may all impact access to social media and other online resources (G. Haddow and K. Haddow, 2013; Fothergill, Maestas, and Darlington, 1999; Cottle, 2014). Poor organisational coordination, communications and structures may result in the ineffectual dissemination of online information, or in exacerbating general public confusion (Shklovski, Leysia Palen, and Sutton, 2008). Information overload may occur when there are high volumes of easily accessible information in circulation that are irrelevant to real-life situations (Bharosa, Lee, and Janssen, 2010). Similarly, the inability to verify information can be highly dangerous to individuals seeking to act upon it (G. Haddow and K. Haddow, 2013). These are particularly difficult problems to tackle in time-critical situations as information can be created and disseminated with little to no authentication online, with individuals often failing to cite original sources (Westerman, Spence, and Van Der Heide, 2014; Laituri and Kodrich, 2008). Some of these limitations however may be reduced. The assessment of case study data may highlight areas to improve technology

infrastructures and media functionality. In geographical areas that are prone to particular hazards (such as earthquake-prone zones along fault lines) analysis of social media usage in case studies can offer valuable insight and applicability during future crises (Kappes, Papathoma-Köhle, and Keiler, 2012).

Given the inevitable re-occurrence of disasters, there is an urgent need to learn from both past and present methods of disaster management and response. By definition, disaster management is the intervention of organisations to oversee resources and responsibilities for dealing with humanitarian aspects of crises. Typically this is conceptualised over the disaster life-cycle phases: pre-disaster, during, and post-disaster. It can be further defined by methods of management, which are termed "the four R's": resilience, response, recovery and rebuilding. During the last decade on average 631 disasters occurred per year, with an estimated death toll of 934, and damages that exceeded 162 million dollars annually (Starr Roxanne Hiltz, P. Diaz, and Mark, 2011). Subsequently, the study of disaster case studies has increased. A majority of published papers have the goal of not only understanding and improving crisis communications during such events, but also of contributing awareness of the variety of social, geographical and other distinct factors that may shape the unique nature of disasters. The role of social media particularly needs to be understood in the context of a globalising world, where population demographics are subjected to extremes and unique factors that shape risk. Additionally, the role of social media should be explored in the context of long term resilience and preparedness efforts as the uptake of such online resources is increasingly being utilised by governments, humanitarian aid organisations, public health authorities, economic stakeholders, military deployment initiatives and the general public alike.

This thesis ultimately aims to reduce the risk of future disasters by understanding current events and the way in which they are managed utilising social media. It approaches disaster management in the context of a rapidly globalising world - outlined above - where information systems, social media and digital technologies are increasingly being utilised during crises. Using an interdisciplinary mixed-methods approach, it seeks to determine what the current relationship between social media and disasters is. It questions who uses social media during crises, for what purpose, and how this may change throughout the disaster life-cycle phases. Furthermore, it identifies the ways in which sociological, demographical, political and geographical factors may influence the outcomes of crises, as well as shape modern disaster management efforts. By assessing and making suggestions for improving social media applications, an acknowledgement of "socio-technical" progression is formed at the centre of this research. This is one of the foundations of Web science, which emphasises the combination of disciplines and methods to produce unique insight into aspects relating to the Web, where the relationship between society and technology underpins globalisation. Within this thesis technical approaches have been taken from the discipline of computer science which involve scripts for data collection and network analysis. Theoretic approaches have been taken from

sociology, which reconsider the role and perception of information systems, social media and digital technologies. Perspectives from both physical and human geography, too, have been employed to understand the complex nature of natural disasters and how they affect populations. In order to contextualise the research topic, this chapter will first provide an introduction to modern disaster management, the rise of new media, and finally the interaction between both of these concepts - where this thesis will contribute original insight.

1.1 The Scope of this Thesis

The increasing interdisciplinarity of disaster management as a field of research has meant that recent studies must define and scope their objectives in relation to particular areas of the topic. Consequently, this thesis must do the same. Ultimately, this study seeks to better understand the relationship between social media and disasters and to scope ways to reduce risk in future events. This is a complex topic as social media are utilised in a number of different ways, by a range of users, and throughout multiple stages of the disaster life-cycle. Much of the literature in this area falls into two main categories of research. Studies which assess social media as tools for management that develop new tools, applications, features or systems are generally regarded as disaster management "in practice". Studies which assess the use of social media as a lens for analysis, contributing to situational awareness and highlighting emerging themes within in particular case studies are considered as the "academic study" of disaster management. While both of these offer value to future crises and conclude with the formation of suggestions, methods or policy to improve social media's role within disaster management, this thesis falls into the latter category of study.

It is important to note that this thesis is primarily concerned with social media use specifically during periods of crisis – as opposed to during times of normality as well. The study only considers natural disasters rather than other forms (for example technological or man-made disasters). Furthermore, this thesis will assess data from selected social media platforms rather than a full range of existing ones. Finally, this study will focus on two main case studies rather than a range of examples. Each of these parameters have been introduced to ensure that a more detailed understanding of the topic is possible given the time and length constraints of the thesis. Therefore, the conclusions drawn from this study may not be considered representative of all disaster case studies, all hazard types, and of all social media platforms. Within these parameters, this thesis seeks to answer the following research questions.

1.1.1 Research Questions

Following the thesis statement, the overarching research question is:

"What is the current role of social media during natural disasters, and how might this be improved to reduce risk in future crises?"

However, in order to assess the role of social media in a modern context, as well as its relationship with disaster management, a number of sub-questions have been formulated. These are as follows:

RQ1. How are different social media platforms used during disasters, by whom, and to what purpose?

RQ2. In what ways does the content of social media change throughout the disaster life-cycle phases, and why?

RQ3. What are the benefits, limitations, and scope of selected social media during case studies, and how might the analysis and comparison of these provide valuable insight for future events?

RQ4. How might original research and insight on selected case studies be used to formulate improved social media protocols or recommendations for disaster management?

Each of these questions represent the different types of knowledge required to answer the overarching thesis question. RQ1 scopes the uses and users of social media, showing what the current role is within crises. RQ2 illustrates how social media content changes over the course of a disaster, demonstrating the importance of the disaster life-cycle phases to the relationship. RQ3 assess the exact nature of social media during disasters, laying the foundations for improvement within disaster management methods. Finally, RQ4 shows how the analysis of case studies reveal unique insight which is vital to the understanding of the relationship in practice within the real-world. Information from each of these answers together may form a broader, detailed understanding of the relationship between social media and disasters.

1.2 Thesis Statement

This thesis argues that social media as an example of new media, hold paramount importance to reduce risk in future disasters. It postulates that in order to lessen negative impacts from future crises, the relationship between social media and disasters needs to be understood in more detail. This includes the current uses, users and applications of social media within disaster management, given the rapid socio-technical progression of a globalising world. It theorises that this knowledge will help to improve modern methods of disaster management, where complex underlying factors still shape the outcome of crises.

1.2.1 The Academic Contributions of this Thesis

The research presented in this thesis contributes to the field of disaster management in three original ways. Firstly, a novel methodological contribution is made through the creation of a conceptual framework to ascertain the users and uses of social media in modern disasters, and to track how and why social media content may change over the course of an event. This has been applied to data collected from the platforms Facebook, YouTube and Twitter as well as to qualitative interviews. This forms a mixed-methods approach which provides a new paradigm on the use of sites during crises. This has practical applications to disaster case studies for situational awareness of social media, conceptualised across the disaster life-cycle phases. The suggested application sequence for the framework is to integrate it with other existing frameworks employed by emergency responders, with the aim of supplementing the knowledge base before targeted actions take place. The integrated framework may then serve as a detailed general guide providing information on the unfolding of events, both online and offline, to be used for improved resource allocation, risk reduction, emergency response and hazard management. Alternatively, the framework may be integrated into the preliminary steps of social impact assessments (SIA) and social risk assessments (SRA) of crises. This would provide an extended dimension for predicting social impacts and uncertainties, taking into account unique aspects of communities. Furthermore, the framework may be employed by itself to generate insight into a case study or for generalised social media data.

The second original contribution of this thesis is through unique insight into the relationship between social media and disasters, as well as the nature of crises themselves. It does this by employing the novel methodological approach on two high-magnitude and highly contrasting disaster case studies: the Kaikoura earthquake (New Zealand, 2016), and hurricane Irma (Antigua and Barbuda, 2017). At the time of analysis little was published about these events making the results original and insightful, especially considering the re-currant nature of both earthquakes and hurricanes which require continued and improved management in coming years. By using social media as a lens for analysis the results have generated unique insight into each case, as well as highlighting the underlying geographical, demographical, political and economic factors which affect the complex outcomes of disaster. It has also demonstrated that variations in platforms utilisation are dependent on a plethora of issues, which may be conceptualised across the pre-disaster, during, post-disaster and throughout all stages phases of an event.

The outcomes of the first and second contributions have subsequently been able to form the third original contribution of this thesis. This takes the form of five proposed recommendations for the improvement of social media as a tool for disaster management in future events. These are (1.) the creation of a range of downloadable media content

aimed at resiliency efforts; (2.) the integration of online and offline volunteer strategies targeted at response efforts; (3.) the incorporation of social media specialists into response strategies; (4.) developing a lessons learned method focused on improving recovery; and (5.) enhancing tailored communications protocols throughout all stages of an event. This thesis concludes by emphasising the importance of research in this field given the increasing severity and frequency of global hazards, especially in conjunction with rapid socio-technical progression which has the power the shape the outcome of future events. Alongside the three main contributions, this research has been published in a series of conference proceedings and journal papers which have been acknowledged in declaration at the beginning of this thesis, throughout the relevant chapters, and re-capped in the contributions listed in overall conclusion.

1.2.2 An Overview of the Thesis Structure

This introductory chapter has provided some initial background information on the relationship between social media and disasters and their value within the field of disaster management. This is an area which must be studied in greater detail in light of modern technological and sociological developments, especially given the increase in severity and frequency of hazards. Ultimately, this thesis contributes insight in several areas that have the potential to affect the outcomes of future natural disasters. This firstly involves understanding the users and uses of platforms, as well as the nature and scope of modern applications, features and services offered by these. Using these findings, a conceptual framework is proposed and applied to selected case studies as part of a novel mixed methods approach. Secondly, it contributes to disaster management through disaster analysis and insight. Finally, it offers proposed recommendations for the improvement of social media use in future cases. The remainder of this chapter details an overview of the work carried out, and is broken down into eight further chapters as follows:

Chapter 2 begins by providing definitions for the key terms and concepts used throughout the rest of the document. Then, it details background information, synthesised from key literature and studies in the topic area. It offers a brief history of social media and their evolution and uptake into modern disaster management methods. It then presents examples of notable case studies, highlighting valuable benefits, limitations, and lessons from social media that have provided similar suggestions for the improvement of disaster management. The findings identify several core issues that are largely focused around the dissemination and reliability of information within crisis communications, the level of accessibility to the Web that individuals may have, and the discrepancies in situational understanding throughout the disaster life-cycle phases. These issues are used to form the basis of a new conceptual framework designed to address gaps in the knowledge.

Chapter 3 discusses the creation of the aforementioned conceptual framework which seeks to supplement other existing frameworks and methods used in disaster management, evaluated during the literature review. This has been created through the collection, synthesis and inductive coding of a range of relevant literature to produce an updated framework spanning across the disaster life-cycle phases, taking into consideration the previously identified core issues of Web accessibility and information reliability. Within this chapter, a literature review of existing frameworks and disaster management protocols are discussed. These underpin the creation of a study approach to validate the proposed framework.

In **chapter 4** the framework is then applied to two pilot studies for validation: the case of Storm Desmond (2016), and the case of Storms Desmond, Eva and Frank (2015-16). The findings reveal that social media are used in a range of ways that radically differ depending on the nature of hazards, characteristics of populations, structure and level of coordination of emergency responders, and accessibility to online services. The conclusions of the pilot studies inform the study approach for the larger case studies featured later. Chapters 2, 3 and 4 provide the theoretical and academic foundations for the remainder of the thesis, on which a methodology was devised.

Chapter 5 proposes a novel methodology to assess the use of social media during disasters through a series of practical steps. Firstly, the selection of social media platforms for analysis details the use of an electronic survey and a matrix analysis. Secondly, suitable case studies are selected by use of another matrix analysis. Thirdly, the stages of data collection for each selected social media platform are explained, which features the use of qualitative interviews. Finally, the stages of applying the previously validated conceptual framework to data from each case study is presented. Each of these strands are designed to provide insights into both social media, the disasters in question, and importantly the relationship between these.

The relationship between social media and disasters is then analysed through two case studies. In **chapter 6**, the case of the Kaikoura earthquake (New Zealand, 2016) is presented. Underlying factors grouped into the broad categories of geographical, demographical, political and economic issues are demonstrated to shape the outcome of the event. The results of the methodology indicate that Twitter, Facebook and YouTube were used in a variety of ways unique to each platform, which changed in content throughout the disaster life-cycle phases. The structure of emergency response is also evaluated which provides situational awareness for issues such as coordination between organisations in response to specific hazards, primarily that of high magnitude aftershocks and a tsunami. Findings indicated that although the death toll was low, there are key areas for improvement for emergency responders, which were largely centred on inter-agency coordination and the reliability of information at particular times within the early stages of the disaster life-cycle.

In **chapter 7**, the second case study of Hurricane Irma (2017) is presented which affected, and continues to have affect, to regions of the Caribbean and the USA. Similar to the previous case study, the uses and users of social media changed throughout the disaster. Again, underlying factors grouped into the broad categories of geographical, demographical, political and economic issues are demonstrated to shape the outcome of the event. The Dissimilarly, the larger geographical area affected by the disaster and the variations in population resulted in a much more diverse and complex emergency response efforts. As a result, the structure of emergency response is largely focused on aspects of international coordination between governments, as opposed to the regional scale of New Zealand. The differences in cases highlighted by using social media as a lens for analysis form an original and relevant discussion, and help to conceptualise the nature of disasters in the modern day.

Chapter 8 explores and frames the discussions raised by the previous two case studies. Geographical factors, such as the inherent resiliency of populations commonly exposed to hazards and the increasing likelihood of environmental hazards triggering cascading disasters, are explored. Social factors, such as the demographics of affected communities and the perception of disasters on a global stage, are compared between the analyses. Political factors are discussed, highlighting the variations between nations and their results on the management of crises. Economic factors, such as the availability of capitol to boost response and recovery efforts, are evidenced between the cases. Following this, the emergent themes of analyses have been synthesised across the disaster life-cycle phases. These feature five proposed recommendations to improve social media for resiliency, response, recovery and risk reduction in future disasters. These proposals are framed with regards to a range of selected emergency responders, organisations, governments and humanitarian aid organisations. The chapter then concludes with an overall summary with final remarks from the researcher. A full visual overview of the thesis document is illustrated in figure 1.1 below.

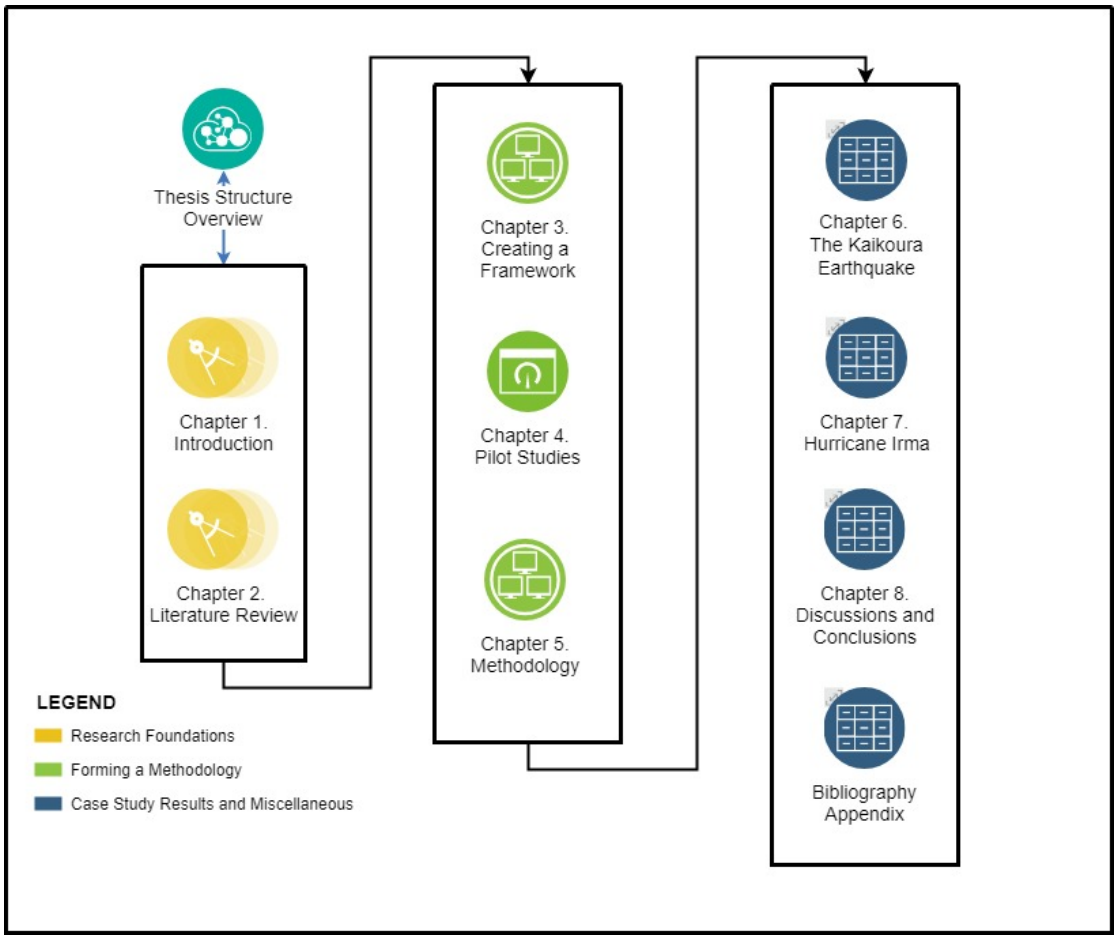


FIGURE 1.1: A visualisation of the thesis structure overview for the remainder of this document.

Chapter 2

Literature Review

This research has begun by stating that the relationship between social media and disasters is of vital importance to reduce future risk, especially in the context of a globalising world where natural hazards are becoming more frequent and severe. Consequently, before this study can begin to assess the current relationship in more detail, it must first understand the history of these concepts, determine what research has been conducted previously, assess the strengths and weaknesses of existing literature, identify gaps in the knowledge, and finally to scope where the thesis research questions fit into this background. To begin, the chapter will explain key terms and definitions associated with social media and disaster management. Next, the chapter will introduce a history of human interaction with disasters and will explain a brief history of technology as a means of communications, detailing how social media have developed over time. Following this, a similar introduction to disaster management is presented, which scopes how technological and sociological developments have lead to what we consider modern-day management. Based on these concepts, the next section of the literature review presents and assesses key studies since utilising social media throughout its development. These are organised by method, disaster life-cycle phase, and across the four R's: this begins with social media for **resilience** (pre-disaster), **response** (during disaster), **recovery** (post-disaster), and finally for **risk reduction** (throughout all stages). This analysis forms the basis for RQ1, RQ2 and RQ3 which all require an understanding of the current nature of the relationship between social media and disasters.

Following the analysis of literature in the first part of the chapter, a set of key limitations will be highlighted which the second half will discuss. In particular, the two issues of Web accessibility and information reliability were found to be prominent throughout each of the disaster life-cycle phases. In addition to these, underlying factors were found to have the potential to shape the outcome of crises, as well as the relationship between social media and disasters themselves. These are categorised into four broad areas: political, geographical, demographical, and economic factors. An understanding of these, too, is relevant to successfully answer RQ4, which seeks to make proposals to

improve the use of social media throughout future disasters. The chapter will conclude with a summary section which will re-cap the main findings of the literature review, scope how the thesis research question fits into this knowledge base, and state how the remainder of the document will be set up to address the identified gaps in knowledge.

2.1 Terminology and Key Concepts

Disasters, Life-cycle Phases and the Four R's

This thesis uses the definition that disasters are *"potentially traumatic events that are collectively experienced, have acute onsets, and are time-delimited"* (McFarlane and F. Norris, 2006). Disasters generally have natural, technological or human causes, and are conceptualised across life-cycle phases which are pre-event, during event, and post-event. Each of these phases has ties to certain disaster management actions which are referred to throughout this thesis as "the four R's", which are resilience, response, recovery and risk reduction. These are illustrated in the diagram below.

FIGURE 2.1: The Disaster Life-Cycle Phases of a Crisis Event with Corresponding Management Actions Across the Four R's; Resilience, Response, Recovery and Risk Reduction

Hazards

This thesis uses the United Nations International Strategy for Disaster Reduction (UNISDR, 2009) definition that hazards are phenomenon that pose a risk to a population. Environmental or natural hazards are natural processes, for example weather systems. Technological hazards originate from technological or industrial conditions, including accidents, dangerous procedures, infrastructure failures or specific human activities. For a hazard to be classified as a disaster it must exceed a country or region's ability to manage the event, and may cause loss of life, injury, illness or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage.

Disaster Management

This refers to the International Federation of the Red Cross's (IFRC, 2018) definition that disaster management is the organisation and management of resources and responsibilities for dealing with all humanitarian aspects of emergencies. The goal is to reduce the risk and impacts of disasters not only to human populations, but in terms of the environment also, relying on national and international collaborative efforts (International Federation of the Red Cross, 2018). The management of disasters is multi-faceted, and so made up of a range of governmental departments, non-governmental organisations, humanitarian aid organisations, charities, volunteer groups, and the public.

Globalisation and the Digital Divide

Globalisation is a term given to a multi-dimensional process of global integration through networks. Commonly, this increased integration happens between technologies, development, economies, populations, industries, markets, cultures and policy (Milio, 2001). The Digital Divide is a term given to uneven development caused by globalisation, which may differ from country to country, or even from community to community. While it applies to all common areas of globalisation, it is especially apparent within the area technological and economic development, and is named after the gulf between those with access to computers and the World Wide Web, and those without (McNutt, 2014).

The World Wide Web

This thesis uses the definition that the World Wide Web, referred to throughout as the "Web", is an information system formed of pages with unique identifiers (URLs) (Berners-Lee et al., 2006). Pages are formatted with Hypertext Mark-up Language (HTML) allowing navigation between them via hyperlinks, and are accessed through a Web browser. The Web is the method by which devices connect to the Internet. The internet is a global network that consists of interconnected networks.

Social Media

Social media are a means of online communication used by individuals to both share and create information (A. Kaplan and Haenlein, 2010). Social media are commonly websites or applications which allow the formation of online communities and networking. They can be generally categorised into three main types. Firstly, social networking sites predominantly focus on peer-to-peer connections and information exchange between users, examples of this are Facebook, LinkedIn and Google+. Secondly, microblogging sites emphasise the creation and spread of content, examples of this are Twitter and Tumblr. Lastly, photo and video sharing sites emphasis the creation and sharing of other forms of media, examples of this are YouTube and Instagram. Social media are considered the "modern-day" equivalent of traditional media, such as printed newspapers.

Common Examples of Social Media

While there are many examples of social media, the following sites are the most relevant for the scope of this thesis:

Twitter is defined by (Kwak et al., 2010) as a social media platform where users write "tweets" about any topic which were capped at 140 characters, but is trial-running 280 characters for particular audiences as of 2018. Users may interact through the service by following other accounts, liking/commenting/re-tweeting (sharing) tweets, and producing their own tweets. User accounts are assigned a handle [@] which others can use to tweet at, or to find certain content. The hashtag [#] function is also extensively used, where users may use key terms with the hashtag at the beginning to ensure that tweets and trends can be found easily. The service was launched in 2005 and currently has approximately 335 million monthly users globally.

Facebook is explained by (McAndrew and Jeong, 2012) as a social networking site where users connect to others, referred to as being "Facebook friends". Once two individuals become friends, they may interact through a number of functions supported by the platform. One may create and share information through writing a status, comment on other status's or shared material, write on someone's personal account, and directly message individuals. One may also engage in wider communities by joining groups or pages, "following" fan pages, and browsing through a "newsfeed" (in which the recent actions of friends is presented to the user). Alongside this, Facebook have in recent years added further services and functions: one may play games with friends, voice or video call individuals, as well as "check-in" safe from geo-located disasters. The platform was created in 2004 and is the first social networking site to surpass 1 billion monthly users.

YouTube is described by (Morris, 2011) as a video content distribution service. Unlike other social media platforms one is not required to have an account in order to use it. Instead, anyone may visit the site and watch the uploaded video content, as well as view the comment threads available on videos: to create or share on the platform however one must have an account. The service allows accounts to follow one another in order to see recent updates easily, and supports similar features such as commenting and allowing

direct messages to be sent between users. Individuals may also download video content. YouTube was founded in 2005, and it is estimated that 300 hours of video content are uploaded to the platform every minute, with nearly 5 billion video views per day.

2.2 An Introduction to the Relationship between Humans and Disasters

The previous chapter of this thesis has introduced the relationship between social media and natural disasters. It has emphasised that understanding this relationship is of vital importance to reduce future risk in the context of a globalising world. Consequently, before this study can begin to assess the current relationship in more detail, it must first understand the history of these concepts, and how they have interacted with one another over time. Fundamentally, humans have always experienced and communicated about crises: natural disasters are re-currant events that can be traced through the geological record to the formation of the Earth, far pre-existing the human race (Coppola, 2007). Our evolution as a species has been shaped by our environment, and subsequently by changes in that environment (Davies et al., 2015). In fact, in notable cases, the archaeological record demonstrates the migration of both Neanderthal and Homo Sapiens in response to sudden extreme events, such as volcanic eruptions and flooding (Davies et al., 2015). As a species whose survival depended on the formation of social bonds and communities, humans have evolved the capacity to communicate with one another from our origins. As our brains expanded, so, too, did the complexities of our communications and the number of social bonds we could maintain (Riva, 2005). Naturally, the communication of threats between individuals was vital to survival, which undoubtedly included the exchange of information about disasters and hazards alike (Davies et al., 2015).

While disasters remain a natural force in shaping human development and history, the way in which we communicate about them has transitioned with the advancement of the species (Cottle, 2014). The ability to create technology has been one such driver of human development. Originating with simple stone tools, this has over time progressed into more complex products as well as methods and applications (Riva, 2005). Historically, the use of technologies as a means of communicating about disasters over geographical space, and throughout time, is extensive (Castells, 2011). Cottle (2014) explains that there have been many notable examples of this in human history that include the use of printing news sheets in England during the 15th century, the creation of public postal services during the 17th century, and the construction of telegraph systems in the USA in the 1840's. In the 20th century, the development of the World Wide Web (referred to as "the Web") in 1991 is considered to be another important example which formed the foundations for "new" networked communications (Berners-Lee, 2000).

For the following decade, new networked media - or "social media"- offered a means of forming social bonds unlike other examples in recent history. It did not necessarily connect individuals to one other, but allowed basic services that one could join, or be used to form virtual communities (Dijck, 2013). After the turn of the millennium, networked communication began to be more interactive. Specifically, this took the form of the creation and uptake of two-way communications between individuals, made possible by new services and technologies such as satellites (Castells, 2007; Cottle, 2014). This saw the increased development of the "social" side of communications, where new behavioural changes were beginning to develop in virtual communities which exist alongside real-world ones. Allen (2004) posits that modern social media vastly out-perform their historical counterparts for several key reasons. Firstly, they are unique in terms of the sheer scale of their reach, which has been made possible through other technological developments (Cottle, 2014). Secondly, the speed at which information can be exchanged has reached a unique pinnacle where "real-time" communication is possible (Palen and Hughes, 2018).

Alongside key technological developments, sociological progression has also been shown to influence communication technology. Bijker's "Theory of Socio-technical Change" (1967), for example, speculates that society and technology interact continuously and in complex ways. Technology is designed and created by humans as well as being used by them, thus technology has the power to shape our daily lives and behaviours in a continuous cycle (Bijker, 1997). While being products of technological construction, modern social media ultimately provide social constructs in the form of networks, in which online behaviour has been a well-documented phenomenon, for example "The Proteus Effect" where online and offline human behaviours have discrepancies. Social media are now considered a part of everyday life (Reuter and Kaufhold, 2017). Currently, the most common types of social media are Facebook (with roughly 1.86 billion users active users on a monthly basis), YouTube (1 billion), WhatsApp (1 billion), Instagram (500 million), LinkedIn (483 million), Twitter (320 million, and Google + (235 million), illustrating the scale of presence virtual communities have in our lives at present (Reuter and Kaufhold, 2017).

The uptake of social media represents another paradigm of human communication, grounded in a globalising world (Castells, 2007). Naturally, then, as a modern tool for the exchange of information, such sites are becoming more extensively used in disaster situations. Palen and Anderson (2016) argue that individuals are utilising communication technology on a scale not seen before to cope with the uncertainties of crises. This has in turn lead to the formation of interdisciplinary fields of crisis informatics and disaster management, which commonly take fields of thought from both computer science and the social sciences (Leysia Palen and K. M. Anderson, 2016). Studies, journals and special issues have consequently gained momentum in recent years that focus on the analysis of social media use during disasters, and more specifically in case studies of

disaster events themselves (Leysia Palen, Sarah Vieweg, et al., 2007). Across these kinds of studies numerous positive and negative aspects of social media have been identified, groups of users defined, and perceptions of disasters analysed (Reuter and Kaufhold, 2017). It is these studies that form a foundation of knowledge and literature on which further case studies may contribute to. This section has scoped the origins of the relationship between humans and disasters, explaining some of driving forces behind social media as a new form of communication. The following section will build on the understanding of this relationship, and will explain the driving forces of disaster management in a modern-day setting.

2.3 A Brief History of Disaster Management

Communicating and exchanging of information about disasters is, in actuality, just one aspect of the general management of hazards. The term disaster management encompasses a range of actions, methods and tools, which have similarly developed over time (L. K. Comfort, 2005). Much of our species early interaction with disasters has gone unrecorded due to a lack of technology to record information over long time-scales (Riva, 2005). It is theorised that methods of early disaster management tended to be passed through oral and cultural traditions, handed down through generations (Coppola, 2007). However, in some unique cases, evidence can be traced as early as 3200BC to the Asipu - a social group located in modern-day Iraq sought out for their guidance. Asipu have been documented using methods to determine and measure the level of risk from different problems, as well as the likelihood of outcomes from events, emulating modern methods of risk management (Coppola, 2007). Methods of response as a means of managing disasters is similarly evident throughout history. For example, in AD79 when Mount Vesuvius erupted both Herculaneum and Pompeii were in the immediate path of destruction. Despite this, most of Pompeii was evacuated in the early stages of the eruption by organised town leadership who recognised that the ash clouds would bring certain danger (Coppola, 2007).

Arguably, modern disaster management has roots stemming back to various ancient civilizations who managed risk presented by their unique environments (L. K. Comfort, 2005). During 1800-1700BC the Egyptians created flood management projects to divert annual flooding (**Birkman2006**). Rome structured the first formal organised fire-fighting response teams, who were also trained on specialised equipment to reduce fire risk (Coppola, 2007). The Inca, during the height of their civilisation, created land terraces at the top of the Andes mountains to lessen the destructive power of landslides (**Birkman2006**). Coppola (2007) theorises that it wasn't until the "Civil Defence Era" - during the first and second World Wars - that modern disaster management as we know it developed with the aim to protecting citizens. This sparked the rapid creation

and improvement of technology and tools for a range of purposes (predominantly warfare), which were then utilised as a means of reducing risk in civilian settings. Following this, during the 1990s, the United Nations (UN) called for the improvement of state capacities to manage disasters in order to promote more stable development of countries (Coppola, 2007). This was termed the "International Decade for Natural Disaster Risk Reduction", and promoted the sharing of science, research, tools and technology between states to promote member nations(Coppola, 2007).

Stemming from the development of the Web, social media represent another tool brought about by the technological and sociological advancement of our species (Reuter and Kaufhold, 2017). The use of social media as a tool for disaster management specifically has evolved over the past several decades, and now plays a significant role in reducing the risks posed by hazards (Chen and Sakamoto, 2014). Academic studies, which seek to understand the relationship between social media and disasters, trace this discourse roughly to 2005 where the functionality and uses of social media began to expand and user uptake increased (Grubmüller-régent, Götsch, and Rainer, 2014). This uptake can, in part, be attributed to the emergence of new platforms that could be used in ways never before seen: for example Facebook's release in 2004, YouTube's release in 2005, and Twitter's release in 2006 (Palen, 2008). These developments increased the value of the online world, not only to individuals using social media on an every-day basis, but also to humanitarian aid organisations, companies, governments and other collaborations pursuing low cost effective methods to support disaster management and crisis communications on a global scale (Olteanu, Sarah Vieweg, and Castillo, 2015). For organisations who seek to improve communications with citizens during periods of crises, online networks offered a means of reaching out to communities that were previously difficult to reach (Baltar and Brunet, 2012).

A shift in global political focus towards sustainability, risk mitigation and climate change is also argued to be a driving factor in the uptake of communication technologies, in particular that of social media platforms (Cottle, 2014). Grubmuller (2014) theorises that third-party-funded research projects within the European Union (EU) targeting disaster management caused a higher awareness of social media's possible functions. Kavanaugh et al. (2012) elaborate that beneficial results stemming from such projects served to start a snowball effect, sparking other larger projects to fund and study social media use in ongoing longitudinal investigations, focused within local governments. Particularly in regions of the USA, the study of Twitter and Facebook during crises in areas with defined parameters - such as college campus's or small towns - demonstrated to regional and national governments the potential for such services in future disaster events on a larger scale (Kavanaugh et al., 2012). Similarly, the gradual incorporation of social media functions into e-government and international risk reduction strategies emphasised the benefits that social media may have to a range of communities (Lindsay, 2011).

The positive outcomes of social media use during disasters became a driving force not only for the expansion of academic research (Westerman, Spence, and Van Der Heide, 2014), but also in the creation of new tools, features, and functionalities, the formation of new online protocols and policies, and increasing funding for disaster management and risk reduction (Reuter and Kaufhold, 2017). According to the Global Facility for Disaster Reduction and Recovery (GFDRR), from 1991 – 2010 international financing for natural disasters totalled $106.7 billion out of a $3.03 trillion fund for international aid. Of this, roughly 13% was spent on disaster risk reduction, 22% on reconstruction and rehabilitation and 65% on emergency response: annual expenditure in these areas more than doubled in years where there was a significant high magnitude event, for example the Indian Ocean Tsunami in 2005, or the Haiti earthquake in 2010 (Reuter and Kaufhold, 2017). Such disasters brought the management and funding agenda to a global scale due to the huge public uptake of social media, and resulted in driving the proportion of risk reduction funding higher compared to other sectors of international aid (Bryant and Zillmann, 2002). Furthermore, it emphasised the importance of underlying factors in the outcome of disasters, which take the form of geographical, political, demographical and economic issues (Bryant and Zillmann, 2002).

Evidently, there is an extensive history between humans and disasters. Social media is a product of our developmental history, and represents a new and emerging tool at the forefront of disaster management (Reuter and Kaufhold, 2017). It is one that has the potential to be used in valuable and effective ways to reduce future risk, and to continue to be developed upon (Cottle, 2014). In order to do this, however, we must first understand its current functions in the field. Considering the scale of disasters, both in a geographical aspect as well as temporally, there is a variety of possibilities that social media may fulfil (Westerman, Spence, and Van Der Heide, 2014). Particularly in a globalising world where the awareness of disasters may now span the entire globe and supersede geographical boundaries, the functions of social media are more important to understand than ever (Palen, 2008). Since the late 1990s studies of social media have sought to scope its uses and users, which have slowly expanded into disaster management as the potential benefits have become more apparent in real-life case study applications (Reuter and Kaufhold, 2017). Much of this literature falls into two broad distinctions: the technical (for example the creation of new platforms, applications and algorithms), and the social (for example crisis communication, behavioural change and usability). The following section of the literature review will analyse key studies in both of these distinctions to scope the current role that social media holds, and in order to fulfil the thesis research questions.

2.4 The Current Roles of Social Media within Modern Disaster Management

According to the World Disaster Report published by the IFRC during the last decade 631 disasters occurred annually (on average), with nearly 84,000 killed, 193,500 people affected, and 162,000 million US dollars in estimated damages. During this period of time many studies have made contributions to the field of disaster management literature which seek to identify important themes and concepts that affect the relationship between social media and disasters, generate a better understanding of case studies, and ultimately to improve disaster management in coming years (Reuter and Kaufhold, 2017). Consequently, there are now a range of established roles that social media can offer disaster management in the present-day setting. Disasters themselves are generally conceptualised by the disaster life-cycle phases: pre-disaster, during, post-disaster and throughout all stages (explained in the key terms section at the beginning of this chapter). Disaster management may also further be broken down into the four R's, which correspond to the disaster life-cycle phases respectively. These are resilience, response, recovery and risk reduction. This section will broadly organise studies into each of these R's, beginning with a definition, in order to form an understanding of social media's role (RQ1), as well as how these may change throughout the disaster life-cycle phases (RQ2). It is important to note however that each of the aspects discussed in the following sections may also have applications in other areas of the four R's, as few are confined to just one part of the disaster life-cycle alone.

2.4.1 Social Media for Building Resilience

Houston et al. (2015) define individual resiliency as the ability to "bounce back" after disaster. The concept can be traced back to the 1980s before the creation of the Web and the emergence of social media. Over time, the concept has evolved with the development of modern disaster management methods, and now spans a range of actions, tools, roles and methods. This section will present some of the most popular of these, where social media is increasingly being used for building resilience in the early stages of the disaster life-cycle. Firstly, the use of social media for community preparedness will be discussed. This is a newly emerging theme as media themselves feature multi-dimensional community structures that are represented in the virtual world (Demchak, Boin, and L. Comfort, 2010). Next, the use of social media for event detection and tracking is explained, and key findings from case study applications are presented. Finally, the section details the use of social media to create warning systems, applications and features which aim to improve future resilience through targeted actioning and information spread in the early stages of an event.

2.4.1.1 Community Preparedness

Demchak (2010) explain that community resiliency can be more complex than individual despite following the same premise as general disaster resiliency. Community resilience is considered to be how well a range of structures and networks – both online and offline – bounce back after disaster (Houston et al., 2015). Often community resiliency encompasses more than groups of resilient individuals alone, and should be viewed as network capacities and activities that are not static end-state (Demchak, Boin, and L. Comfort, 2010). There are four key considerations for community resilience capacity argued by (F. H. Norris et al., 2008): information and communication, community competence, social capital and economic development. (Pfefferbaum et al., 2013) argue four additional considerations: connection and caring, resources, transformative potential and disaster management. Furthermore, the National Research Council (NRC) contend that community resilience needs to incorporate social subsystems (such as economics and civil society) and other sectors also (such as business, healthcare, media and religious organisations) in order to uphold the complex constructs of society (Council, 2015; Houston et al., 2015). The plethora of underlying factors that shape general preparedness and resilience are evidently important considerations for the case study analyses of this thesis, and as such will be discussed in more detail later on in this chapter.

Considerations for building community resilience have been supported in the past decade by the use of social media and other similar technologies (Alexander, 2013; C.-M. Huang, Chan, and Hyder, 2010; White, 2014). These have enabled a range of beneficial features that are well-documented in wider disaster literature. Dufty (2012) posits that social media have already illustrated their value in emergency management, and are steadily becoming more apparent in the specific fields of resilience and community development in recent years also. This, in part, is due to the fact that social media can easily form "communities of practice" (Wenger, McDermott, and Snyder, 2002), or "relational communities" (Paton and D. Johnston, 2017). These are networks of individuals who are connected by their similar concerns, who seek information as well as ways of learning from experience (Wenger, McDermott, and Snyder, 2002). Further insight into social media's beneficial attributes has been scoped in other notable case studies: for example, the degree to which social media constitutes a resilient information conduit was tested during the case study of the Australian wildfires in 2013, and found that the speed of online communication influences the level of resilience a network has (Dufty, 2012). Comparing the resilience of two communities who experienced wildfires in Canada revealed that social capital and underlying factors create a complex dynamic for social media networks that have the power to shape the resilience and engagement a community has (Cox and Perry, 2011). Comparing cases such as these have revealed how dynamic communities may be in the early stages of a disaster. This, clearly, is an important aspect of analysing disaster cases which focus on local communities, and as such is valuable to the later case studies of this thesis.

Other case studies have found that the use of social media for building resiliency and preparedness depends upon underlying geographical, demographical and economical factors for a number of different reasons. Dufty (2012) point out that countries which are small in size, are remote, have unique environments, limited resources, localised politics and insular demographics are more vulnerable to disasters. For example, a study in Barbados highlighted that efforts to improve community resilience must be main-streamed into governmental policy in order to be more effective, and that an emphasis needs to be placed on international efforts that reduce the effect of economic and environmental pressures stemming from changes in climate change and tourism (Pelling, 2012). Similarly, studies in the Cayman Islands revealed that institutional networks and resiliency had a larger role to play in wider community resilience than previously expected, and should seek methods of supporting networks both within their hierarchies as well as nationally (Tompkins, 2005). In these kinds of cases, social media has been argued to act as a valuable resource for hosting information as the easily-accessible and free nature of platforms can be used to support both individual and community preparedness information (Dufty, 2012). Again, this represents further consideration for the analysis of case studies later in this thesis, as social media have become a paradigm which are consistently, and in some cases subtly, affected by the complexities of geography, politics, demographics and economics.

Further to the aforementioned factors, perception has also been highlighted as a contributor to disaster resiliency (**Paton2015**). In a recent study Reuter (2017) found that across European countries social media is used more extensively to search for information, rather than to share it. With such a high percentage of individuals actively seeking preparedness and resiliency information there is an extra strain on emergency services to monitor their information outputs, as well as to manage the level of resources that they host both online and offline (Reuter and Kaufhold, 2017). Bajayo (2012) go on to explain that the perception of resiliency is changing with the development of new technologies, features and applications supported and created by social media. They theorise that this new level of availability will result in the perception of social media being regarded as a disaster management tool itself, and thus increasing public empowerment and general resilience (Bajayo, 2012). While this may be valuable in reducing risks posed by disaster, many studies argue that in order to change an individual and community's perception of social media for disaster management, many more resources must be created and targeted at vulnerable communities (Houston et al., 2015). These may take the form of educational resources, national and regional training and drills, government-produced information in a variety of formats, and the availability of online resources that supports offline protocols (Paton and D. Johnston, 2017). This is an aspect that may shape qualitative methods of data collection and analysis within case studies, where social awareness and the digital divide may potentially dictate a community's willingness to utilise social media. This, on the other hand, may produce

valuable insight into qualitative side data which may then seek to explain quantitative phenomenon.

2.4.1.2 Event Detection and Tracking

According to Imran (2014), most systems for social media processing during disasters begin with event detection and prediction. Historically, methods for this are adaptations of broader methods for the detection of events in a stream of documents, commonly referred to as information retrieval (Imran, Castillo, et al., 2014). With the expansion of document streams into wider news media, and eventually social media, the topic detection and tracking research community formed. Imran (2014) goes on to explain that event detection on social media, as a result of developments of communication technologies, now differ from traditional media in approach. Social media data produce unstructured content, in higher volumes, within a shorter space of time. This gave rise to "New Event Detection" (NED), which, in the field of disaster management, refers to the identification of the first messages related to an event by continuously monitoring a stream of social media messages and content (Atefeh and Khreich, 2015). The approach then determines whether a message refers to something new and previously unreported using a variety of metrics (X. Yang et al., 2012).

NED has evolved over the past two decades and now includes a variety of techniques and approaches. Atefeh (2013) summarise notable examples of this during this period that began on the platform Twitter. Imran (2014) adds to this by presenting a range of literature that have employed techniques from such examples to disaster specific case studies. Robinson (2015), for example, work on the assumption that keyword bursts on Twitter produce sharp frequency increases in the virtual world over time, that can indicate a real-world event occurring. Using this technique, they propose a system for the detection of earthquakes using Twitter data. This identifies keywords in the real-time tweet-stream, and applies burst detection methods to analyse word frequencies in a defined period of time (Robinson, Power, and Cameron, 2015). Events are therefore identified by recording a significantly higher frequency of keyword mentions compared to historical data. While many earthquakes are not initially identified by Twitter users, studies such as Earle (2012) revealed that keyword detection was considerably faster than offline methods of earthquake prediction such as seismographic detection. This was especially prominent in regions of the world with reduced access to instruments or a technological digital divide (Earle et al., 2012). In this sense, the study of real-time streams of social media data may be valuable to the detection and tracking of information - particularly in case studies where one hazard may trigger subsequent hazards. It also presents an interesting area for the comparison of different streams of social media data, where, potentially, the users and uses of a specific platform may unintentionally (through the affordances of underlying factors) or intentionally alter the discourse of

online information. This represents an intriguing area for highlighting differences in data, as well as case studies, later on in this thesis.

Relying on keyword bursts can however be problematic. Many keywords are reused within the virtual world, meaning that methods which look for frequency spikes can record series of events that aren't actually real-world events. For example "fire", which can mean a number of different things, from a "fire" occurring in real-world events, to a new viral video or trend described as "being on fire". To address this problem, Becker (2011) present an approach that differentiates real-world events from non-events on Twitter using four types of features; temporal, social, topical and Twitter-specific. Clusters are initially formed based on temporal features such as frequency of tweets in a defined period of time. Clusters are then refined using social features such as re-tweets and other node interactions. Heuristics are applied which look for high percentages of social features, which indicate whether there is an event or a non-event. Cluster coherence is estimated using cosine similarity metric between messages and cluster centroid. Finally, Twitter-specific features are tested by checking the frequency of keywords which are platform particular, for example known Twitter hashtag trends (Becker 2011). Several other studies have added to this methodology (see for example Weng (2011) and Corley (2013)) which is employed extensively on Twitter. While this can be useful for tracking events on platforms such as Twitter that are capped and used in a particular way, it may pose difficult on other platforms that aren't limited in the same way. This raises a question for the quantitative tracking of trends on examples such as Facebook and YouTube, which may require more complex methods of analysis in order for trends to be compared across platforms.

Domain-specific approaches to NED are also commonly used within disaster literature. Sakaki et al. (2010), for example, use temporal and spatial data as well as natural-language processing applications to indicate disasters and potential hazards on Twitter. Dissimilarly to Becker (2011), Sakaki et al. analyse three types of tweet features; statistical (i.e. number of characters and words), keyword features (i.e. the specific words used), and contextual features (i.e. words that have a relationship to a keyword, for example a tweet with the keyword "hurricane" would likely feature terms such as "category" and "weather"). To ascertain whether a tweet may indicate a hazard or disaster event they employ Support Vector Machines (SVM), which is a classification algorithm extensively used in NED (Sakaki, Okazaki, and Matsuo, 2010). Likewise, the TEDAS system devised by Li et al. (2012) serves a similar function. In this study, tweets are collected from the Twitter streaming API and then classified using features (R. Li et al., 2012). TEDAS differentiates itself from other comparable systems by allowing the extraction of location information, and ranking tweets in accordance with their calculated level of significance (R. Li et al., 2012). While systems like these offer value to the early phases of a disaster, particularly to emergency responders with access to sophisticated technology and man-power for processing, they cannot produce detailed information

about the progression and possible evolution of an event in the later phases. Therefore, in order to fully answer all of the research questions of this thesis, early stage analyses of case studies must be supplemented with during and later stage methods to ensure that information about an event can be tracked throughout its life-cycle.

Evidently, using social media for event detection, prediction and tracking in disaster management still presents challenges. Another such challenge, highlighted by Imran (2014), is the use of inadequate spatial and temporal information by systems that rely on Twitter data. This is not unusual given the features of the platform: it provides a wealth of data which can exceed 400 million tweets per day and can include images, videos, geolocation and more, all while being capped at 140 characters long (Panagiotou, Katakis, and Gunopulos, 2016). Aside from its structure, the platform's popularity plays another significant role in its study. Crooks (2013) further argue that these two components are integral for assessing the true value of social media streams, particularly for data that is constrained by the structure of the platform itself (i.e. tweets capped at 140 characters limit qualitative content). Another critical challenge is that of information reliability across a range of social media platforms (Crooks et al., 2013). While the value of detecting, predicting and tracking events in the virtual world is valuable for disaster management, it may be undermined by information that refer to non-events, false information, or information that is not spatially or temporally relevant to a crisis situation (Thomson et al., 2012). Particularly in the case of Twitter, where tweets may easily be re-tweeted and disseminated quickly through a network, this can create noise that can both confuse individuals and create further challenges for NED algorithms (**Imran2016a**; Thomson et al., 2012). While this seems problematic for the study of Twitter alone, it does raise an opportunity in the analysis and comparison of multiple data from different platforms - a concept rarely documented throughout the literature review. Furthermore, it allows the content of data originating from different platforms to be compared thematically. This would allow for the affordances of the service to be taken into account in later analysis, and may be valuable in answering RQ1 and RQ2.

The role of social media in NED has naturally progressed to the tracking and evolution of such events in the virtual world, commonly referred to as "Event Tracking". Bodies who are managing or responding to disasters, such as emergency responders, primarily employ methods and techniques for tracking crises that span across all of the disaster life-cycle phases. Iyengar (2011) present a general approach to automatically ascertain event phases on Twitter. Their method applies various classification techniques, including an SVM classifier and POS tags, to tweet content to identify tweets as being before, during or after a disaster (Iyengar, Finin, and Anupam Joshi, 2011). This offers responders the ability to track the evolution of disasters in the virtual world, thus allowing targeted disaster management actions that correspond to the event phases (Iyengar, Finin, and Anupam Joshi, 2011). Although approaches of event tracking are valuable to disaster

management, many are targeted to specific social media platforms (commonly Twitter) and are not designed to synthesise multi-sourced data in high volumes.

Consequently, approaches such as Huang (2015) have sought to address this by developing more powerful systems. In their approach, they present DisasterMapper: a CyberGIS framework which automatically summaries a range of data from both social media, as well as socio-economic data (Q. Huang et al., 2015). This allows the tracking of events, the ability to produce maps of the evolution of events, and to perform spatial and statistical analyses for disaster management purposes (Q. Huang et al., 2015). The scale and detail of results generated by these kinds of approaches are rich, however systems can still experience a range of problems. Gandomi (2015) argue that automatically synthesising big data can produce issues with the management and integration of data sources, which may later result in inaccurate representations of events and subsequent analyses. Similarly, Li et al. (2016) highlight that systems which rely on multiple data sources face problems with the quality and verification of data (particularly that of geospatial), and the visibility of data. The differences of domain-specific data, caused by variations in its use and purpose, can therefore be unexplained or unacknowledged in the output of such systems (S. Li et al., 2016). As a result, analyses generated by such algorithms fall short of qualitative insight, given that they are designed to reveal quantitative insight alone (S. Li et al., 2016; Earle et al., 2012; Gandomi and Haider, 2015; Imran, Castillo, et al., 2014). Furthermore, such methods require the creation and adaptation of complex algorithms taking a prolonged amount of time, require large volumes of data, processing capabilities, and man-power. Realistically, such approaches may only be conducted in labs or research projects set up for this purpose, and so this kind of tracking is not feasible for the scope of this thesis.

2.4.1.3 Warning and Sensing Systems

The large volume of data produced by social media are useful for social sensing and warning systems during disasters. In general these systems are designed to sift through big data streams in real-time, which offer a range of opportunities and challenges for disaster management (D. Wang, Abdelzaher, and L. Kaplan, 2015). The producer, users, targeted social media and end goals can shape systems designs, as well as effective implementation and integration with other data sources or similar systems (Aggarwal and Abdelzaher, 2011). As such, there are a range of different systems that have been developed to utilise this output throughout the disaster life-cycle phases, and from different origins. Wang (2015) argues that these can be used to build a "reliable understanding from unreliable data", especially given the prominence of incomplete or sporadic data throughout crises. This further highlights the underlying factor of information reliability during events.

Choi (2010) state that social media can be used as form of "collective wisdom", which can be accurate and readily available, and consequently have large potential impact to disaster-affected areas. This is termed "social sensing", and is explained by Laituri (2008) as using people as part of the system itself for data generation. Furthermore, communities themselves have, too, realised this potential, and examples of community driven sensing systems and structures are identifiable in disaster case studies (Laituri and Kodrich, 2008). They go on to discuss the instance of a group of high school students in New Jersey, USA, who devised and launched a crowdsourced map that locates open gas-stations in the New York area – after locals were struggling to find fuel after the impact of hurricane Sandy. They used social media data in real-time to update the map, and to fulfil the community information gap that residents felt was not being met by emergency responders and the government (Laituri and Kodrich, 2008).

Following this, Choi (2010) built their own real-time monitoring system called "Social Big Board" using the New Jersey community example as a basis. The system crawls Twitter, analyses disaster related tweets, and displays disaster situations and trends in a map (Choi, 2010). The goals of the system weren't to predict hazards, but rather to sense signs within social media data that a disaster was unfolding. While the system can be considered valuable (it was employed by the National Disaster Management Institute in Korea in 2013), there remain limitations to its functionality. Primarily, this is due to information reliability issues on Twitter: these can be magnified when analysing one social media platform alone (Westerman, Spence, and Van Der Heide, 2014; R. Rao, Plotnick, and S Roxanne Hiltz, 2017; D. Wang, Abdelzaher, and L. Kaplan, 2015). Once again, this highlights a lack of documented comparisons between a range of data originating from difference social media platforms, and further shows that tracking trends, themes and warnings between such datasets is not a common occurrence.

Alongside warning and sensing systems there are smaller tools and features that have been created for specific disaster management purposes, generally occurring in the during event stage rather than pre-event. Social media platforms themselves have in recent years recognised the centrality of their services during disasters (Brengarth and Mujkic, 2016). In response to this, many have begun to develop their own tools and applications designed to support disaster management in the virtual world (Brengarth and Mujkic, 2016). Notable examples of this include the TweetTracker tool, which allows aid organisations to gain situational awareness by monitoring frequency of keywords in the early stages of disaster, and tracks their spread through networks (Kumar et al., 2011). Another is Facebook's "Safety Check-in" feature, which geolocates accounts in an area that has experienced a disaster, and allows the user to notify the platform that they are safe from the event (Kurian and John, 2017). As the information is public, Facebook then shares this on the users account so that the user's network can see their safety status; thus reducing the overloading of information during events where loved ones seek to get in contact with one another (Kurian and John, 2017). These developments effectively

represent the progression of social media technology and design over time, and further scope the relationship between platforms and disaster management.

While the idea behind Safety Check-in is to reduce the level of miscellaneous messages and communications sent through social media during an event, leaving channels clearer for more pressing issues such as individuals seeking help, the feature has experienced troubles (Kurian and John, 2017). In it's first case - the Nepal earthquake in 2016 - Facebook failed to add a geolocation criteria for the feature. This meant that users from around the world were able to check-in safe from the event, many of whom did so to try out the latest feature offered by the platform (Rauniyar et al., 2016). Consequently, Facebook generated a large amount of data about the safety status of individuals who weren't located near the earthquake itself, thus rendering the potential benefits of such data useless for targeted disaster management purposes (Rauniyar et al., 2016). Since this case however Facebook have add further parameters to ensure that quality data can be generated and acted upon in future events. This was apparent in several following case studies, and has now became a valuable resource for particular humanitarian aid organisations such as the Red Cross who work in conjunction with the platform (Kurian and John, 2017). The flaw in the feature's initial launch is a valuable reminder that not all data collected from social media platforms are useful. Instead, analyses seeking to offer detailed insight into case studies must carefully consider the parameters for data inclusion, as well as case study inclusion.

2.4.2 Social Media for Disaster Response

The next section will analyse the role that social media has within the during phase disaster life-cycle. This focuses on disaster response, which is defined as emergency reaction and assistance to events once a disaster has occurred (UNISDR, 2018) . Response takes many forms that include evacuation, hazard warnings, allocation of resources, assignment of emergency services, damage control and risk assessments (Levin, Berliner, and Merdjanoff, 2014). This section will present some of the most popular functions of social media for the immediate response stage, which, arguably, is one of the more diverse research areas for disaster case studies. It will begin by introducing the concept of situational awareness during unfolding events: this has become one of the primary targets of disaster management in a modern setting given the diversity of online information that may be used to support offline decision-making (Levin, Berliner, and Merdjanoff, 2014). Next, it will explain how social media may now assist with this through methods such as crowdsourcing, data mining and network analysis of social media.

2.4.2.1 Generating Situational Awareness

Situational awareness is defined as the perception of elements in the environment, an understanding of their meaning, and the projection of their status in the future (Rudra et al., 2016). It is generally well established that the greater the situational awareness of a crisis event, the higher the potential risk may be reduced by employing effective disaster management strategies: these undoubtedly are shaped by a range of parameters, availability of resources, and effective response to information among other factors (Luna and Pennock, 2018). As a result, there have been many systems and methods created which seek to mine social media for information, which consolidate in general situational awareness (**Imran2016a**). These vary in a number of ways, such as in scale, type of data mined, methods of processing the data, and format of information output (Luna and Pennock, 2018). The most extensively used systems have been built to mine popular microblogging platforms. Partly, this is due to the fact that these are often the most extensively used services during crises, and partly due to the availability of data free of significant privacy or formatting issues (**Imran2016a**).

Of the popular microblogging sites commonly utilised for data mining Twitter has become the most extensively mined as well as studied (**Imran2016a**). The short length of tweets reduces the number of errors with analysis compared to other platforms which do not enforce format structures (J. Li and H. Rao, 2010). Furthermore, Twitter is public, meaning that all data published on the platform can be accessed through the APIs, thus allowing a large pool for data mining (J. Li and H. Rao, 2010). Abdullah (2017) utilise this aspect in their Twitter-mining tool "Tweedr" which classifies, clusters and extracts information from the platform during disasters. Emergency responders may harness this data stream to identify where disasters are happening, what areas of a population have been affected, and even flag up potential new hazards (Abdullah et al., 2017; Ashktorab et al., 2014). This can be supported, too, by some of Twitters other functions. The ability to geotag tweets may help to clarify areas at risk, as is demonstrated by (Choi, 2010) in their real-time monitoring system of hurricane Sandy. Imran (2014) document the use of hashtags to label tweet content. They propose the Artificial Intelligence for Disaster Response (AIDR) platform, which enables filtering and content classification methods, further tracking and tagging of information on Twitter. These kinds of system are designed to produce situational awareness of a disaster, and to document how an event may unfold. Similarly to the NED algorithms above however, such systems require a similar amount of resources to run successfully.

Aside from Twitter, there are broader systems for generating situational awareness from social media data, as well as on wider channels of communication such as news media. Rudra (2016) explain that wider channels are difficult to analyse accurately as they tend to present more detailed and rich information than the Twitter stream alone. In their study, they go on to propose a method which automatically identifies and summarises

micro-topics in data streams. This, they argue, provides information about unfolding crises at a finer granularity when compared with larger, generalised topics through Tweet filtering alone (Rudra et al., 2016). Kedzie (2015) likewise present a case for the summarisation of disaster-specific information originating from other social media and crisis communication channels. In their approach they demonstrate how an automatic summarisation system can track events over time by predicting sentence salience, combined with clustering, which they argue is better for adapting to dynamic changes in data (Kedzie, Mckeown, and Diaz, 2015). This is particularly relevant for disaster events which are likely to change unpredictably as they unfold (Kedzie, Mckeown, and Diaz, 2015). Once again, such systems are complex and costly, and so only available to research labs and projects. Despite this, there are other methods of generating situational awareness that are more applicable to answering the thesis research questions.

Doyle et al. (2015) outline that contemporary approaches which do not rely entirely on systems for generating situational awareness are valuable to modern case studies also. Using volcanic hazards in New Zealand as an example, they explain that response planning, multi-agency planning and collaboration, and management training programs have tangible outcomes on what responders and bodies can know about a hazard (Doyle, Paton, and D. M. Johnston, 2015). Vieweg et al. (2010) similarly demonstrate that manual evaluation of micro-blogging during two emergency events - the Oklahoma grassfires and the Red River floods in 2009 - helped to inform situational awareness on the ground. Human evaluation, as opposed to automatic, resulted in extracting useful information from broadcasts by people who were in affected areas due to the contextual understanding that humans have over systems (Sarah Vieweg et al., 2010). This, they argue, is an important reason for social media research to form multi-methodological approaches for data analyses in order to utilise the benefits from more than one approach, while reducing the limitations of relying on just one (Sarah Vieweg et al., 2010).

Vieweg and Hodges (2014) scope the problems associated with automated methods for situational awareness in more detail in a later study. In this, they identify that context poses more of an issue than was initially thought in previous literature (Vieweg and Hodges, 2014). This is due to the fact that physical and social environments, especially in the spaces where they merge and affect one another i.e. during disasters, require pragmatic human interpretation (Vieweg and Hodges, 2014). They therefore argue for an emphasis on human researchers in disaster cases, which may also be informed by automatic methods. Similarly, Meier (2013) discuss potential methods of combining methods for situational awareness that places an emphasis on human interpretation, referred to as human-computation. The study highlights that a mixed-method approach has been beneficial to emergency responders in the past, which can be improved upon by the continued uptake and integration of new technology, methods, and algorithms (Meier, 2013). Adaptive systems, gamification of sourcing information, high-volume analytic techniques, mixed-method methodologies and crowdsourcing are all examples

of how human-computation may increase its benefit to disasters in future events (Meier, 2013). Certainly, this is a more applicable approach given the scope of this thesis, and would allow for the preservation of context which is a vital component for original insight into crisis events.

2.4.2.2 Crowdsourcing and Network Analysis

Crowdsourcing can be defined as a method of generating and collecting information from citizens regarding a specific event or task, via the medium of the Internet (Ludwig et al., 2017). This method of generating information has gained popularity during disasters as it can take pressure off of authorities and organisations who may be limited in resources and man-power able to confirm real-time updates (Gao et al., 2011). Another significant advantage of crowdsourcing for situational awareness is that it can generate reports almost immediately (Gao et al., 2011). Heinzelman (2010) document this with the crowdsourcing platform Ushahidi Haiti – a platform set up just two hours after the Haitian earthquake by volunteers. In a short space of time, the service allowed for additional features, such as free SMS messaging. Several weeks later it had generated nearly 2,500 crowdsourced incident reports that had been verified (Heinzelman and C. Waters, 2010). Starbird (2011) goes on to explain that other systems were developed in wake of the disaster in Haiti too; CrisisCommons being the most notable. This differed from Ushahidi in the sense that it crowdsourced experts, researchers, responders, volunteers and other skilled workers rather than the general public (Starbird and Leysia Palen, 2011). This highlighted the benefits of crowdsourcing for the ability to geotag information originating from different sources, and collecting data from other unstructured sources such as emails (Gao et al., 2011).

While there is an extensive collection of tools, systems and applications for data mining during disasters, there remain barriers for situational awareness and disaster management. As Twitter is one of the most extensively studied platforms, it is important to bear in mind that analysis of the tweet stream alone cannot fully equate to complete and detailed situational awareness of a disaster event (Imran, Mitra, and Castillo, 2016). Instead, studies such as Hughes (2012) and Becker (2011) urge researchers to take into multiple types of data, originating from a range of platforms. Pang (2013) and Gao (2011) similarly add that disaster management strategies which utilise situational awareness generated from platform-specific data mining should consider offline events, incorporate human judgement, and employ skilled teams of individuals for analysis to ensure that enough situational awareness can be generated. This is of paramount importance for strategies that act upon this information, for example for aspects such as resource allocation (Rudra et al., 2016). Furthermore, privacy issues with data can undermine automatic analysis, particularly of systems that analyse platform-specific data (Poblet, García-Cuesta, and Casanovas, 2014; Lindsay, 2011). Crowdsourcing, too, faces

limitations in the information that it can generate (Gao et al., 2011). Most systems lack a mechanism to allow for collaboration and coordination between organisations (Gao et al., 2011). Additionally, there is still a question as to the degree of reliability crowd-sourced information can provide (Poblet, García-Cuesta, and Casanovas, 2014).

The analysis of social network structures may also contribute to situational awareness during disasters. Online social networks can be modelled as a series of nodes which link to other nodes via edges (illustrated in figure 2.2 below) (Boyd and Ellison, 2007). Nodes represent accounts or users of social media, and edges that connect them can vary in function. For example, one's profile account on Facebook can be considered node A, and another's account could be considered as node B. If these two nodes were friends on the platform, and edge can be drawn between the two to signify that they are connected in the network. The study of such networks can offer a wealth of information throughout the life-cycle phases of a disaster, which may reflect issues that communities have in responding or coping with a crisis, provide insight into how and why information spreads, and contribute an understanding as to how online and offline communities differ (Streeter and Gillespie, 1993). A range of software and tools have been developed in recent years that seek to mine and analyse social networks – particularly that of social media platforms – for data and visualisation purposes (Kim and Hastak, 2018). Toolkits and methods for social network analysis can be found in a range of programming languages and in some cases have tools created for this specific purpose (Kim and Hastak, 2018).

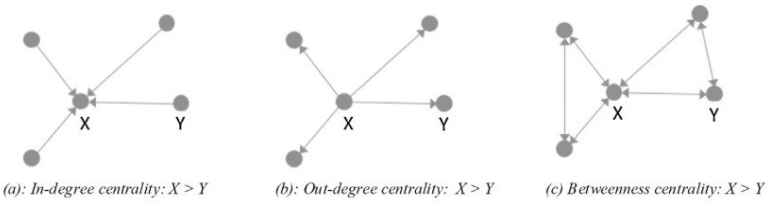


FIGURE 2.2: Diagrams Illustrating the Social Network Models of Different Forms of Centrality within Networks (Kim and Hastak, 2018).

Modelling centrality is another method of social network analysis that may provide a better understanding of networks. Kim (2018) illustrate this in the figure above, showing the differences between the concepts of in-degree centrality, out-degree centrality and betweenness centrality. The types of capital explained in the section previous can be characterised by the notion of centrality, connectivity, and hierarchy of relationships among individuals (Lü et al., 2016). Diagram a. shows in-degree centrality: where many other nodes are connected to node X. In a social network, this means that many accounts look or are directed towards node X (or "follow", or are "friends" with, depending on the nature of the social media platform) (Boyd and Ellison, 2007). This implies that node X has a high level of centrality, thus other nodes are more likely to trust and/or pass on behaviours that it exhibits. During disasters, nodes which represent governments, authorities, involved organisations, stakeholders and humanitarian aid organisations commonly have the highest levels of centrality (Kapucu, Arslan, and Collins, 2010). Moore (2003) evidences the value of centrality in the case of the Mozambique floods in 2000. They conducted social network analysis on inter-organisational relationships between 65 non-governmental organisations (NGOs) involved in disaster response to the event. They then calculated the centrality scores of these NGOs, and concluded that the higher the centrality scored, the more potential for aid coordination and NGO had (S. Moore, Eng, and Daniel, 2003). While this can be valuable for targeted actioning purposes for responders, this kind of method requires enough time for calculation, sophisticated modelling software, and a pre-existing understanding of the social networks being studied - which again are outside the scope of this thesis. Additionally, measuring networks does not offer a qualitative explanation as to why some pieces of information may spread as opposed to others. In this sense, it is vital to have methods or data that seek to explain the quantitative measures found through centrality measures.

In the figure above, diagram B illustrates out-degree centrality. In contrast to in-degree, node X is shown to have many ties that are directed outwards, towards other nodes (Boyd and Ellison, 2007). Kapucu (2010) explain that in this kind of model, node X is likely to be an account that disseminates a high level of information and again are most likely to represent nodes of authority. In a disaster context, these are most likely to be creators of original information, for example meteorological services or updates, or governmental departments who are first responders to crises (Kapucu, Augustin, and Garayev, 2009). Nodes such as these are vital for the spread of valuable, time-critical information during the disaster life-cycle phases, and the best performing actors have individuals and teams dedicated to the creation and spread of information (Tapia and K. Moore, 2014). The spread of information is equally as important in an inter-organisational capacity (Kapucu, Augustin, and Garayev, 2009). Htein (2018) evidence this in a comparison of centrality across an inter-organisational network during the Myanmar floods for 2015 and 2016. In their network analysis they show that number of links between organisations in information sharing and resource sharing, across rescue

efforts and humanitarian assistance both increased significantly. The analysis implies that due to this increase in out-degree centrality across the network in 2016, these aspects were more effective than in the previous year (Htein, Lim, and Zaw, 2018).

Finally, diagram C illustrates betweenness centrality: a measure which indicates which nodes act as "bridges" between others in a network (Boyd and Ellison, 2007). It does this by identifying the shortest paths and then counting how many times each node falls on one. This is valuable for understanding communication dynamics as it can detect which nodes are the most influential in a network (Kapucu, Arslan, and Collins, 2010). Therefore, its connecting nodes are theoretically more likely to pass on behaviour or information it exhibits (Boyd and Ellison, 2007). Networks are typically embedded in non-homogeneous areas and different parts/regions of the network may therefore be at risk from different types of disasters (Iqbal and Kuipers, 2017). This non-homogeneity can lead to difficulties in protecting the network against disasters (Iqbal and Kuipers, 2017). Network operators need to be able to integrate predictions on possible future disaster events in the planning of their network operation (Iqbal and Kuipers, 2017).Kapucu (2017) conduct social network analysis of emergency management agencies during the September 11th terrorist attacks, and throughout hurricane Katrina. Their findings indicate an increase in the interactions of the National Voluntary Organisations Active in Disasters (NVOAD) network member organizations, in conjunction with policy changes in the National Response Plan (NRP) (Kapucu, Yuldashev, and Feldheim, 2017). They further evidence that the organisations close to the centre of the network experienced enhanced communication and resource acquisition, allowing them to successfully accomplish their objectives (Kapucu, Yuldashev, and Feldheim, 2017). They argue that this demonstrates the development of strong betweenness centrality and the benefits it may have for communications during disasters (Kapucu, Yuldashev, and Feldheim, 2017).

While a plethora of studies have applied social network analysis to platforms during disasters, there remain grey areas as to the affects that underlying factors may have on measures of centrality (Freeman, 2017). Wu (2014) explain that in order to predict group decision making (e.g. for safety-critical decisions during disasters, or passing on evacuation information) experts usually need to model and compare a finite set of alternatives of behaviour. However, many decision making processes take place in an environment in which the information is not precisely known, making determining behaviours difficult (Wu and Chiclana, 2014). The study emphasises that trust as an underlying factor of networks is more complex than most studies can actually convey, but remains one of the biggest factors in accurately measuring what is occurring in networks (Wu and Chiclana, 2014). While this represents an interesting and valuable aspect of mitigating future risk from disasters, it once again requires high levels of resources and time outside the parameters of this thesis. On the other hand, Wu (2014) argue that the study of other underlying factors holds as much value as trust, and should similarly be pursued. Fortuin (2015) argues that peer influences, too, may have more complex

impact on network behaviours. Furthermore, they postulate that peer influences themselves may range extensively: from behaviours more commonly found in youth (Fortuin, Geel, and Vedder, 2015), to behaviours shaped by the political orientation of network clusters (Palen et al., 2010). Given the constant changing flows of networks, combined with researchers increasing reliance on tools and automatic measuring of networks, Freeman (2017) stipulate that valuable social network analysis still hinges on understanding nuanced sociological issues such as peer influences. Therefore, taking such aspects into account may seek to better answer the thesis research questions.

2.4.2.3 Social Media and Conceptual Frameworks

Conceptual frameworks are defined as analytical tools used in situations where wider understanding is needed, relating to a specific context, event, or end-goal (Baxter and Jack, 2008). They are used to make conceptual distinctions, reveal dominant themes, and to pull out areas of interest within data (Baxter and Jack, 2008). Conceptual frameworks have been extensively used on different sources of data and for different purposes during natural disasters (J. Birkmann et al., 2013). These generally fall into two main categories of framework: broad and shallow, or deep and narrow (J. Birkmann et al., 2013). Disaster management strategies which combine different frameworks in their method arguably generate better insight into disaster events than singular applications alone (J. Birkmann et al., 2013). However, the combination of frameworks can be difficult given their nature, i.e. a framework must be designed for integration before it is created to ensure that it functions with others easily (J. Birkmann et al., 2013). In many disaster events the use of multiple types of framework is common given their diverse applications, and are often tied to certain disaster life-cycle phases (Houston et al., 2015). The use of social media for generating situational awareness has additionally resulted in the creation of many social media specific frameworks which seek to address some of the issues discussed in the previous section (Houston et al., 2015).

In the pre-disaster phase, Social Risk Assessment (SRA) frameworks are commonly used to ascertain the level of risk a population or community may be exposed to (Enenkel et al., 2018). These are generally board and shallow, and will take into account a range of potential hazards and their impacts, with foundations originating from social risk management (Enenkel et al., 2018). An example of this can be illustrated by the framework proposed by Holzmann (2001) who categorise three strategies to cope with risk, levels of formality of risk management, and many types of individual against a static background of information about different types of risk. The framework was created with a focus on understanding risk to poorer individuals considering that they face higher exposure to risk particularly during crises, as well as more difficulty returning to daily normalities after an event (Holzmann and Jørgensen, 2001). While this kind of assessment is extremely valuable in identifying risk, as well as highlighting those exposed

to the most risk, SRA's can be complex to perform (Lenk et al., 2018). Furthermore, given the range of social factors involved in this kind of assessment, SRAs may take a long amount of time to conduct, and be highly subjective between communities and populations (Lenk et al., 2018). This means that for governments or authorities to gain detailed understanding of social risk a large amount of time, money and resources must be invested before any kind of hazards occur (J. Birkmann et al., 2013). These can be significant issues for lesser developed countries who face a range of other pressing issues, which may need to be prioritised before resources may then be allocated to SRAs (Lenk et al., 2018). This highlights the presence of the digital divide and Web accessibility in disaster case studies, which needs to be taken into account when comparing cases.

Social impact assessments (SIA) are commonly used post-disaster to ascertain the level of impact disasters have had on populations or communities (J. Birkmann et al., 2013). Similarly to SRAs, SIAs focus predominantly on complex social aspects, which together may determine how quickly populations or communities can return to normality after events such as natural disasters (Vanclay, 2003). Going beyond SRAs, SIAs additionally feature the assessment of monitoring and managing the intended and unintended social consequences of interventions (for example methods of disaster management) and any other social processes (Vanclay, 2003). These kinds of framework tend to be deep considering the range of social factors, as well as social interventions, that occur during crises. Consequently, they can take a long time to conduct given the complexities of populations - especially those disrupted by disaster (J. Birkmann et al., 2013). They can become outdated easily given the rapid changes communities experience throughout the disaster life-cycle phases, particularly in the latter stages of the process where communities are recovering and rebuilding (Henk Becker, 2001). Furthermore, in order for SIAs to be as accurate as possible, they require SRAs to have been previously conducted to understand both subjective and objective risk (Henk Becker, 2001). Absence of SRAs may render SIAs irrelevant to case studies, meaning that they are only the most effective when a country has enough capital, time and social resources to conduct both (Henk Becker, 2001).

There are also a range of frameworks which seek to understand social media use during disasters (Ngai, Tao, and Moon, 2015). Generally these focus on the during disaster phase, and aim to provide further information for situational awareness purposes (Ngai, Tao, and Moon, 2015). A majority of such frameworks tend to be narrow, and seek to understand singular or select concepts in the online world compared the range of issues documented by SRAs and SIAs (J. Birkmann et al., 2013). This has allowed disaster management strategies which take into account online information to gain insight into the online vs. offline information spread, differences in online human behaviour, and to scope which areas of social media have potential for targeted actioning purposes and generating situational awareness (J. Birkmann et al., 2013). Similar to other frameworks which precede the emergence of social media as a disaster management tool, these kinds

of framework are created with a pre-determined purpose. Often this isolates one theme or even a certain type of social media data: for example, data originating from Twitter alone (Ngai, Tao, and Moon, 2015). Unlike the previously mentioned frameworks, they often fall short of integration with pre-existing tools given their narrow scope of focus (Ngai, Tao, and Moon, 2015). While this kind of framework may partially answer some of the thesis research questions, given the narrow focus of the method it will likely not provide enough detail on which the latter questions may be answered.

Conceptual frameworks used to generate situational awareness of disasters may be broken down into smaller categories. Comunello (2012) present a framework which seeks to understand the role of Twitter during the Arab Spring event. This demonstrates how a particular platform can be analysed in relation to a specific case study, and is designed to increase the information already known about the even itself in the real-world (Comunello and Anzera, 2012). In this way, social media frameworks can be used to provide an additional paradigm of knowledge, thus helping to draw more detailed conclusions and to enhance general situational awareness (Ngai, Tao, and Moon, 2015). Houston (2015) go on to present another type of social media framework that may be applied to a range of data originating from different social media platforms. In this, their purpose is to determine the variety of uses that social media has been used for by individuals (Houston et al., 2015). This can seek to support online information spread, monitor platform usage for targeted actioning, and to indicate networks of interest that are likely to be leveraged in future disaster cases (Houston et al., 2015). This may offer a more detailed answer for the research questions of this thesis which require a compilation of data and methods to ensure richness of answer. The methodology for creating conceptual frameworks requires fewer resources than SRAs and SIAs previously mentioned, thus fitting within the scope of the study. Furthermore, the framework may highlight some of the more pressing issues of social media frameworks in general.

Firstly, social media frameworks tend to overlook some of the broader issues associated with the use and/or lack of use of social media themselves (Van Dijk, 2006). Particularly, the issue of Web accessibility remains prevalent which is exacerbated by other underlying problems such as the digital divide (Van Dijk, 2006). This, as demonstrated throughout the literature review, is an important factor in understanding how and why online information and resources may be used by individuals during crises. Secondly, the issue of information reliability has been consistently highlighted throughout the literature review: not only for the formation of conceptual frameworks, but for the formation of disaster management methods in general (Westerman, Spence, and Van Der Heide, 2014). This has been shown to have direct links to the level of risk posed to individuals throughout the disaster life-cycle phases (Westerman, Spence, and Van Der Heide, 2014). Subsequently, many existing frameworks choose to discount false or unverified social media data given that verification and validity testing can be costly and time-consuming (Jabareen, 2009). This avoids incorrect analysis, but at the same

time doesn't allow further explanation or categorisation of questionable data (Jabareen, 2009). While some frameworks do aim to take these into account (see for example Imran (2018) robust framework which updates with the progression of social media streams) this takes years of investment, significant research capital and time investments not available to the majority of disaster management strategies.

2.4.3 Social Media for Disaster Recovery

The next phase of the disaster life-cycle is the post-event stage, which is associated with disaster recovery efforts. Recovery is defined as the series of actions undertaken to return communities and environments back to a state of normality after they have been affected by disaster (Coppola, 2007). This is undertaken through policies, tools, and methods to re-build technical and social systems. The section will begin by explaining technical interoperability and the role that systems may play in effective disaster recovery (Coppola, 2007). Following this, interoperability of social media networks specifically will be presented. This, in contrast, focuses on returning social networks and capital back to their original pre-disaster states within the virtual world, utilising social media both as a lens as well as network structure themselves.

2.4.3.1 Interoperability

Interoperability is the ability of computer systems to exchange, utilise, and recognise important information. This is a concept within disaster management that has become more sophisticated in recent years with the advancement of systems, tools and applications able to generate and analyse big data about disaster events (National Research Council (U.S.). Committee on Using Information Technology to Enhance Disaster Management. et al., 2007). Particularly in situations where there are a multitude of agencies and organisations responding to an event, disaster management requires effective collaboration, that is both rapid and in real-time (Janssen et al., 2010). This proves especially difficult for systems: firstly as they often lack the ability to cope with complexity and uncertainty, and secondly as there are a variety of public and private structures in place that make distribution multifaceted (Janssen et al., 2010). The nature of information detected and exchanged is a notable concern for interoperability also. Differences in structured and unstructured data have been theorised to effect detection of misinformation on social media (Luna and Pennock, 2018). This can be vital for crisis communications that rely on interoperability, as well as for the general dissemination of information during disasters (National Research Council (U.S.). Committee on Using Information Technology to Enhance Disaster Management. et al., 2007).

As previously discussed, there are a number of issues with the reliability and credibility of social media data. Interoperability systems may offer a means of identifying false

information, thus providing disaster management responders the ability to inform the public and to prevent the negative consequences of acting upon such information (Luna and Pennock, 2018). These kinds of approaches rely on supervised and semi-supervised learning algorithms, combined with sensor fusion techniques (which early studies in the field revealed was paramount in understanding nuanced human computer interactions, for example in the use of sarcasm) (Janssen et al., 2010). A study conducted by Joshi (2016) found two trends in sarcasm detection: firstly, sarcasm often follows patterns which may then be used as features for future identification, and secondly contextual information aids with identification. Also this tests for just one social concept, the study theorised that this may extrapolated to others, and even unique concepts tied to human interaction during times of crisis (Aditya Joshi et al., 2016; Luna and Pennock, 2018). Similarly, the concepts of culture, sentiment and emotion has been noted in several studies such as Ofoghi (2017) and Zhao (2014). In these, they found that interoperability systems are challenged by the use of hashtags that contrast tweet message (for example, "I love my job #not").

A majority of the discussion generated by advancements in interoperability ultimately question whether sentiment analysis can become entirely possible by automatic systems (Janssen et al., 2010). Certainly, the benefits of these applications to disaster management is promising: automatic analysis of big data is valuable in identifying possible areas of misinformation, sifting through a volume of data that no human team could process, and automatically sharing information between agencies that would otherwise require continuous monitoring (Luna and Pennock, 2018; National Research Council (U.S.). Committee on Using Information Technology to Enhance Disaster Management. et al., 2007; Janssen et al., 2010). In response to issues with understanding culture and emotion several studies have sought to develop frameworks to improve sentiment analysis. Baldoni (2012) propose ArsEmotica, an application software for associating the main emotions to artistic resources on a social tagging platform. While not directly aimed at disaster management, the framework may be extrapolated to other datasets with varying origins, using an ontology driven approach (Baldoni et al., 2012). Houston (2015) argue that their conceptual framework may be applied more successfully to smaller datasets with the aim of finding the users and uses of social media during a given disaster. This follows a manual application by the researchers, and as such produces more detailed sentiment and content analysis than automatic systems alone (Houston et al., 2015). While this kind of framework is promising in answering the research questions that require both qualitative and quantitative insight, it raises questions about the manual processing of data without a team of researchers.

The findings of the study by Baldoni (2012) present rich emotional semantics without the use of big data, and with no immediate time barriers needed for information processing. This would need to be changed for disaster management purposes considering the

temporal nature of unfolding hazards, and varying interpretations of emotion over different cultures. This is particularly prominent when comparing emotional sentiment in different languages (Grassi et al., 2011). While the use of an ontology allows for emotions to be logged in what is affectively a dictionary for all users – designed to avoid errors in interpretation – many studies have found that this is still a common problem with ontology applications (Grassi et al., 2011). Furthermore, while emotional ontologies may lessen the gaps in knowledge that are present in interoperability systems, many studies argue that human interpretation and context is required to generate meaningful analysis – particularly of data with sensitive content (Pozzi et al., 2016; Grassi et al., 2011; Zhang et al., 2013). Instead, theoretical studies on measuring sentiment and semantics postulate that context is better understood when a number of analytical approaches are used in conjunction with one another (Ballatore, Wilson, and Bertolotto, 2012). From a disaster management perspective seeking to analyse social media data, (Janssen et al., 2010; Bharosa, Lee, and Janssen, 2010) additionally argue that human judgement is a necessary component for interoperability systems to process data affectively, and to reduce the number of misinformation errors generated by cultural and emotional sentiment. Consequently, an approach that combines methods, as well as being applied by one or more researchers may result in more rich research outcomes of this thesis.

2.4.4 Social Media for Risk Reduction

While the disaster life-cycle phases are valuable to breakdown and understand the varying tasks of wider disaster management, they should not be considered exclusive. Rather, there are tasks, actions and methods that are employed throughout each of the phases, as well as some that fit into multiple phases. Consequently, this section is associated with the reduction of risk throughout all of the phases. Within this section the use of social media for tasks that do not fit into one defined disaster life-cycle phase are included, with a brief description of why this is the case. The section begins with the concept of crisis communications; one of the most extensively documented roles of social media for risk reduction, as well as for management itself. Following this, the section details information dissemination, as a smaller, more focused aspect of crisis communications.

2.4.4.1 Crisis Communications throughout Disasters

One of the most extensively used functions of social media during disasters is for crisis communications. These are essential for effective emergency response and management and for individual decision making alike (Tozier de la Poterie and Baudoin, 2015; Houston et al., 2015). They are typically categorised by a need for a range of information, high levels of ambiguity, and fluid conditions where information is exchanged readily (Tozier de la Poterie and Baudoin, 2015). Throughout the disaster lifecycle there is an

increased demand on communication networks, particularly as individuals and organisations seek further information using whatever resources are available to them (Palen, 2008). Subsequently, disasters pose challenges both to the crisis communications of individuals seeking information to make critical decisions with, and to the official communications and information distribution of organisations and bodies who respond to such incidents (Tozier de la Poterie and Baudoin, 2015; Palen, 2008). Given the complexity of this aspect there has been a wealth of literature published which seek to better facilitate the reliable flow of communications on social media during disasters.

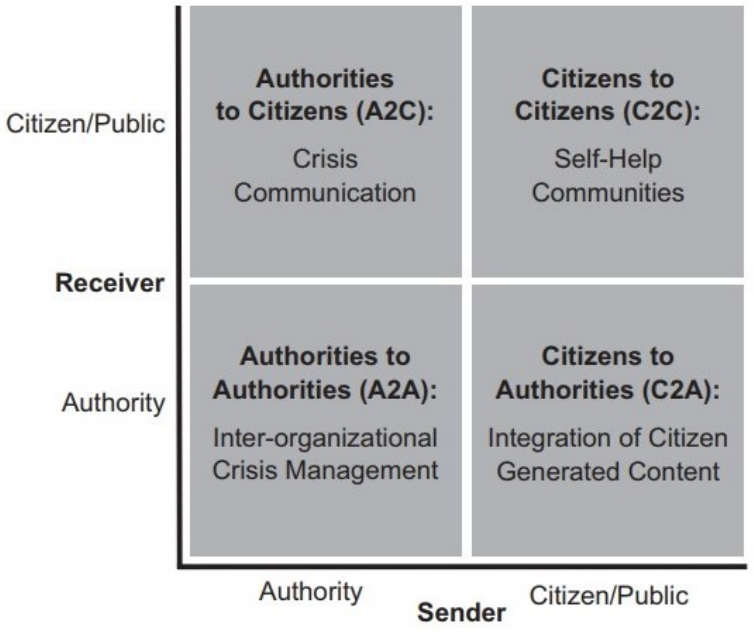


FIGURE 2.3: A Matrix Explaining the Four Types of Crisis Communications during Disasters. Source: Reuter (2017)

Reuter (2017) explains that crisis communications can be categorised by a matrix depending on which body is communicating, and to whom (illustrated in figure 2.3 above). In the case of authorities to citizens **(A2C)** Hughes (2012) argue that authorities use of social media during disasters is paramount in reducing risk throughout all stages of the disaster life-cycle. This is evidenced through case studies such as Hughes (2014) who document the engagement of police and fire services with online networks during Hurricane Sandy, and St.Denis (2014) who highlight the effectiveness of time-critical communications from both local government and emergency services throughout the Colorado Floods. In contrast to these cases however, a large proportion of literature analysing A2C communications reveals that there are significant barriers posed to authorities during disasters (Amanda. Hughes et al., 2014). One of the most significant of these is effective collaboration and communication between authorities and organisations who respond to the same disaster, particularly if they become involved during different stages of the event (St. Denis, K. M. Anderson, and Leysia Palen, 2014). Gorp

(2014) further identifies six main issues that may exacerbate a breakdown in communications. These are; having limited resources, difficulties in the management of volunteers, varying levels of authority/organisational engagement, the level of commitment by volunteers, differences in work methods, and authorities/organisations limited knowledge of volunteer expertise (Gorp and Vries, 2014).

In the case of crisis communications where citizens are communicating with authorities **(C2A)**, data content of messages on social media can be valuable for management purposes (F. Johansson, Brynielsson, and Quijano, 2012). This is due to the fact that citizens share information in many formats, on a range of platforms, and for a range of reasons (F. Johansson, Brynielsson, and Quijano, 2012). This can illustrate what is happening during a disaster from different perspectives, which may potentially flag up issues to authorities that have gone unnoticed by responders (B. F. Liu, J. D. Fraustino, and Yan Jin, 2016). Despite this potential knowledge, the perceived unreliability of these kinds of information can be a limiting factor for utilising such opportunities (Mendoza, Poblete, and Castillo, 2010). In response, crowdsourcing strategies have increased in popularity, where the perceived trustworthiness of information is higher by the introduction of cross-referencing as well as other data collection parameters (Reuter and Kaufhold, 2017). Other methods can be recognised by studies such as Ludwig (2017) who have created a public display application featuring a communications infrastructure, designed to help with crowdsourcing. Similarly, (Imran, Mitra, and Castillo, 2016) present methods of processing messages during disasters such as data characterisation, event detection and tracking, classification techniques, and semantic technologies. Pohl (2012) go on to highlight the benefit of frameworks in understanding crisis communications. They argue that, as an alternative to crowdsourcing, frameworks may offer a quicker application that does not suffer from the technological functionalities or limitations of an automatic system (Pohl, Bouchachia, and Hellwagner, 2012). This may be a valuable method in answering the thesis research questions given its scope, while still be able to identify the different types of crisis communications present during an event.

Perhaps one of the most discussed areas of crisis communications is that of authority to authority **(A2A)**, which is vital for disaster management, response, relief and recovery (Reuter and Kaufhold, 2017). Despite the level of discussion generated in this area, there is a lack of social media data concerning this kind of communication. This is due to the fact the A2A tends to happen on secure channels, rather than on social media itself (L. Comfort, 2007). Consequently, studies such as Kapucu (2011) postulate that disaster literature analysing crisis communications, especially those that focus on social media, should additionally consider a qualitative, mixed methods approach to gain any kind of insight from within organisational hierarchies. Further studies illustrate that inter-organisational social networks are utilised in different ways to that of public (L. Comfort, 2007). This does not necessarily mean however that A2A crisis communications are not present on public social media at all (Ley et al., 2014). Tapia and Moore (2014) for

example highlight the failings of governmental use of A2A based in the USA. Their study employs qualitative interviews to avoid the limitations of analysing social media data alone (Tapia and K. Moore, 2014). It concludes that while authorities often have access to a large amount of social media data, it is the fundamental discrepancies in their methods in sharing information of a high standard that undermines collaboration and wider A2A communication (Tapia and K. Moore, 2014). A study by Garnett (2007) in further argues that the presence of A2A on public social media can imply a number of things, ranging from poor inter-organisational communication to the breakdown of phone and other secure networks during crises.

The final part of the crisis communications matrix is that of citizen to citizen **(C2C)** communications. Unlike the other types of crisis communications, this has roots in literature that can be traced back to the 1970s. Quarantelli (1985) documented emergent citizen groups during disasters, defining them as "citizens who work together in pursuit of collective goals in response to disasters, but whose organisation has yet to become institutionalised". They go on to argue that in order for C2C to form a supportive social climate, a network of social relationships, and the availability of resources (chiefly that of information) are needed (Quarantelli and Stallings, 1985). Later, a myriad of studies - after the creation and uptake of online social media - continue to identify C2C throughout disasters. Lu (2011) document how citizens gathered and synthesised information during the Szechuan earthquake in 2008. This was one of the first cases that documented C2C both in the offline world, as well as in online spaces and social media (Lu and D. Yang, 2011). Qu (2011) similarly note emergent citizen communities exchanging information online in the form of microblogging during the Yushu earthquake in 2010. This differs from ancient communications about disaster throughout human history by offering a new paradigm of information sharing online, and additionally documenting that C2C may happen differently for the same event both offline and online (Qu et al., 2011).

In recent years, C2C communications have taken on new and emerging roles within social media, which differ from Quarantelli's original observations. For instance, Smith (2010) notes the importance of C2C communications between individual social media users by using qualitative analysis of tweets in response to the Haitian earthquake in 2010. Starbird (2011) report on the same disaster case study as Smith, identifying "digital volunteers". These are defined as citizens who rely, amplify and synthesise information during disasters, thus going above and beyond the original notion of emergent C2C communications (Starbird and Leysia Palen, 2011). White (2014) document new forms of C2C during the case of hurricane Sandy, where citizens coordinated operations between themselves that were unlikely to be done by authorities, such as recovering lost animals. Birkbak (2012), too, brings to light the use of Facebook groups during an extreme blizzard in Denmark. The study demonstrates that C2C on different groups is shaped by self-selection, thus resulting in different perceptions of the disaster (Birkbak and Andreas, 2012). While the nature of C2C communications is evolving alongside the

availability of digital technologies, there remain significant barriers for emergent citizen groups. In particular, issues with information reliability, timeliness and contradicting information are prevalent in C2C communications regardless of media (Westerman, Spence, and Van Der Heide, 2014). Evidently, the types of crisis communications can be considered central to the relationship between disasters and social media, and subsequently must be taken into account in answering the research questions of this thesis.

2.4.4.2 Information Dissemination

Information dissemination is considered another component of crisis communications. It represents one-way communication, rather than two-way, which the previous section focused on. Information dissemination during disasters is one of the most extensively researched areas due to the fact that the timely spread of relevant information has always been a vital factor in reducing risk, damages and mortality during crises, that pre-dates digital technologies (Lu and D. Yang, 2011; Cottle, 2014). Partly, this is also due to the increase in methods of information dissemination, and the expansion of digital technologies and their functionalities (C.-M. Huang, Chan, and Hyder, 2010). The dissemination of information however is a multi-faceted and complex issue. The reliability of information is defined as being how accurate a piece of information is: not only in terms of relevancy to the disaster situation, but also in terms of the accuracy, timeliness, and whether it might contradict other sources of information (Abdullah et al., 2017). It is the combination of these factors that determine the extent to which individuals may act upon information (Abdullah et al., 2017), which they may then potentially use in personal safety-critical decisions (Lu and D. Yang, 2011). Information dissemination, similarly to crisis communications, can be categorised by who is creating information, and who is consuming information. For disaster management purposes, a range of authorities, organisations, humanitarian aid organisations, and the public uses information exchange on social media (Abdullah et al., 2017). Lu (2011) argue that social capital is the primary influencer of information exchange, and that there are many dimensions to this. They go on to explain that this notion is comprised of three types of capital.

Firstly, structural capital has the power to influence patterns of information exchange between individuals during disasters. This tends to reflect real-world social relationships and connections between users (Lu and D. Yang, 2011). The incorporation of social capital into disaster management strategies for information dissemination can be traced back to the Kobe earthquake in 1995, Japan. This was one of the first case studies to recognise the value of social flows and solutions as being similarly important as engineering and technological ones (Nakagawa and Shaw, 2004). The study goes on to show how separating out earthquake-affected areas into *"machizukuri"* – an organisation consisting of residents, agencies and local authorities of a defined region – allowed for

the preservation of community relationships (Nakagawa and Shaw, 2004). The study explains that social capital in machizukuri was bonded through trust (present in existing community ties), social normalities and participation (which was able to form due to the smaller regionally defined scale), and multidisciplinary bridging (which extended information exchange out of the machizukuri to stakeholders, volunteer groups and investors also) (Nakagawa and Shaw, 2004). While it was a combination of factors that played a large role in response and recovery, it is important to note however that social capital on digital technologies can also be exclusionary (Ganapati, 2013). In cases such as the Izmit earthquake in 1999, Turkey, Ganapati (2013) noted that gender bias affected women's access to networks, and subsequent information exchange. Similarly, Wallace (2008) documented poverty as an exclusionary factor to information dissemination in the aftermath of hurricane Katrina. Evidently, these remain important issues in the study of disaster cases where social media use may be shaped by underlying factors, especially given the extent of globalisation and the digital divide.

The second aspect information exchange is that of relational capital, which is defined as the nature and quality of these social relationships, as well as how this affects behaviours (Lu and D. Yang, 2011). Issues such as trust within networks have the power to shape relations between users, but also to create preconceptions about any information exchanged (Mendoza, Poblete, and Castillo, 2010). Trust is a concept that has been extensively studied in online social networks for a number of different online activities (Golbeck, 2009). During disasters however, it has been observed that "regular" information exchange takes on new dimensions (Starbird and Leysia Palen, 2010; Simon, Goldberg, and Adini, 2015; B. F. Liu, J. D. Fraustino, and Yan Jin, 2016). Liu (2016) concluded in their experiment on disaster communications that the desire to communicate about an unfolding crisis was one of the strongest intentions of the public – regardless of information medium or source. They further that this kind of information exchange largely occurs between individuals with an existing relationship, and is more rich is quality with those who have stronger social bonds (B. F. Liu, J. D. Fraustino, and Yan Jin, 2016). Starbird (2010) postulates that the likelihood of individuals passing on information during disasters is higher when the perceived creator or source of said information has a high degree of trust. While these theories are valuable, they may pose a problem for disaster management. For instance, Thomson (2012) report on the Fukushima Nuclear disaster in 2011, Japan, highlighting that the spread of unreliable information on Twitter contributed to public confusion during evacuations. They go on to theorise that the quality of relational capital was affected by the creation of fake Twitter accounts that were used to disseminate information, and that the fact social media require little to no authorisation to create accounts may be an underlying factor in mis-information in future events (Thomson et al., 2012)

Finally, cognitive capital is conceptualised as the set of values and beliefs individuals and groups hold within networks (Lu and D. Yang, 2011). Wasko (2005) hypothesise

that information exchange is heightened when individuals are motivated to engage with the community, and to engage with a topic with which they value. Consequently, studies such as Mendoza (2010) highlight disasters as events that greatly affect whole communities, warranting a heightened sense of engagement, and thus information exchange. Chiu (2006) go on to explain that, as well as the factors of structural and relational capitals, cognitive capital is an important driving force in information exchange. This can be heightened through shared notions or experiences, such as practising the same religion or even attending the same school (Chiu, Hsu, and E. T. Wang, 2006). In an experiment between offline vs. online information seeking during disasters, Austin (2012) found that individuals consuming information in online networks – particularly that of Twitter and Facebook – were more likely to seek further verification of said information due to preconceived beliefs about the reliability of social media over other more traditional forms of communication such as TV media. This implied that communities with high cognitive capital trust their real-world members more than online resources or networks alone (Austin, Fisher Liu, and Yan Jin, 2012). Kelman (2015) argue that particularly in the case of rural or isolated communities, such as on small island developing states (SIDs), higher cognitive capital may result in increased innovation and resilience to disaster. Despite this, measuring the presence of this capital may be difficult given the differences of information exhange in online vs. offline situations (Ilan Kelman, Burns, and N. M. d. Johansson, 2015). The presence of cognitive capital clearly may shape the outcomes of information dissemination between communities and individuals, and subsequently is a valuable factor for consideration in the selection of disaster case studies.

Scoping the barriers of information dissemination is of high importance to disaster management strategies that aim to incorporate social media into their methods (Starr Roxanne Hiltz, Kushma, and Plotnick, 2014). Information reliability is one such barrier that remains prevalent in disaster literature (Starr Roxanne Hiltz, Kushma, and Plotnick, 2014). Westerman (2014) recognise this issue across all social media platforms regardless of medium. In their study they tested the perceived credibility of information by asking individuals to view fake Twitter pages where information varied in recency. They concluded that the more recent a tweet was, the more likely an individual was to perceive it as being credible (Westerman, Spence, and Van Der Heide, 2014). Other studies, too, found that reliability of information was affected by other measures. Mendoza (2010) discuss that information exchange as a product of individuals wishing to help and contribute to the community after a disaster in fact often undermine other forms of information (for example, from organisations and authorities). This is due to the fact that many individuals do not cite credible sources, which makes determining what can or cannot be trusted difficult (Mendoza, Poblete, and Castillo, 2010). False information can be considered unreliable too. There is however a distinction between unintentional and intentional false information - although (Thomson et al., 2012) argue that actually determining which is which can be tricky. This is due to the fact that an individual may be subject to any number of situations or influences which ay distort

the information they have created or shared (Amanda Hughes and Leysia Palen, 2012). For example, another individual may have used their social media account, the person in question may actively wish harm on other members of the community, or they simply may not be aware that they are citing unreliable information (Amanda Hughes and Leysia Palen, 2012).

Finally, variations in culture, language and interpretation play a large role in issues of information exchange. Jok (1996) is one of the first cases to raise the issue of culture as an underlying factor for the effectiveness of information exchange in communities. In a case seeking to help war-afflicted communities in south Sudan, the project flags up challenges in the communications and information dissemination between aid workers and citizens (Jok, 1996). This occurred when organisations and aid workers failed to fully incorporate local culture into the needs assessment, which is argued to have slowed community resilience and response to crises (Jok, 1996). Online information dissemination, particularly in disaster cases with a large international aid presence, can be problematic also. In an analysis of the Haiti earthquake and tsunami, VanHoving (2010) emphasise the need for disaster management to take into account tourist demographics, as well as the local population. They argue that countries requiring the most international aid during a disaster, coupled with a high level of volunteers originating from around the globe, must take extra care in information dissemination (Van Hoving et al., 2010). This is to ensure that language, culture, religion and other demographics do not essentially become exclusionary criteria (Van Hoving et al., 2010). While there has been an increased call for information exchange to follow more robust protocols before sharing, issues with information reliability remain relatively unincorporated within methods of online data analysis used for disaster management purposes (**Bharosa2010**; Meissner et al., 2002; Lu and D. Yang, 2011; L. Comfort, Ko, and Zagorecki, 2004). Evidently, the barriers to effective information dissemination have the power to shape the outcomes of events throughout the life-cycle phases, and as such should be incorporated into the methodology which seeks to better scope the relationship between disasters and social media.

2.5 Underlying Factors that Influence Social Media during Disasters

The literature review has so far presented the emerging popular roles that social media fulfils throughout the disaster life-cycle phases. Through this assessment it has become apparent that there are several underlying factors to these roles, which can be found in multiple phases, across all types of social media, and for many types of methodology. These represent some of the gaps in the knowledge that remain to be fully addressed by disaster management policy, actions and methods. To answer RQ2, RQ3 and RQ4 further evaluation of these factors is needed in order to formulate future proposals to

reduce risk. Firstly, information reliability, overload and dearth stemming from social media data is discussed, followed by Web accessibility and the digital divide. Following this, geographical factors will be presented in more detail. This will argue that despite a globalising world, there remain many issues such as physical location and availability of natural resources that still affect disaster management. Then, demographical factors will explain how the compilation of population, religion, class and gender still have the power to increase an individual's level of risk during an event. Next, political factors, will explain how underlying methods of government, policy and political tensions have the ability to shape the uses and users of social media during disaster. This is a particularly important issue for case study analyses which seek to understand specific aspects of disasters. Finally, economic factors will scope how a country's Gross Domestic Produce (GDP), investment and economic standing shapes the effectiveness of disaster management efforts.

2.5.1 Information Reliability, Overload and Dearth

As evidenced through the review of literature in this chapter, information issues such as reliability, overload and dearth are a major concern for risk reduction during disasters (Shklovski, Leysia Palen, and Sutton, 2008). This has become especially prominent for the use of social media, which, as previously explained, fulfil a variety of roles throughout the disaster life-cycle phases, therefore warranting further study in order to address RQ3. In summary, many individuals are subject to changes in their regular online behaviour during a crises (Paton, 2003). Consequently, individuals may act out of panic, or out of an inherent desire to help others experiencing a disaster (Siegrist and Cvetkovich, 2000). A common result of this is the sharing of information during crises without citing a credible source (Shklovski, Leysia Palen, and Sutton, 2008). This makes determining the validity of information difficult, and also requires further time and effort for responders to track and confirm said information - arguably better spent on other management actions and methods (Mendoza, Poblete, and Castillo, 2010).

Information dearth and overload - two contrasting concepts - still remain problematic when utilising social media during disasters (Shklovski, Leysia Palen, and Sutton, 2008). Dearth is defined as a lack of valuable information, which subsequently can leave individuals with limited knowledge with which to make safety-critical decisions (Sutton, Leysia Palen, and Shklovski, 2010). Conversely, overload is defined as having too much information available which results in a similar level of confusion (Starr Roxanne Hiltz and Plotnick, 2013). Both concepts may be caused by a lack of enforced inter-organisational, as well as cross-organisational, protocols and strategy throughout a disaster (Starr Roxanne Hiltz and Plotnick, 2013). Particularly, this issue is becoming more prominent on social media channels, where governments, organisations, humanitarian agencies and

other emergency responders are now expected to spread online disaster-specific information as well as offline (Tapia and K. Moore, 2014). This can be further undermined by such agencies failing to employ staff to manage social media strategy, relying on staff who haven't undertaken information dissemination training, or agencies failing to realise the significance that social media may have on the outcomes of a disaster (Tapia and K. Moore, 2014).

2.5.2 Web Accessibility and the Digital Divide

The digital divide is a term that is largely focused on socio-demographic and geographical variables, as well as the level of accessibility that an individual has to the internet (McNutt, 2014). It encompasses the notion that particular variables dictate the level of accessibility one has to social media and digital technologies, which require the Web as a prerequisite (Van Dijk, 2006). VanDijk (2006) further explains that the digital divide is composed of five different types of inequality. Technological inequality is the limitation of technological opportunities for example for populations with a low annual income, it is generally the case that fewer individuals own a technological device that is able to connect to the internet (Van Dijk, 2006). Immaterial inequality is the limitation of life chances and freedom, for example for individuals who are fleeing from war, or are trapped within a societal system ruled by a dictator (Van Dijk, 2006). Material inequality is that of capital and resources, for example the abundance of these increases the likelihood that one can access the internet more regularly on a number of devices (Van Dijk, 2006). Social inequality encompasses flows of power and participation, where it is generally evidenced that stronger social networks and community reduce the level of risk one is exposed to (Van Dijk, 2006). Finally, educational inequality is the level of skills and capabilities an individual has, for example areas that are more prone to particular reoccurring hazards are often trained in resilience and preparedness skills for these types of events (Van Dijk, 2006).

A majority of literature which seek to analyse the digital divide and its affects on disaster management focus on the concept of material accessibility, mentioned above (Van Dijk, 2006). Fothergill (1999) documents the rise in this kind of research emerging in conjunction with the Web, social media, and the first digital technologies in the early 1990s. During this time, the first national surveys were developed and conducted in the US by bodies such as the National Institute for Trial Advocacy (NITA). They sought to identify variations in physical access to the Internet, and some of the obvious demographical factors such as income and age (Van Dijk, 2006). In addition to these kinds of surveys, literature such as Norris (2001), too, illustrated the relationship between physical accessibility and demographic factors. Only, unlike previous national studies, this took into account the Web accessibility of 179 countries around the world. The study revealed that a global divide was present between more developed and lesser developed

countries, not just within the localised regions of a nation (P. Norris, 2001). It also confirmed that the digital divide across its many concepts remained prevalent within national populations and communities, as well as on online communities (P. Norris, 2001).

Digital divide research later progressed from identifying demographic, social, political and geographic factors to actually measuring their affects (Van Dijk, 2006). An emphasis was placed on identifying which particular factors had the most impact on the divide itself. From this, VanDijk (2006) argue through statistical analysis that the most important factors were that of education and occupation. From the early 2000s digital divide research then began to acknowledge that during times of crises, where regular systems are disrupted, factors may shape Web accessibility in other and more complex ways. In turn, this lead to the measurement of these factors during disasters themselves. Schultz (2013) argue that it is this re-framing of disasters from sporadic events, to events which reoccur and feature a range of underlying factors, which has lead to an intellectual shift. They go on to explain that during crises, demographic factors intrinsically linked with disasters such as vulnerability and risk, become more prominent (J. Schultz and Elliott, 2013). These are affected by the same influences as the digital divide, only with the potential to result in more negative outcomes such as death and damages (Murthy, 2013).

Many studies have called for more extensive research into aspects of the digital divide, particularly given the variations both on regional and international scales, and between smaller local communities themselves (Alexander, 2013). However, in the current literature there remain several key issues in the context of a globalising world. Firstly, the emergence of new underlying factors linked to uneven development are a considerable concern. These evolve and develop in conjunction with the flows of globalisation, where the digital divide is constantly shifting (Pick and Nishida, 2015). This means that addressing factors that contribute towards the digital divide in a given case may not necessarily mean that the divide is addressed permanently (Pick and Nishida, 2015). For example, for populations with changing demographics it is likely that an entirely new set of factors may have the most influence on Web accessibility in the space of several generations (Pick and Nishida, 2015). This is also a particularly complex issue with forced demographic changes, for example asylum seeking brought about by war or large disease pandemics (Pick and Nishida, 2015). Web accessibility shaped by the digital divide is clearly an important factor in scoping the relationship between disasters and social media, and is extensively documented throughout the literature review. Ultimately, in order to answer the research questions of this thesis is must be acknowledged in the study itself.

2.5.3 Geographical Factors

The increase in globalisation has reduced the impacts of traditional territorial boundaries, connecting individuals on a scale never before experienced through new media (Cottle, 2014). Despite this, a number of physical geographical aspects may still shape the outcomes of disaster which are still important to note. This is particularly the case for areas prone to specific re-currant hazards - an issue that has been touched upon previously throughout this chapter (Coppola, 2007). In the geographical sense the concepts of place, space and landscape are interconnected (Cutter et al., 2008). Communities are shaped by a sense of these concepts, where aspects of their identity are tied through the environment (Cutter et al., 2008). MullerMahn (2013) explain that the spatial dimension of risk can be considered a "riskscape", which are defined as areas within the environment which are exposed to higher levels of risk, for example from natural hazards. Riskscapes are generally static in hazard-prone cases, but can be subject to change from other factors such as variations in population, multi-hazard disasters, or global concerns such as climate change (Müller-Mahn, 2013).

The physical factors of geography associated with place and space may similarly contribute to or form riskscapes, partially dictating how an individual may cope with disaster. Jigyasu (2002) demonstrate that isolated communities tend to be exposed to higher levels of vulnerability within riskscapes. Schwarz (2011) explain that this is due to the fact that geographical isolation can be enhanced by particular hazards such as bad weather, or negative impacts of disasters such as the collapse of transport links. Geology, too, may lessen or worsen the affects of disasters depending on its local composition (Schwarz et al., 2011). For hazards such as earthquakes this causes another complexity for their management, where weaker rock and faultlines are more likely to fracture under the huge pressure released (Alexander, 2017). The likelihood of passing this released energy, again, is dictated by the wider geology of the area (Alexander, 2017). Topology, too, may exacerbate disasters in a similar way. For hazards such as flooding, the physical structure and lay of the land can essentially redirect flood waters (Özdamar, Ekinci, and Küçükyazici, 2004). This becomes dangerous for settlements in flood-risk zones that feature no man-made or natural draining facilities should they become inundated with waters, or methods of flood defences (Özdamar, Ekinci, and Küçükyazici, 2004).

2.5.4 Demographical Factors

Similarly to geographical factors, the characteristics of populations and communities has been proven to have significant affect on risk (Benjamin. Wisner, 2004). Although these far pre-date the emergence of the Web, and by extension of social media, demographic issues remain important for the management of disasters (Alexander, 2002). Alexander

(2002) goes on to explain that understanding the concept of vulnerability is the foundation of understanding underlying social factors. Vulnerability and risk are two different notions: vulnerability refers to the potential for damages, mortality and other elements of risk associated with the outcomes of disasters, whereas risk combines this with the probable level of loss to be expected from a disaster (Alexander, 2002). Vulnerability can be considered an inherent combination of underlying social factors, which in reality may greatly differ from the direct affects of a disaster (Benjamin. Wisner, 2004). Vulnerability, too, affects the concept of resiliency to disaster previously explained in this chapter. Vulnerability needs to be acknowledged as part of this literature review as it shapes the social processes and risk posed by hazards, therefore effecting how and why individuals may use social media during crises.

Wisner (2004) speculate that a range of issues removed from the direct impacts of disaster are responsible for shaping one's vulnerability during crisis. Personal income has been demonstrated to affect safety-critical decision making during hurricane Katrina evacuations (Kahn, 2005). Individuals who were in a lower income bracket were more likely to stay in at-risk areas due to a combination of little to no disposable income to leave New Orleans, and a lack of public transport for those who could not afford a vehicle (L. Comfort, 2007; Masozera, Bailey, and Kerchner, 2007). On the household level of income, too, disasters increase the vulnerability of families (Bui et al., 2014). Bui (2014) illustrate this through surveys in Vietnam, where they found that flooding disasters decrease family income and expenditure on average of 7.1%. This level of financial decline means that individuals and families alike have fewer resources to cope with hazards, and is argued to be considered as a factor in designing poverty alleviation policies to reduce the risk posed by future events (Bui et al., 2014).

Vulnerability may be increased by one's age, where the older and the youngest demographics can be more at risk from hazards (Benjamin. Wisner, 2004). Klinenberg (2015) note this in a social autopsy of the Chicago heat wave in 1995, where more than 700 people died. The death toll was found to be exponentially higher than expected due to the social breakdown of neighbourhoods exposed to extreme conditions: this meant that for more than a week individuals and family groups were isolated by the extreme weather (Klinenberg, 2015). The largest proportion isolated were elderly individuals who lived alone, and had little means of contacting others. As a result many died from exposure, lack of resources due to the fact they were unable to leave their homes, and the inability of other community members to check on their welfare due to prolonged extreme conditions (Klinenberg, 2015). Brown (2016) argue that increased vulnerability of the elderly is more than simply a disaster related issue. Instead, they theorise that changes in country's demographics should more accurately be reflected by the social policies published to help to protect the most vulnerable (Brown and Frahm, 2016). Especially in country's where there are ageing populations, reduced funding and resources for vulnerable

people, and differences in the national digital divide it is of paramount importance to address these areas before disasters occur (Brown and Frahm, 2016; Klinenberg, 2015).

Similarly, one's gender is another key factor in vulnerability. According to international humanitarian aid organisations such as the UN, gender is a consistent disparity globally which is unequally affected by disaster risk (Arnold, 2017). Particularly in lesser developed countries (LEDCs) women are the most socially, politically and economically constrained demographic, typically making them the most susceptible to risk (Young, Greenbaum, and Dormady, 2017). DeSilva (2014) illustrate this through the case study of flooding in Sri Lanka as a result of gendered social roles, social normalities and gendered employment status. They go on to explain that despite flood response and management being in place, social policy failed to take into account rigid gender stereotypes which meant that community projects and recovery was greatly slowed (De Silva and Jayathilaka, 2014). This is a similar case for many other areas of the globe prone to disasters, and is strongly reflected in vulnerability literature. Other notable cases include enforced gender norms in Bangladesh flooding (Juran and Trivedi, 2015), gender-based violence amidst disaster in Uganda (Morof et al., 2014), forced migration of women and families from war (Berlaer et al., 2016), and heightened exposure to famine and drought in Sub Saharan Africa (Arora-Jonsson, 2011).

2.5.5 Political Factors

The governmental structure of a nation can dictate how well a country may cope with crises (F. Schultz and Raupp, 2010). Therefore, the policies designed, supported and implemented by governments is of vital importance to disaster management (F. Schultz and Raupp, 2010). For areas prone to specific disasters, governments are more likely to have invested and developed detailed policy in the case of emergency (Semaan and Hemsley, 2015). In these kinds of areas, more resources and funding are often earmarked for emergency purposes compared to their other counterparts in less at-risk regions (Kapucu, 2005). Governments may develop pre-existing policies for disaster management before the occurrence of events which while valuable in reducing potential risk, this is often underused by authorities as commonly there are larger and more demanding issues running a country (Semaan and Hemsley, 2015). Performing risk and resource assessments of areas may too reduce risk from disasters. These can be costly and time consuming, and therefore tend to be conducted on a local and regional level in areas considered at-risk to re-currant hazards (Kapucu, 2005). Devising national communication plans, which remain in place regardless of political terms, is another way in which politics may reduce future risk posed by disasters (Wentz et al., 2014). Often these are amended by whomever is currently in power, or version history of such documents can become confused over long periods of time (Tapia and K. Moore, 2014). This makes common-knowledge of the protocols difficult, and therefore application to

real-world cases may be confused (Wentz et al., 2014). Tapia (2014) go on to explain that many governments are slow in the uptake and application of social media as a tool for disaster management, which must be changed across all levels of politics in order to harness its full potential.

International politics holds a different power over the outcome of natural disasters (Ben Wisner, Gaillard, and Iian Kelman, 2012). In light of the divide in social media uptake across global authorities there has been a general agreement that guidelines and usability of social media in disaster situations needs to be clarified internationally (Tapia and K. Moore, 2014). Partly, this falls to the international community, where organisations such as the UN dictate what is to be expected of disaster social media and their relationship within disaster management (L. Comfort, 2007). Partly, it is also the responsibility of national and local governments who must focus their attention on the immediate concerns of communities within their jurisdiction (Kapucu, 2005). International documents for disaster management policy, actions and methods are regularly updated and released which is generally considered a driving force for the adoption of disaster social media (Coppola, 2007). The discourse between international and national powers can however be shaped by political movements, and even particular figures (Coppola, 2007). For example despite representing the biggest social media market in the world, the Chinese government currently blocks many of the largest social media sites such as Facebook and Twitter (Qu et al., 2011). Consequently, the roles that social media may have within China vary compared to other nations, and as such there is a different political balance struck between the national government and international authorities (Qu et al., 2011).

While generalised statements about national and international authorities are easy to make, there is in fact a much more complex network of political undercurrents at play during crises (Birkland, 2006). This takes several forms, which may be expressed at any point during the disaster life-cycle phases. First, the political composition of the national government may shape the nature of policies passed depending on the overarching goals of the party in power (Lindsay, 2011). Second, the political tensions between governmental parties, or even NGOs and aid organisations, may similarly sway the progress of policies introduced (Birkland, 2006). Finally, the political tensions between government and the public is arguably one of the most important social factors of disasters (Mitchell, 2006). The breakdown of this relationship has been documented in many disaster case studies where authorities have made decisions (or lack there of) that have caused the public to distrust advice, form their own methods of helping themselves, and in extreme cases to revolt (Birkland, 2006). Social media, as online networks of individuals, can be considered a new dimension for the expression of political flows (Mitchell, 2006); a significant consideration for how online human behaviour during disasters may be shaped, the representation of online information subject to political motivations, and public perception of hazards based on media representation (Siegrist and Cvetkovich, 2000).

2.5.6 Economic Factors

The importance of economic development in a country's ability to respond to disasters is a well-observed factor in reducing risk and vulnerability (Toya and Skidmore, 2007). A country's wealth, as opposed to GDP, has been argued to be a vital factor in the level of greater resources it may devote to safety actions and methods (Horwich, 2000). It is generally observed, then, that as a country develops, it invests more resources into methods of disaster management (Toya and Skidmore, 2007). Horwich (2000) further explains that in the case of the Kobe earthquake in Japan 1995, the application of basic economic concepts to the event revealed a number of negative impacts. These were noted across each of the disaster life-cycle phases, and are argued by Horwich (2000) that timely economic investment in the resilience stage prior to the earthquake may have significantly reduced damages and mortality. Furthermore, economic investment in the post-disaster recovery stages, too, may have resulted in the faster bounce-back of the country, and the quicker it could have returned to a state of recovery and rebuilding (Horwich, 2000).

Infrastructure is one of the more critical aspects of economic investment that a country may develop in response to disasters (Huq et al., 2007). Physical infrastructure refers to the physical structures required to keep the economy functioning, such as buildings, transport links, facilities such as power, and services such as waste disposal (Horwich, 2000). The reinforcement of physical infrastructure is a long-observed method in reducing risk and vulnerability posed by disasters. However, many methods given their scale, high level of resources required, and the long transition time for building and switching over system reliance remain out of reach for countries with lower GDP and wealth (Huq et al., 2007). Shultz (2016) discuss that technologies and methods of construction, such as earthquake-proof buildings, are at the forefront of disaster management efforts in the modern day. They go on to highlight that, generally, it is only countries who had enough wealth many years in advance who have been able to invest in such developments (Shultz, Cohen, et al., 2016). Huq (2007) raise the point that all countries are subject to global risk from issues such as climate change, and so lack of economic development can leave countries more susceptible to risk.

2.6 A Summary of the Literature Review

The literature presented and analysed within this chapter has provided an introduction to the relationship between social media and disasters in a globalising world. It has synthesised the most popular roles that social media can be used for, the benefits and limitations of these, and what impact this potentially has for wider disaster management methods and actions. The main roles have been conceptualised over the disaster life-cycle phases which in turn correspond to the main areas within management efforts. In the

pre-event stage the chapter discussed resilience actions and methods such as individual and community preparedness, event detection and tracking, and warning systems and tools. These areas highlighted that social media networks may now be used in a plethora of ways to detect and track potential risk online as well as offline, acting as a new data source for management. Furthermore, it demonstrated that community ties can now be transposed into online communities, that similarly may be utilised for building resilience before disasters occur and even for seeking more information.

In the during event phase the chapter discussed methods and actions for disaster response. It illustrated that the generation of situational awareness is of high importance during this phase in order to effectively respond to hazards, and to prevent risk from increasing. This involved many new forms of data mining derived from social media channels, as well as the processing and application benefits and limitations. It similarly assessed crowdsourced data, and the applicability of network analysis for targeted actioning purposes. It presented the notion of conceptual frameworks as a key way to generate situational awareness relying on the richness of data supported by human-driven methods, which gradually are becoming more utilised for social media data. Although there are limitations with the methods, the literature argued that this was one of the most viable solutions in both understanding the role of social media during disasters, as well as understanding the underlying factors that shape their outcomes. In the post-event stage the chapter focused on the concept of disaster recovery. Interoperability, as a means to return systems and structures to normal, was discussed. This was broken down into technical interoperability in the form of networks, structures, and technologies as well as social interoperability of social networks, communities and every-day practices in the online-world.

Finally, in the throughout stage, management methods and actions for generalised risk reduction was discussed. These are arguably the most important notions due to their applicability to disasters throughout all stages, and to all different types of audiences. The review broke down communications into a matrix of types, which allowed for each to be explained in detail with reference to case study illustrations. Next, information dissemination was discussed, and its relationship to crisis communications defined. The benefits and limitations of these were demonstrated using social media case studies as a lens for analysis. The presentation and review of this literature highlighted that a range of limitations for the use of social media in disaster management were still present. From the limitations highlighted, two were selected for discussion in more detail as they represented gaps in the knowledge base, commonly overlooked by other studies in the topic area. Notably, issues of information reliability, overload and dearth were significant with data generated from social media. This undermines management methods and actions which rely on exchanging information to reduce risk. Following this, issues of Web accessibility and the digital divide were found to have serious impact on social media use throughout disasters. This was especially impactful in the context

of a globalising world, combined with a range of other factors determining one's digital literacy and accessibility.

It was determined that issues originating from a range of disciplines needed to be explained to fully understand what may shape the outcomes of a disaster. These were broken down into several broad categories. This began with issues of information reliability, and was followed by Web accessibility. Next geographical factors such as physical region and availability of resources which may still dictate how and why an individual may use social media. Then, demographical issues were presented which identified the characteristics of income, age, gender and religion as further complexities for risk. Next, political issues were outlined and the ways in which they still have power to alter the course of social responses to disasters. Finally, economic issues were presented, such as GDP and level of national and international infrastructure which may determine how fast countries may rebuild after crises. The literature review has provided a foundation of knowledge with which to answer the thesis research questions. It has indicted several gaps in the literature where new research may be able to provide an original contribution to the field. In order to do this, the following chapter of the thesis will breakdown the steps, methods and data required to answer the sub research questions respectively. Beginning with RQ1, the next chapter will devise a conceptual framework designed to measure the users and uses of social media during disasters. The framework will take into account key limitations identified in this chapter and seek to address them through a novel methodology.

Chapter 3

Creating a Conceptual Framework to Understand Social Media Use during Disasters

In the previous chapter, the literature review scoped the current roles of social media during disasters. This forms the knowledge foundation on which the remainder of this thesis will be based upon. Additionally, it highlighted gaps where an original contribution may be made to the field of disaster management. However, in order to address these gaps, a study approach must first be devised specifically. Therefore, this chapter will begin by presenting a discussion on the chosen study approach, following on from the list of methods discussed in the literature review. This will provide a rationale for a mixed-methods design based on the need for both quantitative and qualitative insights into the research questions. The conceptual framework represents the first tool within the wider method. This was created as a means to analyse the users and uses of social media throughout the disaster life-cycle phases of events, and in doing so answer RQ1.

The second part of this chapter explains the method for creating the conceptual framework itself. This used a range of relevant literature highlighted in the review as a basis on which inductive coding was applied. This produced a series of categories of the uses of social media, which form the conceptual framework. Following the method, the framework itself is then presented. This is a tool which will be utilised throughout the remainder of this thesis to assess the users and uses of social media (RQ1), to reveal how social media content changes over time (RQ2), and to highlighted the differences between content of different platforms (RQ3). It features 27 unique categories that are conceptualised across the disaster life-cycle phases. Finally, the chapter concludes by outlining how the framework will be validated through case study applications in the succeeding chapter. Work presented in this chapter has been published under Gray et al. (2016).

3.1 Devising a Mixed-Methods Study Approach

The first possibility for this research was to follow a strictly empirical approach. This would emphasise quantitative methods and focus on using the scientific method to create and test hypotheses about the parameters of the relationship between social media use and disasters. This would then need to measure the relationship between the different variables involved, and compare these to measurements of the same variables recorded in an everyday setting (i.e. not during a period of crisis). A bias towards quantitative techniques would provide a wealth of possibilities for measuring the exact effects of social media, which may then be used to influence performance, targeted at online campaigns or developing new services (Sale, Lohfeld, and Brazil, 2002). However, as the literature review has revealed, a large number of the underlying factors that shape social media use were unlikely to be directly measurable on the Web itself, and would require significant resources on large scale to investigate and understand in any detail. A qualitative approach that was grounded in constructivism and interpretivism could have been used to support this element of the research (Sale, Lohfeld, and Brazil, 2002). This would have allowed the researcher to construct theories around the research questions based on case studies that developed and changed as rapidly as the constructivist paradigm suggests that reality does – in contrast to the empirical approach which would have insisted on there being one objective truth that may be tested and measured (Sale, Lohfeld, and Brazil, 2002).

To find a suitable balance between these approaches, an examination of the research questions, and the objectives that they sought to achieve, was required. The nature of this indicated that, based on the apparent lack of understanding about the exact value that social media offered during periods of crisis, an exploratory, rather than conclusive design, was required (Baxter and Jack, 2008). On the other hand, an inductive approach, that gained understanding and adjusted theory through developments, was similarly suitable (Koenig, 2006). This was more appropriate than a deductive approach to measure the success of social media, which would have left many broader issues uncovered: an understanding of these contribute more the wider picture of what its value may be (Moran-Ellis et al., 2006). To fit this into a research design, a purely quantitative approach would therefore not have been suitable, but were not excluded completely. This is argued to develop a more expansive technique that avoids a definitive decision between a quantitative or a qualitative approach (O'Cathain and K. Thomas, 2006; Sale, Lohfeld, and Brazil, 2002). In areas where the underlying complexity requires a variety of perspectives and data - such as the relationship between social media during disasters that relies upon many wider geographical and social factors – a more pragmatic, mixed method approach is required (Sale, Lohfeld, and Brazil, 2002). A mix of both methods and sources of data was evidenced throughout the previous chapter.

Mixed methods research encourages the combination of approaches from different paradigms, which includes both quantitative and qualitative research throughout all stages (Baxter and Jack, 2008; O'Cathain and K. Thomas, 2006). As a research design, it allows flexibility in the way that approaches are merged, which draws on the strengths of each across studies (O'Cathain and K. Thomas, 2006). This is particularly important for interdisciplinary research in order to maintain a pragmatic approach that can effectively combine schools of thought from different disciplines (Creswell and Plano-Clark, 2007). Furthermore, this allows the focus of the study to remain on the research questions as the most important elements, rather than on study approaches or methods (O'Cathain and K. Thomas, 2006), which makes it valuable and appropriate for the nature of this thesis. Within this approach, there are different possible design types that relate to the way in which quantitative and qualitative elements of the research are combined. Four major generalised classifications of mixed method design are stated by Creswell and Plano-Clark (2007), shown in the table 3.1 below.

Multiple stages of methodology are required due to the nature of the relationship between social media and disasters shown in table 3.2 below. This makes the latter explanatory and exploratory approaches listed in the figure the most suitable for this thesis. The cases of RQ1 and RQ2 use a two-stage explanatory method where qualitative data are used to provide insight into quantitative results, again as suggested by approaches in the literature review. RQ3 and RQ4 are designed to follow on from the outputs of RQ1 and RQ2 in the main body of the thesis. These follow an exploratory approach where measurements between variables are analysed and assessed using additional methods and data listed in the figure below. It is important to note, however, that due to the iterative process of mixed methodologies, the approach that this thesis follows is not strictly bounded to either being explanatory or exploratory. Rather, these approaches are loosely followed as guidelines to allow the strengths of the methods to be revealed, while also maintaining a pragmatic approach to understand the complex relationship between social media and disasters, as well as the plethora of case-specific underlying factors that shapes said relationship.

Category	Description	Weighting	Timing	Details
Triangulation	Concurrent but separate study of both quantitative and qualitative data, which are then merged together to create a single interpretation.	Equal	One Stage	Each piece of data is analysed independently, but there is the risk that the results from each do not match.
Embedded	One data set acts to support findings based primarily on the opposite data format.	Favours either qualitative or quantitative	One or Two Stage	Qualitative or quantitative data are used for a different purpose to answer a specific question in an overall study that favours the other data type.
Explanatory	Qualitative data is used to explain quantitative results.	Favours quantitative	Two Stage	Qualitative data provides additional insight into surprising or outlying results, but requires additional time.
Exploratory	Qualitative results inform the later quantitative method.	Favours qualitative	Two Stage	Qualitative approach explores a phenomenon, before using quantitative to interpret these results, but requires additional time.

TABLE 3.1: A Matrix Showing the Categories of Mixed-method Research Designs. Source: Creswell and Plano-Clark (2007)

		Data Needed	Data Type
Pilot Study	Explanatory Approach	RQ1 – What are the uses and users of social media during disasters?	Qualitative
		RQ2 – How do these change over time?	Quantitative
Main Study	Exploratory Approach	RQ3 – What is the nature of disaster social media?	Quantitative
		RQ4 – How can disaster social media be improved for future crises?	Qualitative

TABLE 3.2: The Approaches used for the Mixed-Methods Research Design of this Thesis.

In this study approach, RQ1 and RQ2 require a tool to help provide both qualitative and quantitative answers. In the previous literature review a series of such methods were sourced and critically assessed. During this, it was found that conceptual frameworks may offer a valuable way to identify the users and uses of social media, as well as recording how this changes over time - an important component for the RQs. Furthermore, it was found that these were both plausible and valuable on smaller datasets where application was conducted by one or several researchers, compared to larger studies involving big data and automated algorithms. A gap in knowledge was identified as many of the existing frameworks used to determine the uses of social media did not address core underlying factors such as Web accessibility or information reliability of data. These issues are of paramount importance when analysing social networks as they may dictate who can use social media, when they do so, and the spread of the information within the online world. Furthermore, it was found that many existing frameworks were either limited by use of data from one social media platform alone, one or few types of event, or one or few concepts. The literature then highlighted that the barriers for the creation of frameworks played a large role in their adaptability, integration with other methods, and the type of themes that emerged through their application. This demonstrated that the creation of a new framework could be achieved that considered these issues, but avoided the barriers of previous methods: namely that of high costs, a long time taken to create, and the framework itself becoming outdated quickly.

In conclusion, the first logical steps to answer the RQs is to create a conceptual framework. This will provide an analytical tool that reveals situational awareness surrounding social media data throughout disaster life-cycle phases, which may then be used in part of a larger mixed-methods approach. The remainder of this chapter therefore presents the framework that was created, which features 27 unique categories conceptualised across the disaster life-cycle phases. It further explains the suggested application sequence of the framework, and how it may be validated using disaster case studies. Finally, it concludes with a diagrammatic breakdown of the overall study approach, which demonstrates the different stages in the methodology as well as illustrating where the framework fits into the wider mixed-methods approach.

3.2 Creating a Conceptual Framework

Creating the framework required several inductive methodological steps. Firstly, an online literature search was employed with the aim to select the most relevant and recent publications. This was particularly important as the literature review in this thesis had previously identified the rapid development of social media, technology, features and applications as an important issue requiring more frequent study to avoid outdated knowledge of crisis communications (J. Fraustino, B. Liu, and Yang Jin, 2012). The method for framework literature review was adapted from similar previous processes,

for example studies such as Rodriguez et al. (2007) and Houston et al. (2012). In these methods literature is categorised as being online literature (for example blog posts, forums and websites), official literature (for example governmental or organisational reports), or scientific literature (such as journal and conference papers). Each different type of literature was searched for using key term searches on Google and Google Scholar. Key words included disaster, disasters, crisis, crises, and catastrophe used in conjunction with social media, communication, crisis communication, social networking, Web, and online. Sources were only included if they were published within the past five years to avoid any large technological or sociological leaps in development. Personal judgement was additionally used to identify sources which featured content that was more topic-relevant. Selected literature produced a short-list of 59 sources.

Secondly, the short-list of literature was analysed and used to create the framework categories. Inductive coding was used to condense extensive and varied text into a summative format, and allowed for the identification and summary of themes or concepts (D. R. Thomas, 2006). Themes and concepts were unknown prior to coding, and instead became apparent through a constant comparative method. This method allowed the researcher to distinguish categories based on themes and concepts of interest that were reoccurring within the short-list of sources (Glaser and Strauss, 2009). The researcher then generated theories seeking to explain the relationship between social media and disasters that was conceptualised over the disaster life-cycle phases. The life-cycle phases were chosen for inclusion as a means to measure the temporal uses of social media use throughout disaster, helping to answer RQ1 and RQ2. Additionally, by grouping categories into phases the framework is easier for the researcher to read and apply to data manually. Qualitative grounded theory was used throughout the process which followed the directions of Corbin and Strauss (1998) to aid with the formation of framework categories. Once potential categories were identified, the most relevant and reoccurring sections of the sources were assigned to the most applicable category to illustrate the nature of the theme or concept. This formed a framework of 27 unique categories, conceptualised across the disaster life-cycle phases.

3.3 Framework Results

The creation of the framework highlighted different categories of user type who utilised social media during disasters. The literature suggested that there are five generalised categories of user, each of whom engage with social media in different ways, vary in size, and have different structures. Individuals, who are citizens not using social media on the behalf of any other accounts or networks, can be located anywhere in relation to the disaster. Communities, who are groups of individuals connected by a common denominator (for example neighbourhood communities living in the same area, or linked by an online group), similarly may engage with the disaster in any geographical space.

Within this category there is shared information and communication where social media may facilitate connections and support resource sharing (Shklovski, Leysia Palen, and Sutton, 2008). Organisations, which are structured groups of individuals that respond to and manage disasters, generally engage with disasters in a targeted manner: despite their physical geographical base they respond to, manage, and share information about disasters on a national and international scale. Governments, which represent the elected political structures governing countries, are primarily located in the country in which the disaster occurred. Less commonly, governments from other countries provide support or resources from different geographical locations. Finally, media, which is a broad term for organisations that disseminate news, can be located anywhere in relation to the disaster. Each of these categories produce or create information on social media as well as consume it, thus demonstrating two-way communication – a characteristic of social media networking.

The creation of the framework summarises the varying uses of social media during disasters. The results of the framework are shown in table 3.3 below. The column to the left of the table conceptualises the disaster life-cycle phases, which are throughout all stages of a disaster, pre-disaster, during disaster, and post-disaster. These correspond to the disaster social media uses that are listed in the right hand column by way of grouping as and when they are predicted to emerge throughout the event. Each of the right hand columns summarises a concept present in the literature review which forms the varying categories of uses. The uses summarised in categories cover a range of two-way communications which may be open-ended and have several aspects or steps associated with them. Well documented concepts in the literature, such as re-connecting with loved ones, make up the majority of the framework composition. However, in contrast to previously identified similar frameworks, the presence of new concepts has been recorded. For example, issues such as Web accessibility and online information reliability are more prominent in the framework than in previous studies, suggesting changes in the relationship between social media and disasters in recent years.

3.3.1 Suggested Application Sequence and Validation

The literature review indicated that there are multiple possible ways to apply a conceptual framework to case studies. In a disaster management capacity, there are two appropriate procedures. The first is to integrate the conceptual framework with others similar in type and content, for example that of Houston et al. (2012) and Eisner et al. (2012). This would supplement the knowledge base throughout the stages of the disaster lifecycle, while contributing original insight in the form of the most up-to-date categories as well as the themes of Web accessibility and information reliability which are often overlooked in other examples. The integrated frameworks may then be utilised

Disaster lifecycle phase	The uses of disaster social media
All stages	1. Evaluate the reliability of information 2. Identify and/or contain false information
Pre-event	3. Provide and seek general disaster preparedness information 4. Provide and receive general national and regional disaster warnings
Pre-event → During	5. Detect and warn of disasters and specific hazards locally 6. Identify the differences between actual and potential uses of social media
During event	7. Send and receive requests for help or assistance 8. Inform others about ones condition and location
During → Post-event	9. Provide, receive and analyze big data generated by the event 10. Provide, receive and encourage information sharing in multiple formats 11. Document what is happening during a disaster online and offline 12. Consume or create news coverage of the disaster 13. Provide and receive location based real-time warnings 14. Express public and/or individual emotion or empowerment; reassure others 15. Raise and develop awareness; donate and receive donations; list ways to help or volunteer 16. Seek to inform and support existing disaster management strategies 17. Provide and receive specific disaster response, rescue and evacuation information 18. Seek and assess mental, behavioral and emotional health support 19. Filter, categorize critically analyze information 20. Understanding how online and offline situations differ 21. Provide and receive information regarding disaster response, recovery and rebuilding; tell and hear stories from the disaster 22. Understand how ones access to the Web has had an effect on their experiences
Post-event	23. Discuss socio-political causes, implications and responsibility 24. Re-connect community members 25. Discuss the accessibility of the Web as an intermediary to social media 26. Discuss the accessibility and reliability of specific social media; discuss perceptions
Post-event → Pre-event	27. Consolidate lessons learnt to develop new/improved social media applications

TABLE 3.3: The Conceptual Framework Showing the Uses of Social Media Throughout the Disaster Life-Cycle Phases (Gray, M. Weal, and Martin, 2016a)

as a general guide for disaster management purposes, i.e. for targeted information dissemination, decision making, and supporting crisis communications to a range of users such as governments and humanitarian aid organisations. The second procedure is to integrate the conceptual framework into the preliminary stages of social impact assessments (SIA) and social risk assessments (SRA) of disaster events, such as Mahmoudi et al. (2012), or existing government protocols. This would provide an extended dimension for predicting probably social impacts and uncertainties in particular case studies.

Although the aforementioned procedures would be valuable to practical disaster management, the scope of this thesis is to better understand academic disaster management. The conceptual framework that has been created may be considered a tool for the analysis of data relating to selected disasters. Consequently, in order to answer RQ1 and RQ2 through the use of this tool, it must then be validated and applied to case studies for analysis. This requires a different application procedure to assess the strengths and weaknesses of the framework as well as ultimately helping to scope the relationship between social media and disasters. The literature review indicated that the validation of the framework was necessary for a number of reasons. In a methodological sense the researcher needed to know whether the tool worked as expected, whether complications with its application were likely, if so what the nature of the complications are, and the length of time it may take to apply to case studies. In an outputs sense, the researcher

needed to know the nature, strengths and weaknesses of the results of applying the framework, and the volume and quality of results that may be expected from case study applications. By understanding whether the tool and method produced any issues, the researcher could then amend and refine the process to ensure that the RQs are answered fully.

3.4 Summary

This chapter has discussed the study approach for the remainder of this thesis. It has decided upon a mixed-method approach, designed to combine the use of both qualitative and quantitative data. Gaps in the literature review were identified and used as the basis for the creation of a conceptual framework. This may be used as a tool to determine the users and uses of social media throughout the disaster life-cycle phases (RQ1), track content change across different types of social media data (RQ2), and highlight the differences between these (RQ3). The framework was created through the inductive coding of suitable literature previously identified, and the synthesised results have formed 27 unique categories which form the framework itself. Analysis of existing frameworks presented in the literature review indicated that such tools require validation before they are able to be applied to large case studies. Therefore, the following chapter will present the cases of the pilot studies, which are smaller in size and feature contained data sources. This ensures that should validation issues occur, they can be identified more quickly and easily within smaller datasets. Furthermore, it allows for the refinement of the overall methodology following the pilot study results. This is necessary for the analysis of larger case studies in the future as they are complex, feature many different types of data, and are affected by a range of underlying factors.

Chapter 4

Pilot Studies for Framework Validation

The previous chapter explained the creation of a conceptual framework, designed as a tool to determine the users and uses of social media throughout the disaster life-cycle phases (RQ1), track content change across different types of social media data (RQ2), and highlight the differences between these (RQ3). Given the nature of frameworks, validation is required to ascertain firstly whether it works in the expected way, and secondly to be able to amend any issues with the methodology. To design a mixed-methods approach which answered the RQs, a decision was made to split the main portion of the study from the pilot study for the sake of validation. Separate from the main methodology (chapter 5), this pilot study followed an inductive approach to test which aspects of social media could be measured by the application of the conceptual framework. The pilot was carried out in the early stages of the research, and was subsequently used to inform the later main methodological design. Therefore, it is important to note that the results detailed in this chapter are not designed to answer the research questions fully, or to present detailed and rich data analysis. Research presented in this chapter has been published in the papers Gray et al. (2016a) and (2017).

This chapter begins by stating case-specific terminology relevant to the pilots. It then explains the process for the selection of the disaster cases used. This took the form of an analysis matrix, which concluded by suggesting the case of storm Desmond as the most suitable pilot case. This was an uncharacteristically high magnitude storm system that made landfall in the UK in December, 2015. Following the lessons learnt from the pilot study, it was decided that a second study would be valuable for validation purposes. Primarily, this was to test whether the framework could be successfully applied to complex cases that occurred within quick succession of one another, thus featuring multiple hazards. It also tested how the framework could perform on data that may

originate from multiple different disaster life-cycle phases at the same time. Therefore, the analysis matrix was used to select a second case study, comprised of storms Desmond, Eva and Frank.

Following the study selection process, the chapter then discusses the method used for the pilot cases. Twitter data was used to test the framework throughout the pilot studies as this produced the least problems with analysis, as highlighted by the literature review (as only one data source is used this cannot fully answer RQ1 and RQ3). The section then explains the collection of Twitter data, methods of analysis, and the application sequence of the framework. Following this section, the results of both studies are presented sequentially, each detailing results as well as the the general limitations that were found. The cases additionally show how social media content change over time (RQ2). The chapter concludes by consolidating this information to form the basis of the wider thesis methodology, taking into account aspects that must be considered in future case study analyses, and addressing the study limitations that were identified.

4.1 Pilot-Specific Terminology

Twitter Twitter is a social media microblogging service that allows users to publicly publish short post called “tweets”. It currently has 336 million active users per month worldwide, and is one of the most popular social media platforms.

Tweets and Direct Tweets Tweets are short posts users of Twitter may publish that anyone may read. A direct tweet is a post that is addressed to a specific account using their unique account name, which begins with the “@” symbol. Although a direct tweet may still be read by any user, the recipient will receive a notification of the action. Tweets are generally capped at 140 characters in length, however a longer format of 280 characters is currently under testing by the platform.

Re-tweeting Re-tweeting is the act of posting the same tweet that has already been published by another user. This shares the tweet to a users personal network, but keeps the original information of the tweet i.e. who published it, when, and the tweet content.

Hashtags Hashtags are a method of tagging content so that words or phrases can easily be searched for. They are made by putting the ”#” in front of a word or phrase. While hashtags are used on other social media too, they are extensively used on Twitter.

Application Programming Interface (API’s) API’s are a set of functions and procedures that allow for the creation of applications which access operating systems, other applications, or Web services and features such as social media.

4.2 Selection of Pilot Case Studies

The literature review indicated that conceptual frameworks need to be validated to assess its strengths and weaknesses, and to determine whether it may be appropriate for use in future disaster case studies (Jabareen, 2009; Eldridge et al., 2016). To do this, a suitable case study was selected for a trial application through the creation of an analysis matrix, which used a series of attributes required of the case study as its axis (Stake, 2016) (a summary of this is shown in table 4.1 below). Again highlighted by the literature review, the primary concern was for the case study to be located in an English speaking country to avoid errors in translation or communication (criteria a). This was paramount in understanding the initial nature of the framework without any added complications concerning language barriers (Grubmüller-régent, Götsch, and Rainer, 2014). Another attribute for consideration was that of the geographical location of a suitable case study (criteria b) (Luna and Pennock, 2018). Literature indicated that smaller areas produce a lower volume of data that is less nebulous than high magnitude events affecting large regions (Grubmüller-régent, Götsch, and Rainer, 2014). The selection of a smaller magnitude event that was relatively bounded to a small geographical area was therefore deemed the most suitable. This discounted high magnitude events, for example hurricanes over category 3 on the Saffir-Simpson scale, or earthquakes over magnitude 6.0 on the Richter scale.

The availability of social media data was another concern for the case study selection(criteria c), given that different platforms may allow historical data to be accessed through APIs or may be limited in the amount of data an individual may access without paying for the service (Seawright and Gerring, 2008). Twitter was selected for data collection as literature indicated it proved the easiest for analysis due to its succinct format, allowances for data collection through the University of Southampton's Web Observatory and wealth of meta-data. The recency of the case study was an additional attribute which would ensure that the data, applications and outcomes would be as up-to-date as possible (criteria d)(Stake, 2016; Seawright and Gerring, 2008). This was necessary to guarantee that the framework was valid for present-day disasters, which may then be used as a basis for future events later in the thesis. Finally, the originality of the case study was an attribute which was taken into consideration at the time of selection in 2016 (criteria e) (Seawright and Gerring, 2008) (this has since changed with the progression of time where more studies have been published about the case as of 2019). Disaster literature suggested that application to a case that had previously been researched extensively may lead to underlying issues such as information bias, where previous findings unknowingly or unintentionally affect the outcome of the methodology or perception of the framework itself (Stake, 2016; Baxter and Jack, 2008).

Generalised disaster archives such as ReliefWeb were used to compile a list of suitable cases for analysis which document the history of disaster events since records began.

This is a specialised digital service of the UN Office for the Coordination of Humanitarian Affairs (OCHA). The researcher's personal judgement was then used to determine a shortlist of ten cases that matched a majority of criteria outlined in the above paragraphs. Each of the short-listed case studies were then scored against the axis criteria, compiling a final score at the end and ranked in order of the best match. The analysis revealed that the case of storm Desmond was the most suitable for the pilot study having scored the highest across the analysis matrix axis (shown in table 4.1 below). A full copy of the analysis matrix including the entire shortlist can be found in the appendix.

Following the initial pilot study of storm Desmond, the conclusions suggested that extending framework validation to another pilot study would be valuable. This would generate a better understanding of which aspects of social media could be measured across multiple disaster life-cycle phases, as well as test how the framework was able to process multiple similar hazards. Consequently, a second pilot study was selected which used the following two cases in the analysis matrix - that of storms Eva and Frank - as they scored identically and were of the same hazard type. In the second pilot study each of these storms were analysed individually, as well as being compared directly to one another. This was done to ascertain how the framework performed on data originating from different disaster phases, while the control variables of language, location and type of hazard were kept constant. The following section of this chapter details the method for both pilot studies.

Analysis Axis	**Storm Desmond**	**Storm Eva**	**Storm Frank**
Did the disaster occur in an English speaking country?	Yes	Yes	Yes
Was the disaster considered low to mid magnitude?	Yes	Yes	Yes
Was the disaster confined to a specific region of the country?	Yes	Yes	Yes
Were social media accessed throughout the disaster life-cycle?	Yes	Yes	Yes
Did the disaster occur within the past 2 years?	Yes	Yes	Yes
Did a range of individuals access social media during the disaster?	Yes	Yes	Yes
Has the state of emergency been lifted after the disaster?	Yes	Yes	Yes
Is there a lack of academic research about the case to date?	Yes	Yes	Yes
Is it unlikely information bias will be present in the validation process?	Yes	Yes	Yes
Are there no or limited issues with data access about the disaster?	Yes	Yes	Yes
Did the disaster cause mortality?	Yes	No	Yes
Did the disaster cause political, economic, demographic and geographical issues?	Yes	Yes	Yes
Did the disaster cause sustained damages to infrastructure and transport links?	Yes	Yes	Yes
Were evacuations conducted during the disaster?	Yes	Yes	No
Total /14	**14/14**	**13/14**	**13/14**

TABLE 4.1: A Summary of the Analysis Matrix Created for Pilot Study Case Selection

4.3 Method

The first pilot study analysed storm Desmond which made landfall in the UK in December, 2015. Data was collected using online and offline media content: online included social media data, online news articles and blogs; offline included physical media such as newspapers and TV broadcasts. These sources were cross-referenced with one another to provide a detailed account of the storm over its life-cycle. Twitter was chosen for the validation of the framework as the literature review indicated this was the most extensively used platform for social media analyses during disasters at the time (Robinson, Power, and Cameron, 2015). Due to it's capped character limit (140) it allowed analysis to be succinct but demonstrative due to the wealth of meta-data collected (Imran, Mitra, and Castillo, 2016). Finally, the University of Southampton's infrastructure supported a Twitter data collection set-up – the Web Observatory - that had been previously tested, meaning that anomalies or errors with collection were reduced. This was utilised to collect a dataset from December 2015 until January 2016 using the Twitter streaming API. Tweets were collected for featuring the term "storm Desmond" or "#StormDesmond" which generated a dataset of around 10,000 tweets.

Following collection Tweets were grouped into "subsamples" collected for single 24 hour periods, systematically every 7 days. This process is visualised in the figure below, and is employed for all large Twitter datasets throughout this thesis. Subsamples of the full dataset are designed to show condensed change in content over a short period of time, while avoiding manual analysis or large volumes of data better suited to processing algorithms or teams of researchers (Hoeber et al., 2016). A summary of each subsample, the date it was collected, and the volume of tweets within it is shown in tables 4.2 below for storms Desmond, Eva and Frank. It is on these subsamples that the conceptual framework was applied to test its output. Each tweet in the weekly subsamples was manually analysed by the researcher, and a numbered category of the framework assigned to the content. Once each subsample had been assigned categories the framework results were able to demonstrate how Twitter communications changed over the course of the disaster life-cycles, how these interacted with one another, and generate insight into the pilot studies.

The second pilot study followed the same method as the first, only for storms Eva and Frank. Subsequently, search terms included "storm Eva" or "#StormEva", and "storm Frank" or "#StormFrank", resulting in two further datasets. The dataset for storm Eva totalled roughly 12,000 tweets, while storm Frank totalled 105,000 tweets. A summary of the subsamples for each of these are shown in tables 4.3 and 4.4 below. Framework application followed the same method as detailed in the first pilot study, again demonstrating how categories, and therefore content, changed over time. Following this, framework results were compared between subsamples from different storms. For example, the subsample one of each storm event was compared to one another, then

subsample two to one another, and so on. This allowed a unique insight into Twitter use across varying life-cycles of very similar events at the same time, showing clear differences and similarities in content. Again, it is important to note the comparison and analysis of these results are designed to validate the framework, rather than to go into rich analytical detail. An overview of the pilot study method is shown in figure 4.1 below.

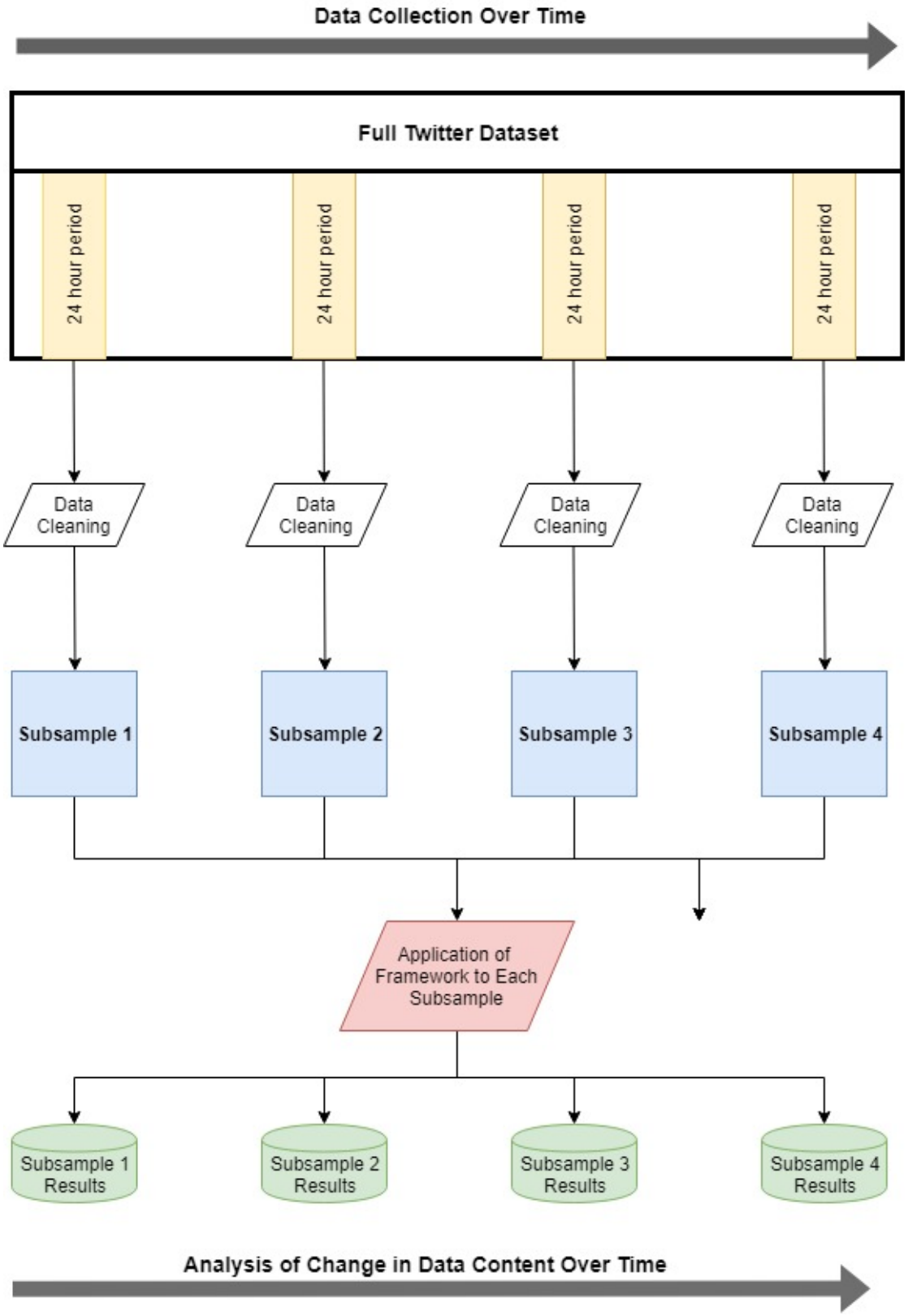


FIGURE 4.1: A Visualisation of the Subsample Creation Process for the Pilot Studies

Desmond Twitter Subsamples	Subsample Collection Period	Total Data
Subsample 1	15th December 2015	3346 Tweets
Subsample 2	22nd December 2015	972 Tweets
Subsample 3	28th December 2015	160 Tweets
Subsample 4	4th January 2016	69 Tweets

TABLE 4.2: A Table Summarising the Date and Volume of Subsamples for Storm Desmond

Eva Twitter Subsamples	Subsample Collection Period	Total Data
Subsample 1	23rd December 2015	3395 Tweets
Subsample 2	30th December 2015	296 Tweets
Subsample 3	6th January 2016	61 Tweets
Subsample 4	13th January 2016	12 Tweets

TABLE 4.3: A Table Summarising the Date and Volume of Subsamples for Storm Eva

Frank Twitter Subsamples	Subsample Collection Period	Total Data
Subsample 1	29th December 2015	30198 Tweets
Subsample 2	5th January 2016	666 Tweets
Subsample 3	12th January 2016	95 Tweets
Subsample 4	19th January 2016	36 Tweets

TABLE 4.4: A Table Summarising the Date and Volume of Subsamples for Storm Frank

4.4 Pilot Study One: The Case of Storm Desmond

4.4.1 Background Information

Storm Desmond made landfall in the UK on 4th – 6th of December 2015, and considered the fourth named extra-tropical cyclone of the UK and Ireland Windstorm season (usually active from November until March). According to the UK MET Office (2016), the 2015-16 season featured 11 named storm systems making it the most active year on record to date. Desmond was the most destructive with damages estimated be between £400-500 million. The areas worst affected were the counties of Cumbria and Lancashire, the Scottish border territories, and parts of the West and Midlands of Ireland. Further areas were affected by hazards triggered by the storm, such as flooding and road subsidence. Social media was used extensively throughout the storm season as 90% of the population has regular access to the Internet. A chronology of storms Desmond, Eva and Frank are shown in figure 4.2 below, illustrating how they fit into the wider context of the storm season.

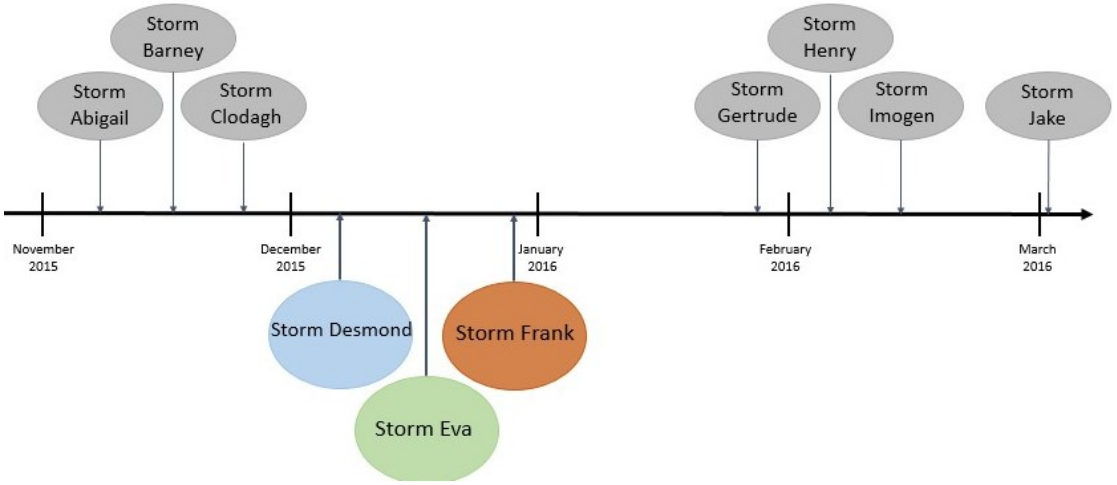


FIGURE 4.2: A Chronological Visualisation of the UK and Ireland Storm Season, Highlighting the Pilot Study Storms Desmond, Eva and Frank

4.4.2 Storm Desmond Results

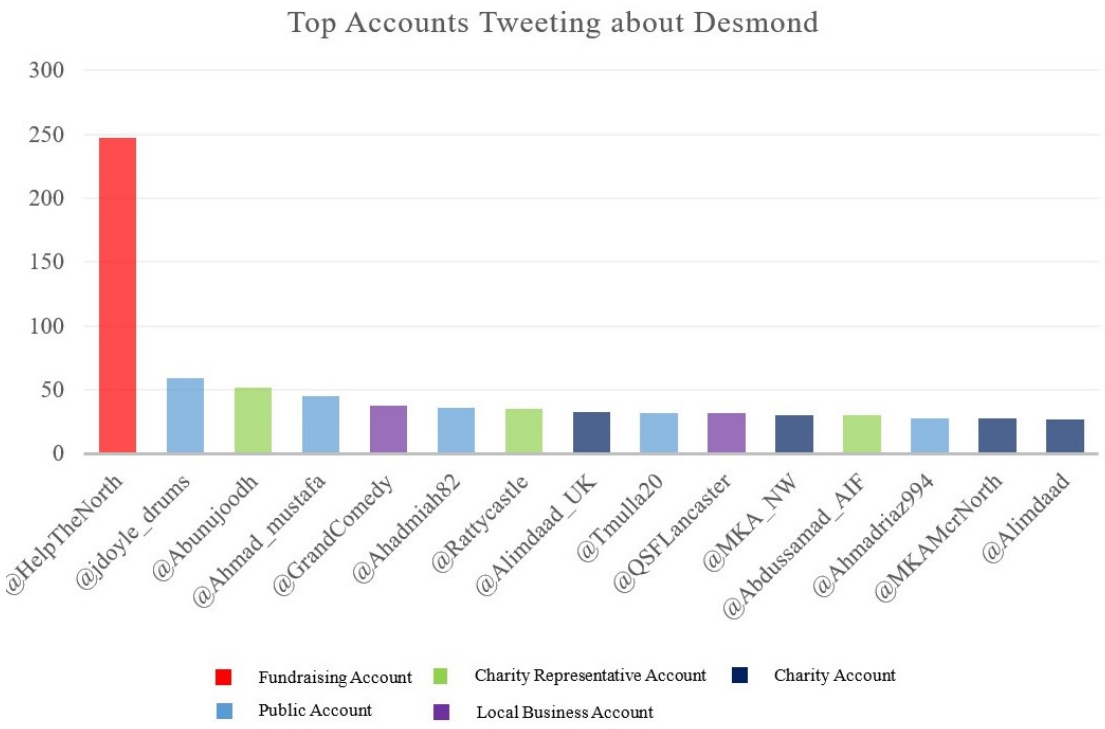


FIGURE 4.3: A Bar Graph Illustrating the Accounts which Tweeted about Storm Desmond the Most Throughout the Datasets

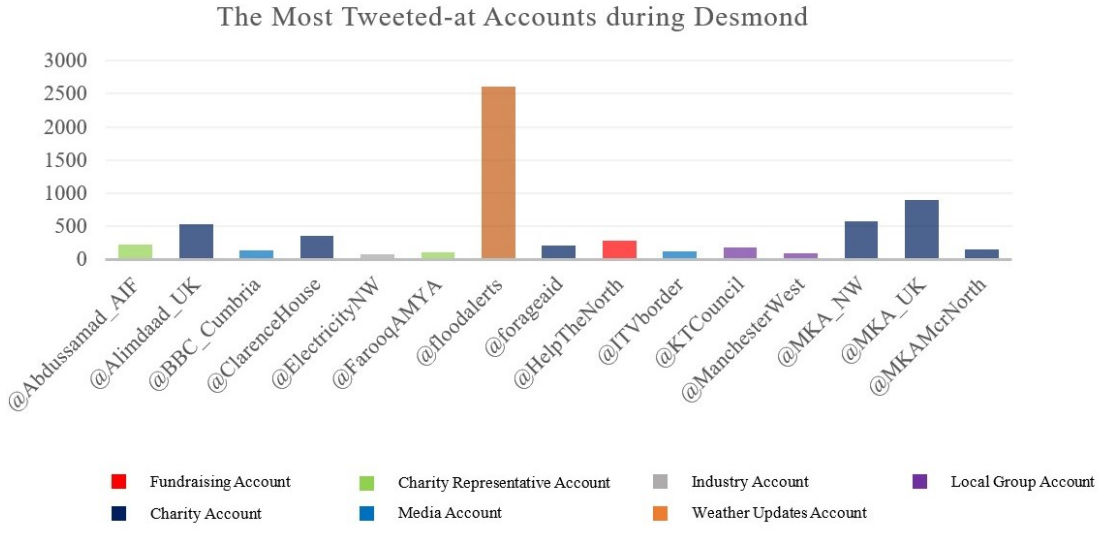


FIGURE 4.4: A Bar Graph Illustrating the Accounts That Were the Most Tweeted-at During Storm Desmond

Although many organisations had a physical presence in affected areas, only a handful of these created and disseminated online information during time-critical situations (shown in the figure 4.3 above). This indicated that organisations in the real-world had incorporated a structured and coordinated online presence where only selected accounts created new data. The figures show that the primary account for this was the Cumbria Police who created and disseminated updates, information and advice that was tailored for the public in areas that were affected by the disaster. The content produced was then re-tweeted and shared by other coordinating organisations, predominantly that of charities and organisations in local areas, such as HelpTheNorth (figure 4.4 above). The British Damage Management Agency (BDMA) who were responsible for creating the largest amount of tweets featuring the term "#stormDesmond", and producing original information sourced from authorities.

Unlike the offline content of the Cumbria Police, The BDMA produced time-critical online content designed for the wider public by using #stormDesmond as a general hashtag. Other types of update were created and disseminated by accounts such as the MetOffice and FloodAlerts who focused on communicating weather warnings and developments for meteorological hazards only. This is illustrated in the figures above where FloodAlerts is not present in the top accounts tweeting about Desmond, but is present in the accounts most tweeted-at where individuals were requesting additional weather information and clarifications. By using different hashtags and considering the content of tweets before publication, accounts like FloodAlerts were able to ensure that the information they were producing did not conflict with that produced by other organisations. Interestingly, there is correlation between the accounts producing general content (including retweets) in the figure above, compared to the accounts that are the most tweeted-at in the following figure below. This implies that accounts featured in both of these figures are likely to be hubs with high levels of centrality as explained by the literature review.

Many disaster studies commonly identify official media channels, such as government departments, as hubs during crises. In this pilot study there is also a high number of charity representative accounts revealed as hubs also. Accounts such as Abdussamad_AIF and MKA_NW feature highly in both figures most likely caused by underlying factors. This is due to the fact that these accounts are representatives of the Alimdaad foundation – a Muslim charity who mobilised to provide volunteer support and response to those affected by Desmond. This generated high levels of political discussion in regions of the UK at the time due to complex perceptions held by the affected population demographic. Similarly, content analysis of popular hashtags supported this, with a rise in tags such as "#MuslimsForHumanity" recorded as the subsamples progressed. While this is a valuable contribution to understanding underlying factors, the pilot study was only able to demonstrate this through the medium of Twitter data, and so it was not

possible to identify whether these trends were present on other social media platforms as well.

4.4.2.1 Changes in Social Media Content during Storm Desmond

The figure below illustrates the results of the conceptual framework application to the case of storm Desmond throughout the life-cycle of the event. Each of the large spheres represent the subsamples created from the Twitter data, progressing from the 15th December 2015 until the 11th January 2016 (summarised in the subsample figures earlier in the chapter). The smaller circles situated within the larger spheres denote the most popular framework categories present in the data, where the larger the circle, the higher the percentage of tweets was assigned to the category. Each subsample features varying numbers of circles representing framework categories: this is due to the fact that only categories which have recorded 10% or more of the total tweets within a subsample have been included in the figure. Therefore, one can clearly see the change in popular categories over time, but also the volume of particular categories. The most popular category of each subsample is highlighted at the top of the spheres, with its full title written above. Subsequent less popular categories have been labelled, and their full titles will be referred to within the text – however these can also be found by referring back to the conceptual framework detailed in the previous chapter.

A Key for Figure 4.5

No.	Framework Category
4	Provide and Receive General national and Regional Disaster Warnings
5	Detect and Warn of Disasters and Specific Hazards Locally
9	Provide, Receive and Analyse big data Generated by the Event
10	Provide, Receive and Encourage Information Sharing in Multiple Formats
11	Document What is Happening during a Disaster Online and Offline
12	Create and Consume News Coverage of the Disaster
13	Provide and Receive Location Based Real-Time Warnings
14	Express Public and/or Individual Empowerment; Reassure Others
15	Raise and Develop Awareness; Donate and Receive Donations; List Ways to Help or Volunteer
16	Seek to Inform and Support Existing Disaster Management Strategies
17	Provide and Receive Specific Disaster Response, Rescue and Evacuation Information
21	Provide and Receive Information Regarding Response and Recovery; Tell and Hear Personal Stories
23	Discuss Socio-Political Causes, Implications and Responsibility

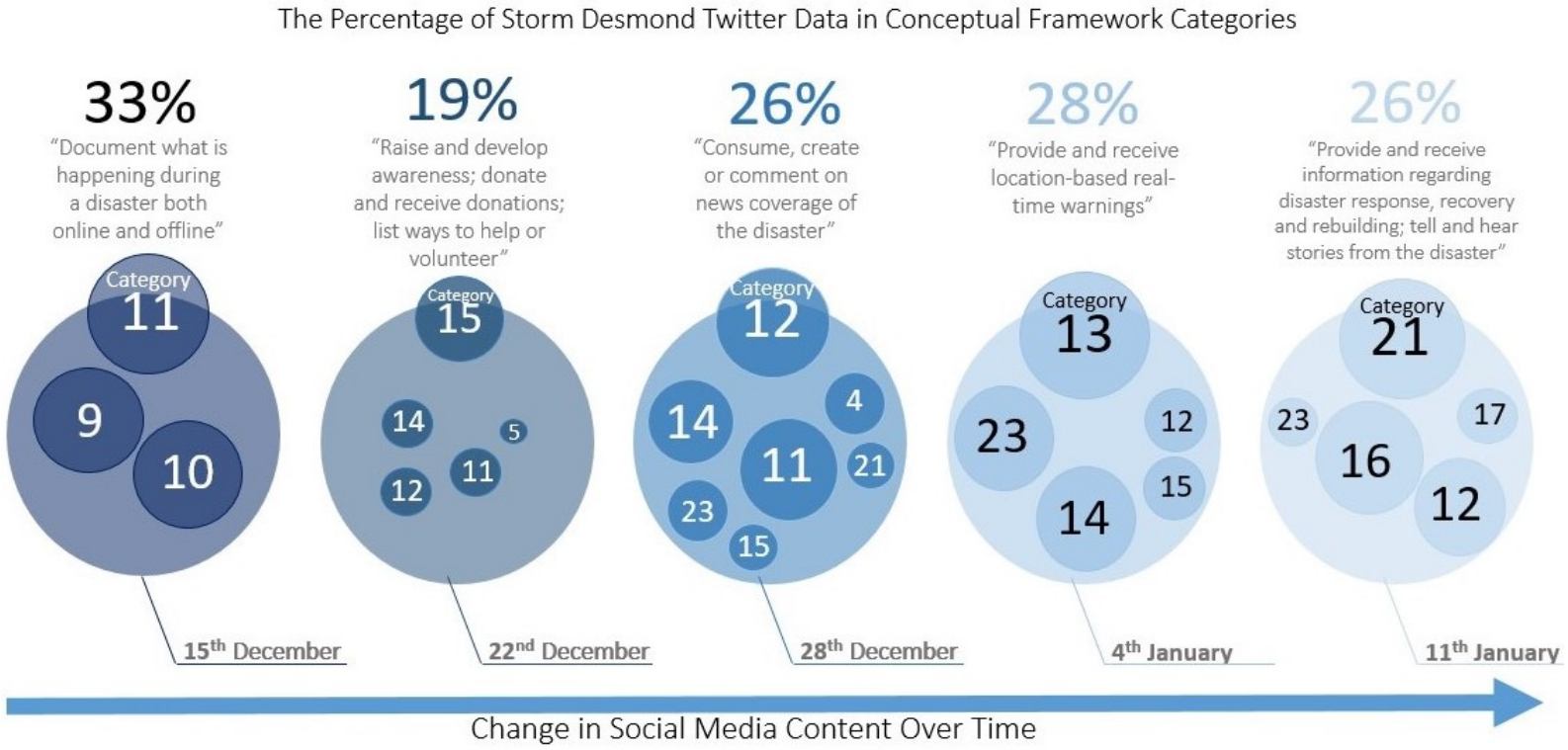


FIGURE 4.5: A Visualisation of the Changes in Framework Category Content Throughout Storm Desmond

In subsample 1 there was a surprising level of tweets concerned with data. This is shown in the popularity of categories **9** "provide, receive and analyse big data", **10** "provide, receive and encourage information sharing using different formats", and **11** "document what is happening during a disaster online and offline". While many of these tweets originated from public accounts requesting more information generally, or directed at particular official accounts, a majority of tweets can be accounted for by automated systems such as FloodAlerts. This, along with several others, was launched for the first time during the storm and generated automated tweets as well as automatically collecting, analysing and redistributing tweets about weather updates. As it was the first instance of its use, the updates still featured issues that affected the volume of tweets they were producing. For example, FloodAlerts posted whenever there was a measurable change in meteorological hazards for the entire country rather than being tailored to smaller regions, or having a measurable change threshold such as only posting if the change in hazard was increasing significantly. This is reminiscent of the failings of Facebook's Safety-checkin feature discussed in the literature review previously, and emphasises the importance for data dissemination and classification parameters. Eventually this error was identified and changed in the 3rd and 4th subsamples, but remains responsible for high levels of data orientated categories at the beginning of the storm.

Subsample 2 instead showed that during disaster categories became more popular as the storm progressed. Category **15** "raise and develop awareness; donate; list ways to help/volunteer" took over as the most popular category. This can be attributed in part to the unexpected severity of the storm and the damages it was causing, as well as the launch of the HelpTheNorth campaign: a movement to generate donations, resources and help for affected communities. The category popularity was furthered by the uptake and re-tweeting of HelpTheNorth content by a range of high profile accounts, for example celebrities and politicians, which resulted in a wave of immediate re-tweets by the wider public and represents underlying factors such as politics and demographical issues. Category **14** also become prevalent as individuals began expressing concern and voicing best wishes to those affected by the storm, as well as individuals affected sharing their immediate thoughts and feelings. Documenting the disaster online and offline (**11**), as well as creating and consuming news coverage of the storm (**12**) were popular too which was predicted by similar studies of social media content in the literature review.

In subsample 3 categories **11** and **12** became even more popular. This may be linked to a steep rise in the number of hazards caused by the initial storm. Saturated ground caused landslides and subsidence, electrical power cuts affected large regions, extensive flooding caused infrastructure damages to buildings and transport links, and nearly 1,000 were evacuated. During this time, Twitter accounts mainly sought to share and re-tweet news updates on the variety of hazards which were continuing to unfold over time, as well as to continue to express their feelings towards those affected. The popularity of category **13** "provide and receive location-based real-time warnings" corresponded to

the hazards extensively discussed and shared in the previous week, with the addition of more information about them, as well updates on their progress while being responded to by a range of authorities and organisations. This generated a rise in the popularity of category **23** "discussing the socio-political causes, implications and responsibilities" as individuals began to express thoughts and feelings regarding the way in which the hazards were managed.

In subsample 4, categories associated with post-disaster increased in presence, with category **21** "provide and receive information about response, recovery and rebuilding" becoming the most dominant. This was supported by the presence of categories **16** "informing and supporting existing management strategies" and **17** "provide and receive specific response, rescue and evacuation information". This may be explained by a rise in individuals telling their own personal stories from the storm once the immediate threats had dissipated and coinciding with power being restored, as the literature suggested. The continued presence of category **12** was comprised of warnings and preparedness information broadcasts about the upcoming imminent storms within the season. Similarly, category **23** remained within the sample, as individual's concern over flood defences, compensation, insurance and cost of damages was still heightened given both the immediate fallout from Desmond combined with the imminent landfall of similar storms.

4.4.3 Concluding Storm Desmond

The Desmond pilot study concluded that the conceptual framework, when combined with a mixed methodology, provided original insight into the event. The results highlighted networks and accounts of interest, popular terms and hashtags - as well as trends in these, illustrated underlying factors, and demonstrated tweet content change over time. The framework itself revealed that the categories formed were indeed valid and present in the social media data. Furthermore, the application demonstrated that the categories changed during the course of the disaster depending on the life-cycle phases. These correlated with cases in the literature review which predicted that certain types of social media uses and functions were more extensively used during particular phases of disasters. Categories in the pre-disaster phase of the framework were present in subsamples 1 and 2, and then declined during 3 and 4 as studies such as Shklovski (2008) and Hughes (2010) indicated. This may be due to individuals seeking specific preparedness information online on which will form the basis for time-critical decisions. Similarly, during disaster categories gradually increased throughout the subsamples as news of the disaster began to spread through various media channels. Unique framework categories such as "Discuss the accessibility of the Web as an intermediary to social media" provided new insight into the issue of Web accessibility. While this was expected to mainly be focused in the post-disaster phase, it also appeared in the during disaster phase as a series of hazards caused flooding and power outages.

The literature review indicated that a single successful case application may not be fully representative of how well a framework functions over multiple disasters. Therefore, by applying it to multiple cases it could be tested in greater detail while contributing further to RQ1 and RQ3. The addition of a second pilot study was consequently decided a necessary step. Desmond was just one of the storm systems in the 2015-16 UK and Ireland storm season of which several other storms caused substantial damages to similar regions. Many of the same emergency responders, organisations, charities and governmental departments who managed storm Desmond remained active throughout other events. In addition to Desmond, storms Eva and Frank were selected for the second pilot study, concluded through the analysis matrix and explained earlier in this chapter. Together, these were the three largest and most destructive storms of the winter storm season, which scored the highest for selection. The similarities between these cases allowed the same data collection and application method to be used uniformly, and results to be compared more easily.

4.5 Pilot Study Two: The Case of Storms Desmond, Eva and Frank

4.5.1 Background Information

Storms Eva and Frank were the following two named storms of the 2015-16 UK and Ireland storm season after Desmond. Eva made landfall on the 23rd – 24th of December 2015, and Frank made landfall on the 28th December – 3rd of January 2016, illustrated in the figure below. In the figure points stemming from a circled named storm system cross a central timeline, which refers to the date of it's landfall. Damages caused by Eva are estimated at between £500-800 million, with estimations for Frank at £200-300 million. Similarly to Desmond, Eva triggered a series of other hazards such as high winds, flooding and subsidence across regions of the UK and Ireland: some of which were areas still coping with the aftermath of Desmond and its hazards. This meant that throughout each of these storms additional flood defences, resources, volunteers and emergency responders were drafted in to reduce further risk to the population.

4.5.2 Results

Given the similarities of the storms Desmond, Eva and Frank it was reasonable to expect that social media use throughout each of these would be comparable. Results showed that more than 100 agencies created, discussed or disseminated information regarding the storms. These fell into the same four categories: government, commercial organisations, self-funded organisations, and media outlets. Between December 2015 and January 2016 data showed that emergency responders sustained high levels of public

engagement through offline channels such as news broadcasts, as well as online channels such as Twitter, blogs and other social media platforms like Facebook. The most active emergency responders and organisations on Twitter throughout the storm season remained similar (shown in figure 4.6 below), indicating that the level of inter-agency coordination for the regions affected was effective and consistent.

Information was created by a select few Twitter accounts managing the hazards, whereas dissemination of information was spread by a larger range of accounts, which included; emergency services, meteorological services, transport services, government, local companies, charities and voluntary groups, members of parliament (MPs), celebrities, researchers and the public (shown in figure 4.7 below). Of these accounts, a majority were consistent throughout the sustained period of crisis, and throughout each of the storms. This resulted in the formation of authoritative accounts as hubs (Adar and Adamic, 2005), which individuals directed messages and tweets at in high volumes. Some accounts, for instance @jeremycorbyn, received a high amount of public interaction for other underlying factors - in this case political - documenting the actions of MP Jeremy Corbyn who visited areas in the North suffering from the storms.

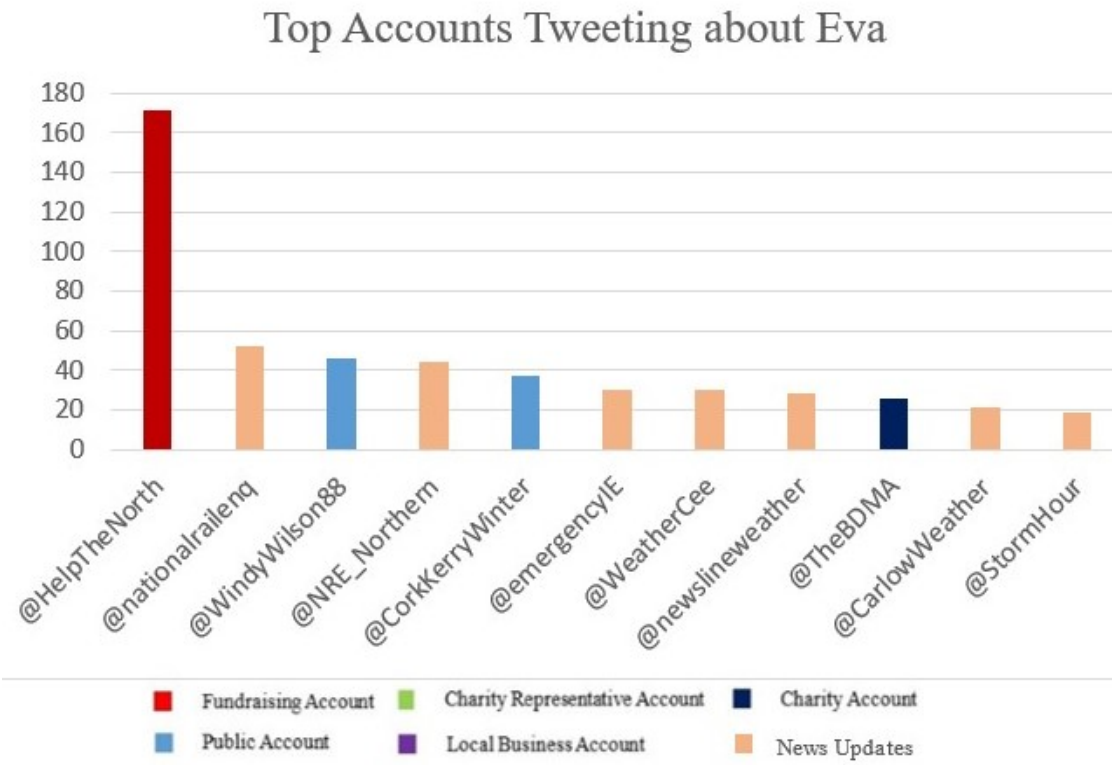


FIGURE 4.6: A Bar Graph Illustrating the Accounts which Tweeted about Storm Eva the Most Throughout the Datasets

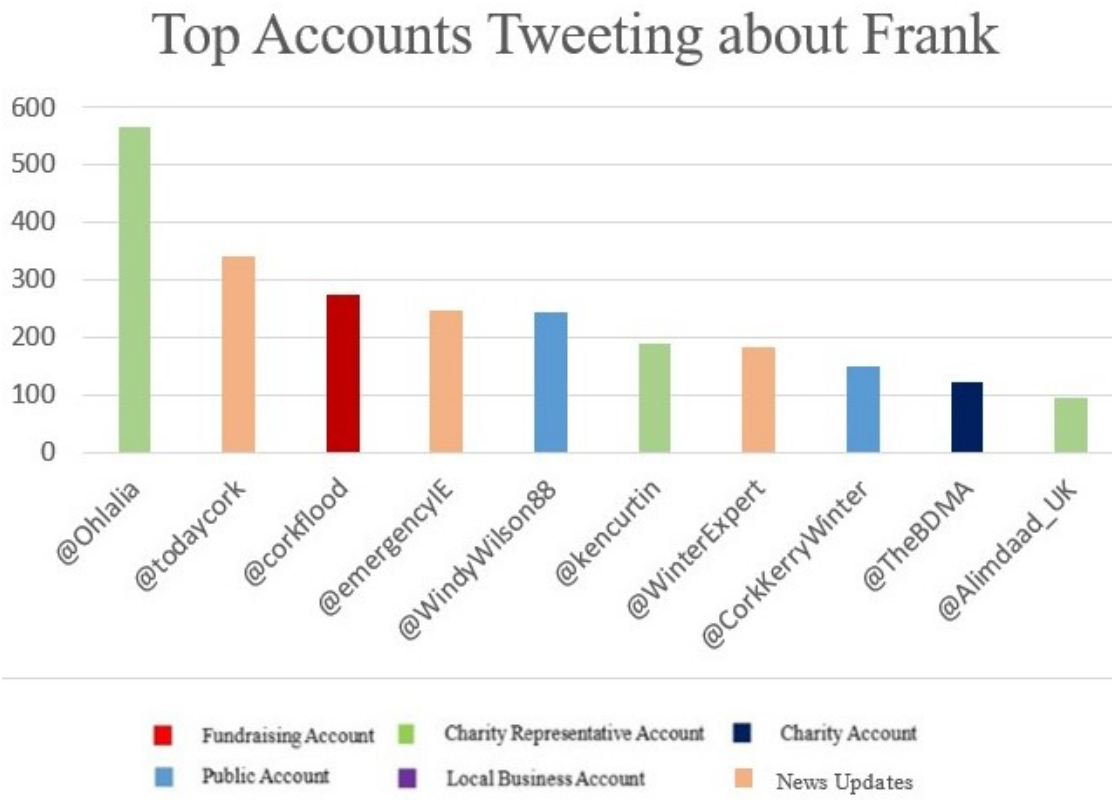


FIGURE 4.7: A Bar Graph Illustrating the Accounts which Tweeted about Storm Frank the Most Throughout the Datasets

4.5.3 Changes in Social Media Content during the Storm Series

Figures 4.8 and 4.9 below illustrate the results of the conceptual framework application to storms Eva and Frank throughout the life-cycle of the events. The figures illustrate the framework results, and are structured in the same manner as the results from storm Desmond where each of the larger circles represents a subsample, and the smaller circles within them illustrate the framework categories present.

A Key for Figures 4.8 and 4.9

No.	Framework Category
3	Provide and Seek General Disaster Preparedness Information
4	Provide and Receive General national and Regional Disaster Warnings
5	Detect and Warn of Disasters and Specific Hazards Locally
11	Document What is Happening during a Disaster Online and Offline
12	Create and Consume News Coverage of the Disaster
13	Provide and Receive Location Based Real-Time Warnings
14	Express Public and/or Individual Empowerment; Reassure Others
15	Raise and Develop Awareness; Donate and Receive Donations; List Ways to Help or Volunteer
16	Seek to Inform and Support Existing Disaster Management Strategies
17	Provide and Receive Specific Disaster Response, Rescue and Evacuation Information
18	Seek and Access Mental, Behavioural and Emotional Health Support
21	Provide and Receive Information Regarding Response and Recovery; Tell and Hear Personal Stories
23	Discuss Socio-Political Causes, Implications and Responsibility
26	Discuss the Accessibility and Reliability of Social Media; Discuss Perceptions
27	Consolidate Lessons Learnt to Develop New/Improved Social Media Applications

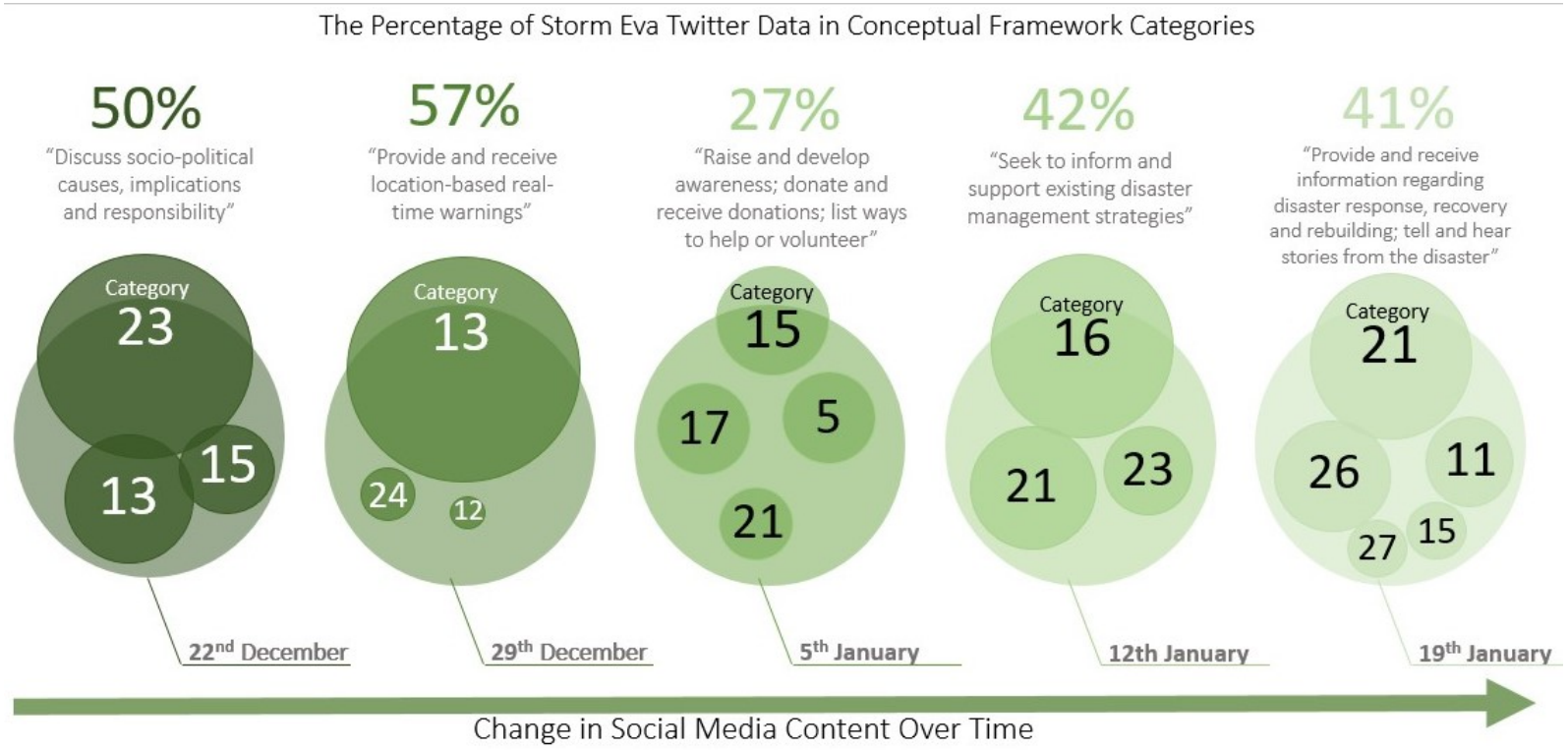


FIGURE 4.8: A Visualisation of the Changes in Framework Category Content Throughout Storm Eva

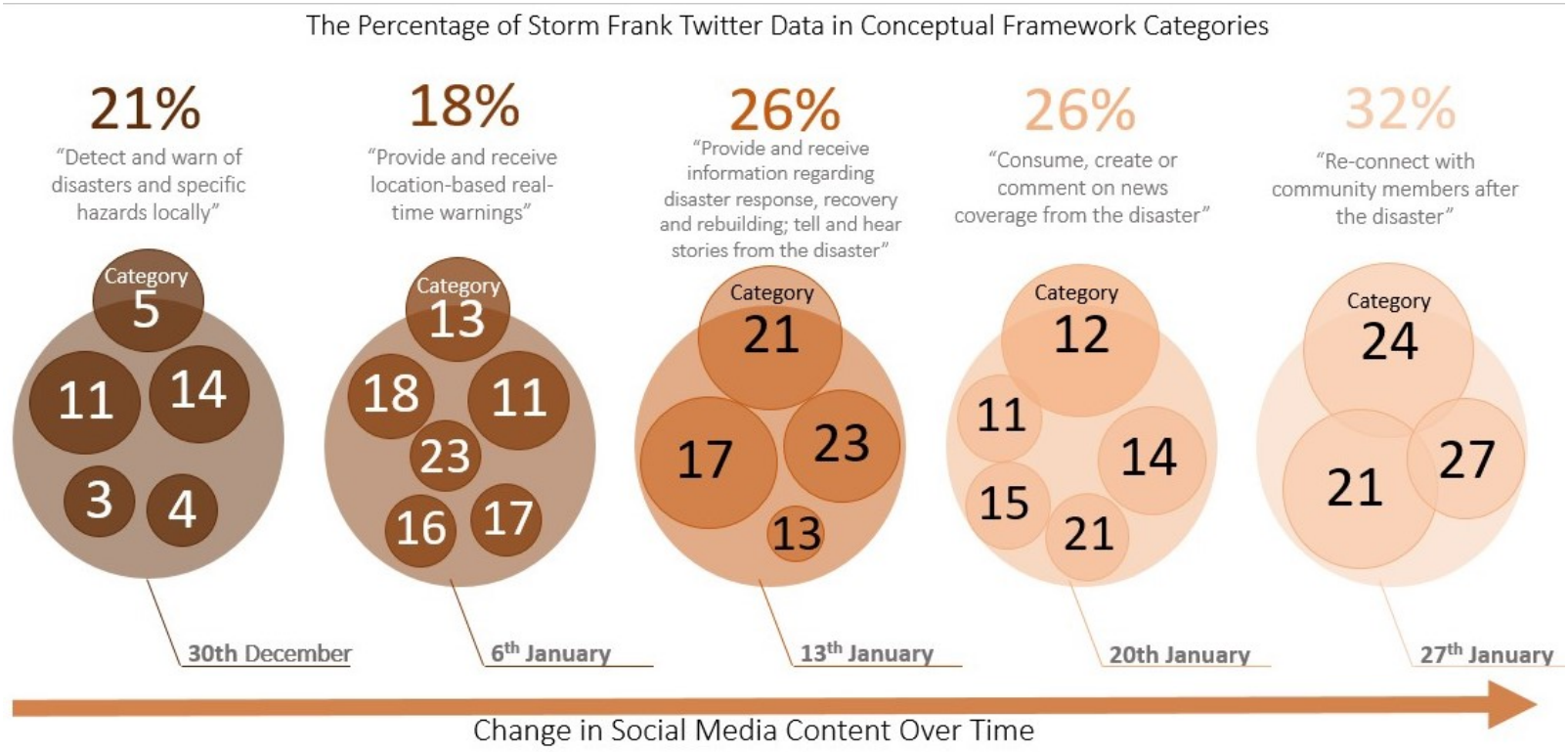


FIGURE 4.9: A Visualisation of the Changes in Framework Category Content Throughout Storm Frank

In contrast to the results from storm Desmond, subsample 1 of Eva featured much later categories (commonly associated with the during and post disaster phases). Category **23** "discuss socio-political causes" was the most popular, which may be attributed to the aftermath of Desmond. By the time Eva had made landfall, information and news media had been shared around the country regarding Desmond and the severe impacts it had had. In turn, these had sparked a political debate about how the storm was handled, the interactions politicians had had with the event, and various aspects of the response and recovery processes. This meant that information sharing about Eva and its own hazards, summarised in the next most popular of category **4** "provide and receive location based real-time warning", was happening secondary to larger political underlying factors. Category **15** "raise and develop awareness; donate and receive donations; list ways to help or volunteer" was the third most recorded category which was identified later in the Desmond subsamples compared to that of Eva. This may be explained by the awareness generated by Desmond, including the calls for charity donations to HelpTheNorth, already being in wider circulation.

In subsample 2 of Eva, category **13** dominates Twitter content. Partly, this can be explained by the continuing and unfolding hazards of Eva which took the form of land subsidence, flooding, collapses of infrastructure such as roads and bridges, and the cancellation of many national transport links. Partly, it may also be attributed to the imminent approach of the next storm in the season; Frank. In light of two large storm systems, information spread about specific hazards once again became the primary focus of Twitter. The automated warning systems previously identified in Desmond, such as FloodAlerts, similarly became active once more given the range of hazards affecting large regions and the changes in flood waters. It is within 24 hours of this sample that subsample 1 of Frank was taken, which also highlights the presence of information warning categories such as **4** "provide and receive general national and regional disaster warnings", and **5** "detect and warn of specific hazards locally" considering that many tweets featured the combination of #StormEva and #StormFrank in conjunction.

In subsample 3 of Eva international awareness was at the forefront of framework results in light of the combined severity and quick succession of hazards from Desmond and then Eva. As a result, category **15** once again became popular. This was fuelled by the unusual severity of the storm season causing shock to the population, as well as the wider world who watched events unfold through online media. This was similarly noted in the following subsample of Frank taken at the same time by the presence of category **18** "seek and assess mental, behavioural, and emotional health support". While the nature of tweets that fell into this category were with regards to sharing information about seeking support, there were also a range of tweets telling and hearing personal emotional stories from the disaster. These originated from all three storms, but interestingly were tagged with unique relevant hashtags for each of them. This may reflect that individuals thought the events so alike that associated experiences with each,

rather than just one. This was noted in the literature review in disasters that did not necessarily happen at the same time, but were so similar online information did not differ extensively (for example in the series of wildfires in California reported by Sutton (2010)).

In subsample 4 of Eva, information shifted towards that of category **16** "seek to inform and support existing disaster management strategies". Alongside this, in subsample 3 of Frank, categories **21** "provide and receive information regarding disaster response and recovery", combined with that of category **17** "provide and receive specific disaster response, rescue and evacuation information" became more popular. This indicated that the information spread on Twitter was actually seeking to inform and support the response and recovery of multiple storm systems. While literature indicated that citizens desire to help throughout a disaster in whatever capacity they can – usually in the form of disseminating information created by trusted accounts - a majority of literature focus on this kind of help during singular disasters. In the case of storms Desmond, Eva and Frank, this transposed throughout each defined disaster. This may be due to the fact that the disasters themselves were similar in nature, or perhaps as they happened in such quick succession. Consequently, the framework application has highlighted new findings for information dissemination over a sustained period of crisis.

In subsample 3 of Frank, coinciding with the final subsample of Eva, Twitter content shifted back to categories **11** and **12**, as by this stage many of the disruptions to road and rail links, as well as power outages and flooding, had been resolved. Instead, we see a shift towards documenting and consuming news coverage about the storm season in general, and also an emphasis of the later post-disaster activities conceptualised by the framework. For instance, the increase of category **26** "discuss the accessibility and reliability of specific social media; discuss perceptions" was previously unrecorded. Arguably, this is because during disasters, the immediate priorities of communities in crises shifts away from discussion or assessment of resources or functions that do not directly affect their decision-making (Chen and Sakamoto, 2014; Chatfield, Scholl, and Brajawidagda, 2014; Abdullah et al., 2017). Once the immediate threat posed by disasters then subsides, a rise in discussion of the wider underlying factors may once again be picked up without increasing their risk (**Hagena2016**; C.-M. Huang, Chan, and Hyder, 2010; Rudra et al., 2016).

Finally, in subsample 4 of Frank, the presence of post-disaster life-cycle phases is further evidenced. Not only are post-disaster categories the most popular, but only post-disaster categories were recorded. This was interesting as neither final subsample taken from Desmond and Eva featured this. It can be speculated, then, that the presence of multiple disaster life-cycles unfolding at the same time on Twitter affected the content of recorded for each of the storms. Therefore, at the end of the last of the large storms, a clearer demonstration of post-disaster categories was more easily identifiable. The

presence of category **27** "consolidate lessons learnt to develop new/improved social media applications" was another category that had yet to be identified in the post-disaster phase of Desmond and Eva. As outlined in the paragraph above, it is likely this is became more discussed as citizens immediate concerns were able to begin to shift back towards every day considerations that did not affect their immediate risk. Further to this, the awareness of access to the Web, as well as to social media, may be an indicator that the UK public (who created and disseminated the largest amount of tweets) have a culture of regularly using social media, and as such certain behaviours may be a result of this.

4.5.4 Concluding the Storm Series

The second pilot study sought to build upon the findings from the first and to further test the validity of the framework. In conclusion, the application to the storms of Desmond, Eva and Frank has demonstrated original insight not only into the individual disasters themselves, but also in terms of comparing social media output during a sustained period of crisis. This is a novel contribution to the field of disaster management, as few case studies have achieved insight into similar hazards within the same geographical region, and within a short period of time. Therefore, the outcomes of these studies were published in several papers which are detailed at the beginning of this thesis (Gray, M. Weal, and Martin, 2016a; Gray, M. Weal, and Martin, 2016b; Gray, Mark J Weal, and Martin, 2017). The results have identified hubs, popular terms and hashtags, change in Twitter content over time, and importantly highlighted some of the issues that arise when a region is experiencing different phases of the disaster life-cycle at the same time. The pilot studies have also demonstrated that the framework may be compared across different case studies. The framework, therefore, may be viable to use in conjunction with the wider mixed methodological approach in future cases once the study limitations have been taken into account. These will be explained in the following section, before the wider methodological approach of the thesis is detailed.

4.5.4.1 Study Limitations

The pilot studies have highlighted several issues for further consideration in the remainder of this thesis. Firstly, it has become apparent that the study of Twitter data alone would not be able to address each of the RQs entirely (issue a). Although the application of the framework to Twitter data has validated it as a functioning tool, it has additionally raised several other issues. The incorporation and analysis of other social media data originating from multiple social media platforms is needed, as previously highlighted throughout the literature review. Only then can a picture be built of the different uses, functions and users of these channels that take into consideration the variations of their structures, demographics, features and applications. It is these variations

that are the key to scoping the current relationship between social media and disasters, and understanding how they may be used to their potential in future events.

Secondly, further considerations need to be made for the timing and methods of data collection (issue b). While the collection of Twitter data through the University of Southampton's Web Observatory resulted in functional datasets, this set up does not transpose onto other platforms easily. This will require individual, tailored methods depending on the platforms themselves given their structures and variation, which will need to be addressed in the thesis methodology. Timing of data collection, too, must be regarded in more detail. While this wasn't prevalent in the pilot studies as the method allowed for historical queries using Twitter API's, it will become more important for the collection of data on other platforms which do not have access to API's (for example Facebook), or have a limit on the amount of data collected. This is especially important for the collection of pre-disaster data for rapid onset events that have little to no warning. To address this, the methodology must device a mechanism for data collection as soon as is possible to ensure that data may be collected in the early stages of an event, rather than the during and post-disaster stages alone.

Thirdly, the thesis must acknowledge that there are some data that do not completely fit into the framework (issue c). Literature such as Jabareen (2009) outline this as one of the limitations of conceptual frameworks which is difficult to avoid. During the pilot studies this was not common, with less than 10% of data needing to be removed. This may be attributed to a unique framework category which allows the inclusion of such data without skewing the results of the overall application. While a small amount of data doesn't fit into the application, literature suggests that this may increase for larger, more complex datasets (Jabareen, 2009), which naturally will need to be addressed in more detail in the wider thesis methodology potentially through the division of a rigorous data cleaning process prior to framework application.

Finally, it is apparent that the use of contrasting case studies is required to fully address the RQs (issue d). Although the use of similar events was necessary to avoid identification errors for the validation of the framework, the wider thesis case studies should demonstrate that it is also applicable to a range of different hazard types. This is important in supporting the original contribution of the framework itself to disaster management, and to illustrate its versatility in future events regardless of scale, hazard type, and underlying factors. This is particularly valuable to disasters in upcoming years as the literature review has argued that disasters are increasing on a global scale (Kappes, Papathoma-Köhle, and Keiler, 2012). Furthermore, the selection of contrasting events may demonstrate differences in the use, users and content of social media that may explain underlying factors, thus illustrating original insight into the disaster cases themselves.

4.6 Summary

This chapter has presented the findings of the pilot studies that were conducted earlier on in the research of this thesis. It has taken the conceptual framework created in the previous chapter and has applied it to three storm systems to test its validity. The results of the applications have not only demonstrated that the framework categories are relevant to disasters, but have also highlighted contributions to the areas of information reliability and Web accessibility previously noted in the literature review. This is especially important due to the lack of frameworks and methodologies which take these into account, particularly as social media evolve in terms of their applications and features, as well as the way in which they are used. While the pilot studies have contributed to RQ2, they have several key limitations which must be taken into consideration in later research. In order to address this the following chapter describes a larger methodology for the remainder of this thesis. This takes into account the lessons derived from the pilot studies, as well as the remaining requirements needed to fully answer RQ1, RQ3 and RQ4.

Chapter 5

A Novel Methodological Approach to Assess Social Media During Disasters

The work presented in this chapter is the methodology for the remainder of this thesis and has been informed by previous chapters. To re-cap, the literature review and pilot studies have indicated several key methodological issues to consider. Firstly, social media data for particular case studies must be collected from a range of platforms to ensure that a range of users and uses of such networks are active (issue a). This is necessary to form a more detailed understanding of the true role that these kinds of media hold within disaster management and to answer RQ1 and RQ2. Secondly, methods of data collection must be tailored to specific platforms given their variation in structure, output, and scope (issue b) (RQ3). While the data collected cannot be considered a representative sample of the total populations affected by disaster – especially on a global scale – maintaining standards for its collection can nevertheless reduce other issues with sampling. Thirdly, the processing and analysis of social media data must be rigorous to ensure case study insight is of high quality and originality (issue c). Particularly, acknowledging the limitations of the methodology and results are important in understanding the relationship between social media and disasters. Finally, different case studies which are contrasting to one another are required to demonstrate that the methodology is applicable to a range of future events (issue d), while also revealing how variations in underlying factors potentially shape the outcome of disasters and the ways in which social media are used throughout the life-cycle (RQ4).

This chapter details a mixed-methods approach which builds upon the findings of the previous chapters, and is broken down into four main sections. The aim of the first section is to explain the process that was followed to select which social media platforms should be used for data collection in the case study analyses. To do this, an electronic

survey was created to ascertain which particular platforms individuals commonly utilised throughout the disaster life-cycle phases. The survey was distributed online using a targeted sampling method which produced a high response rate. Alongside this, an analysis matrix - the same method employed in the pilot studies - was created. The survey results indicated a short-list of the most popular social media used during disasters, which were then incorporated into the matrix for further evaluation. Using the findings of the previous chapters a new set of criteria were drawn up thus forming the analysis axis of the matrix. The combination of the matrix output, combined with the survey results, concluded that the platforms of Facebook, YouTube and Twitter would be the most appropriate for future case study analysis.

The second stage of the methodological approach aims to identify which disaster case studies would likely be the most valuable for analysis. Similar to the process followed for case study selection for the pilot studies, this matrix aimed to source and evaluate the appropriateness of cases using online resources such as ReliefWeb as a basis. In contrast to the pilot study matrix however, the short-list of cases used took into account high magnitude events: this was due to the successful validation of the framework, as well as the need to evaluate large-impact events to answer the remaining RQs. The findings of the previous chapters once again informed the criteria of the analysis axis, which will be discussed in more detail later in the chapter. The matrix concluded that two cases would be the most suitable for evaluation. These are the Kaikoura earthquake which occurred in New Zealand in 2016, and hurricane Irma which occurred in 2017, specifically for the country of Antigua and Barbuda.

The third stage of the approach explains the methods for data collection that were employed. Data sourced from the different social media platforms for both case studies can be categorised into quantitative and qualitative data types (previously explained in chapter 3). The section begins by stating methods of collection for quantitative data sources, which vary depending on the platform sourced from. For Twitter data, a similar approach to the pilot studies was employed by using the University of Southampton's Web Observatory to collect relevant tweets for both case studies. For YouTube, a Web browser plugin was used to scrape YouTube data searching for relevant videos. A free research tool was then used to crawl relevant videos and collect meta-data about them. Another free research tool was used to scrape data from Facebook, but was limited to that of open groups and pages only given the platforms privacy laws. This kind of data collection, combined with methods assessed in chapter 3, revealed that qualitative data would be needed to support a explanatory approach. Consequently, the section then details the methods of qualitative data collection undertaken which took the form of semi-structured interviews with a range of individuals who experienced both disaster cases.

The final stage of the methodology details the methods employed for data processing and analysis. This is of high importance given the range of data collected for a

mixed-methods research design. Within this section, each source of data collected is summarised and the steps taken for data cleaning, processing, and analysis are detailed. This includes the cleaning of quantitative datasets collected from Facebook, YouTube and Twitter, as well as the steps for processing qualitative interview data which include assigning anonymous IDs. The process for applying the conceptual framework previously created and validated is then re-capped, and details provided on its application to the varying different datasets. Finally, study and data limitations for the methodology are discussed. A full flowchart diagram of the methodological overview and its relationship to one another is figure 5.1 below.

FIGURE 5.1: A Flowchart Overview of the Methodological Process of this Thesis.

5.1 Selecting Social Media for Analysis

5.1.1 Electronic Survey

The literature review and pilot studies highlighted the need for diverse data that originate from different social media platforms in order to answer the thesis research questions. They further evidenced that social media are used in different ways during disasters based on a number of criteria, such as the platform affordances and structure, behaviour of users, and the availability of applications and features. In addition to this, they found that underlying factors, such as one's personal preferences, may too dictate which sites an individual uses and for what reason. In order to scope the relationship between social media and disasters, then, we must first be able to identify which platforms are the most extensively used during disasters and why that may be. To do this, a semi-structured electronic survey was designed which allowed individuals to express their preferences for platforms, as well as allow them to add unstructured explanations (as an option) as to why this was the case. The electronic format was selected over traditional surveys (such as on paper) as literature suggested individuals who utilise social media during disaster are likely to be more directly accessible through the Web (McNutt, 2014). For instance, populations affected by disasters may be hard to reach physically as a result of the damages caused by an event (Sadler et al., 2010).

The electronic survey was designed and hosted using the software "iSurvey", which is freely accessible and supported by the University of Southampton. This was chosen over other software for its ease of access (requiring the researchers student login details), the security of data storage offered (only accessible to the researcher hosting the survey), the accessibility for participants (which allowed access through Web browsers, as well a generated email link) and the ability to choose different types of question format (for example both closed ended and open ended questions). The survey was hosted on the site from July until November 2016. A combination of closed and open-ended questions were chosen, as highlighted in chapter 3, explanatory qualitative data may allow individuals to explain quantitative answers i.e. should a participant state that they used a particular social media platform, they may then state in their own words why that was the case. Additionally, closed ended questions allowed the participant to rank answers in order of preference, which was highlighted by literature such as Manfreda (2003) as an effective way of stopping individuals discounting other answers for reasons such as personal bias. It also allowed different platforms to be ranked across a number of responses, thus providing more accurate measure of use (X.-J. Wang et al., 2009).

To populate the available answers on the survey a short-list of the most used sites was created using online listings such as Wikipedia, in addition to previous lists created by similar studies (Sarah Vieweg et al., 2010). The short-list discounted any platforms in languages other than English to avoid problems with later analysis. The short-list length

was set at 10 as literature indicated participants are more likely to complete surveys that require less time to answer questions, thus cultivating a higher response rate from which a better average may be drawn (Nulty, 2008). The top 10 social media sites were chosen for the criteria of high number of monthly users which indicated general popularity, presence of organisations and authorities known to respond and manage disasters using the site, and a user demographic that was roughly balanced for both gender and age brackets. This combination would allow the results of the survey to be the most relevant to the thesis research questions. The short-list of platforms were Pinterest, Google+, Twitter, LinkedIn, YouTube, Reddit, VK, Facebook, Flickr, and Vine.

The survey began with basic information questions such as asking for the participant age bracket (varying from 18, to 65+ years) and average weekly use of social media in hour brackets (varying from less than 3, to 40+ hours). The survey then had four main sections which corresponded to the disaster life-cycle phases. Each section asked the participant to identify the sites they used the most for each of the phases, explain why that was, and to add any other relevant comments that they felt they used the site over others. Closed question answers allowed for the participant to rank the possible answers so that a clearer idea of the most popular sites could be formed, and whether these sites varied depending on the phase of an event. The final section of the survey asked participants to reflect on their overall experience of using social media during disasters. It made a series of statements such as "I felt that my preferred social media site was quick and easy to use throughout a crisis" and asked individuals to strongly agree, agree, neither, disagree or to strongly disagree. This allowed the survey to identify whether there was scope for the improvement of particular sites based on user experiences, thus forming a basis for RQ4. It also provided further context on how and why individuals may use certain sites (RQ1 and RQ2) as, for example, a participant may have stated that they used a platform the most throughout an event but could then state that they didn't think the site was easy or valuable to use: this would imply that there were other motivations for its use, such as the individual only being aware of one platform, or that they didn't have accounts on other social media.

To ascertain where the survey should be distributed, a list of the most relevant online areas was created. This was achieved through a series of online keyword searches using a Web browser. Key words included disaster, disasters, crisis, crises, and catastrophe used in conjunction with social media, communication, crisis communication, social networking, Web, and online. These were designed to target individuals who had experienced disaster as well as used social media, which are the criteria for participation (in addition to being above 18 years old). The researcher then used personal judgement to determine which social media sites, forums and online spaces were the most suitable for survey distribution. This was chosen over quantitative methods such as assigning rankings to avoid errors in context and content of sites, (for example the researcher was able to critically assess the content of sites for suitability) (McPeake, Bateson, and A. O'Neill,

2014). Once a list of suitable areas was created, the link to the survey accompanied by a pre-amble explaining the nature of the research, was posted to each systematically. The following section will present the results of the survey, rather than in the later chapters of the thesis, due to the integral role its conclusions have in the selection of social media platforms for future study.

5.1.2 Electronic Survey Results

The electronic survey was posted to a total of 53 groups, forums, sites, and threads. Each of these featured variations in group size, characteristics of users, objectives of the site, and popularity/exposure to encourage a range of respondents. The study therefore acknowledges that the survey respondents were not representative of any defined population demographics. Results showed that 598 individuals accessed the survey, with 29 fully completed results and a further 15 partially completed. The high response rate to the survey indicated that the method of distribution was successful, and did indeed target individuals who met the inclusion criteria. The completion rate, compared to that of the response rate, was much lower. This may have been caused by a number, or combination, of well-documented factors in survey design such as individuals beginning the survey and then failing to complete it due to a long duration (Nulty, 2008). It is also possible that the survey description highly suited the interests of individuals who read it, only to later realise they did not fully match the inclusion criteria. Despite this, the survey results were viable in indicating the which platforms would likely be the most suitable for future analysis.

The electronic survey results indicated that the most commonly used social media during crises were Facebook, YouTube and Twitter (shown in figure 5.2 below). While the popularity of these changed with regards to the disaster life-cycle phases, they nonetheless recorded the most positive user experiences throughout disaster events and throughout each of the phases overall. It is important to acknowledge that since the creation of survey some of the features of the platforms have changed, for example the site Vine has been terminated. It is also important to note that Facebook, YouTube and Twitter are extremely dissimilar in terms of technical structure and characteristics. Consequently, data from each of these are in different formats: YouTube hosts videos and comments; Facebook hosts comments, status updates, pages, groups and likes; and Twitter is capped at a 140 character limit. The differences in data therefore require further methodological steps, discussed later on in this chapter, to ensure that they may be compared in an insightful and original manner (RQ3).

The results additionally showed that there were mixed feelings towards the quickness of accessibility and the ease of use (figure 5.3), and the relevance of information found on the sites (figure 5.4) throughout the disaster life-cycle phases. This highlighted that both RQ3 and RQ4 were valuable in explaining this phenomenon, and that there was

scope for the improvement of social media use in future disasters as the literature review had previously suggested (figure 5.5). This was further supported by the final question of the survey where a majority of participants stated that they would definitely access social media in a future event should they experience one (figure 5.6). Not only is this relevant to RQ3 and RQ4, it also illustrates the importance of the research in this thesis to the field of disaster management.

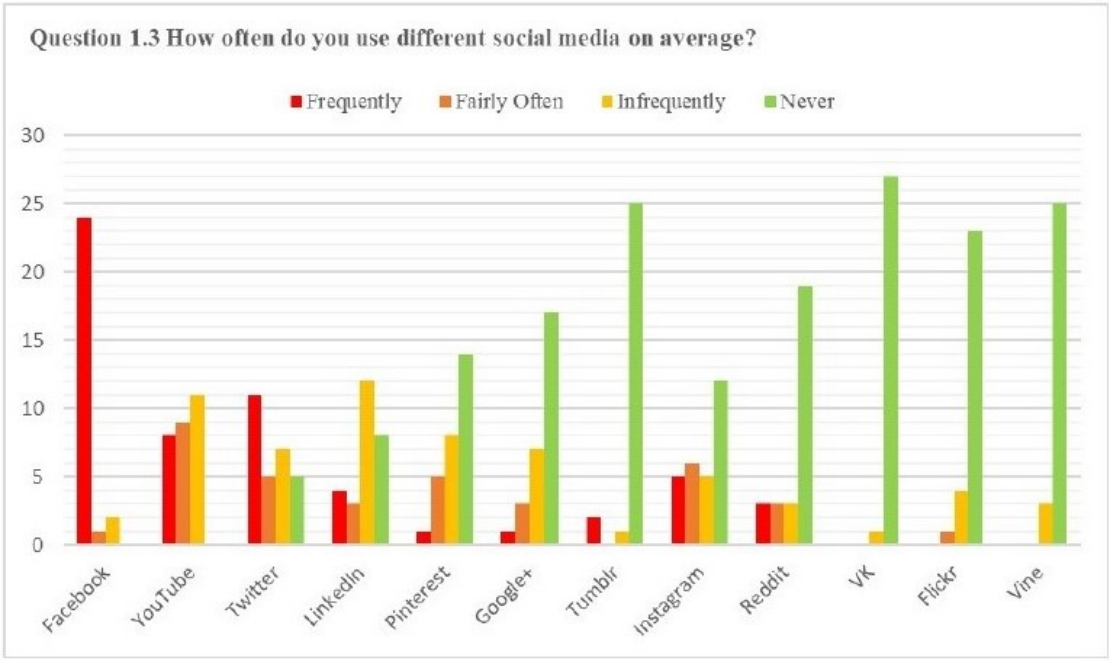


FIGURE 5.2: A Bar Chart Showing the Results of the Most Used Social Media Platforms during Disaster.

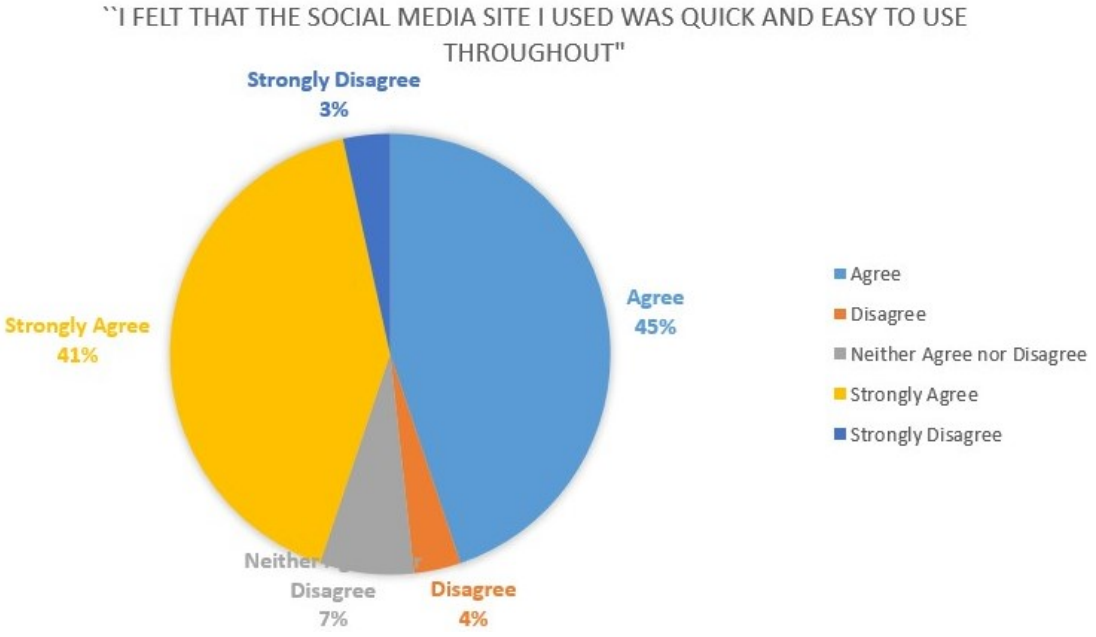


FIGURE 5.3: A Pie Chart Showing the Opinion of Participants on the Ease of Access for Social Media Sites during Disasters.

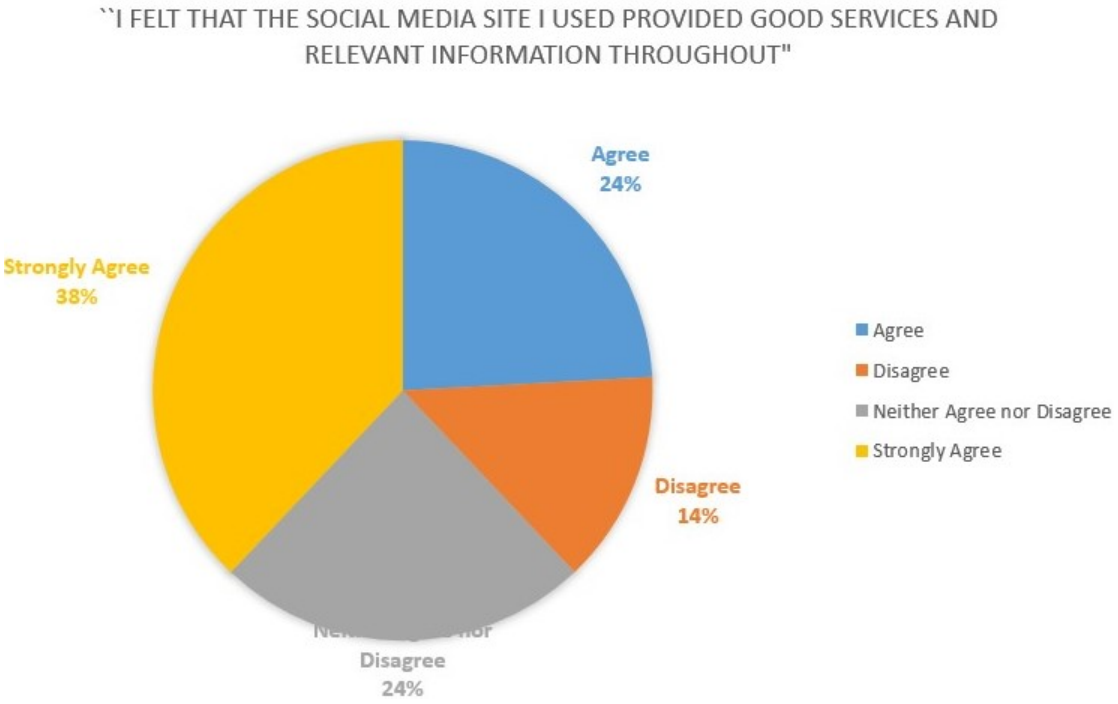


FIGURE 5.4: A Pie Chart Showing the Opinion of Participants on the level of Information for Social Media Sites during Disasters.

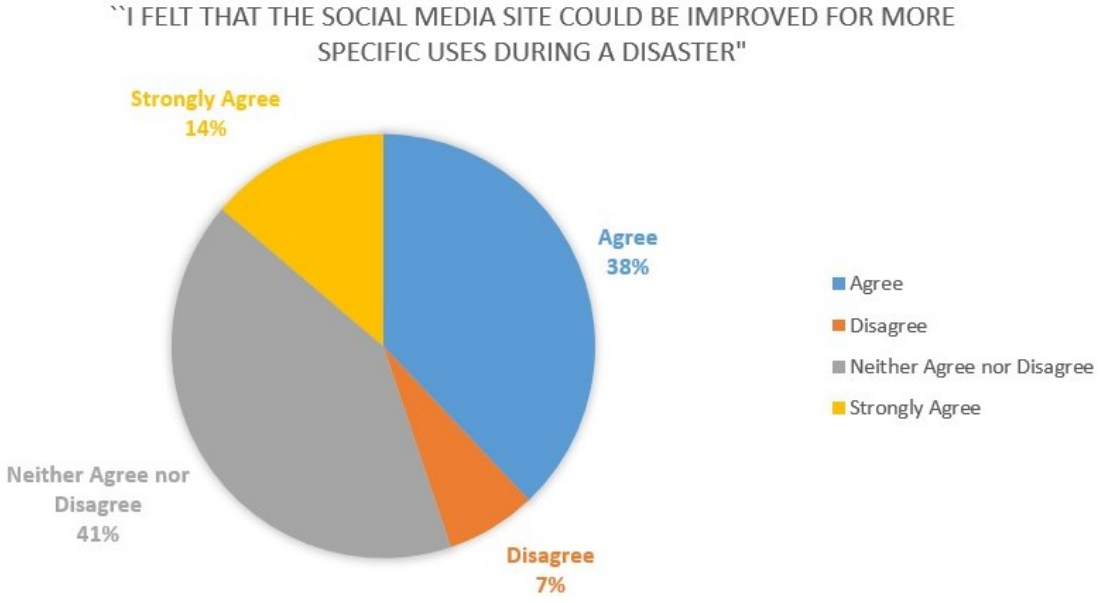


FIGURE 5.5: A Pie Chart Showing Whether Users Thought Social Media Could be Improved in Future Events.

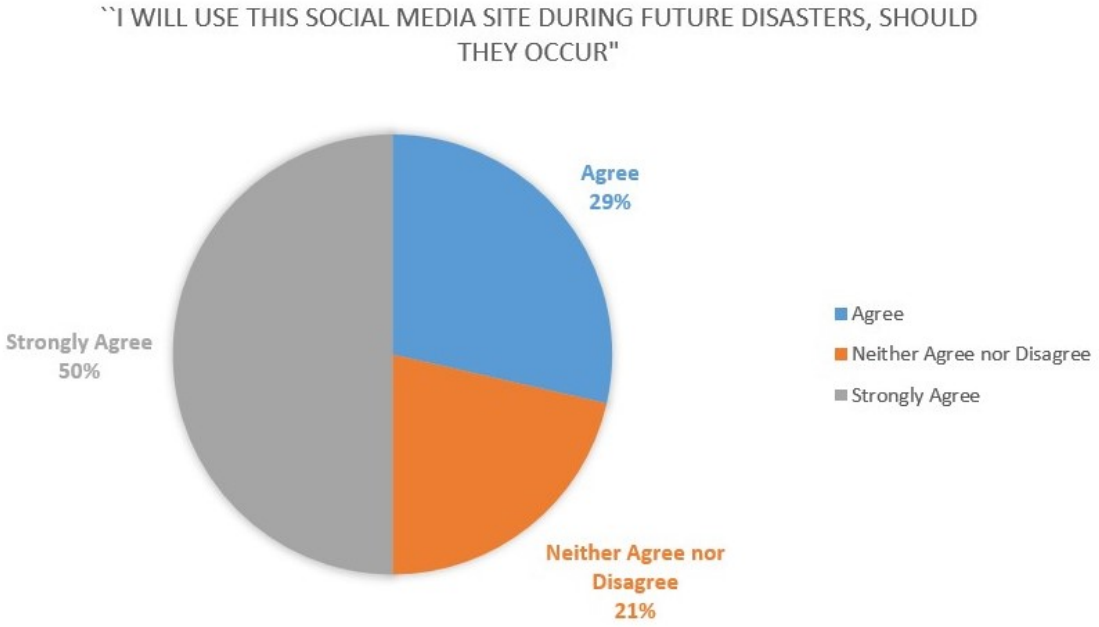


FIGURE 5.6: A Pie Chart Showing that Users will use Social Media in Future Disasters

5.1.3 Matrix Analysis for Social Media Platforms

In conjunction to the survey results, an analysis matrix was also created using the short-list of social media platforms on the survey as a basis. The matrix was used to rank the technological suitability of platforms and the data they produce against a number of suitability criteria. Such criteria were informed by the literature review, findings from the pilot studies, and additionally considerations that were necessary to answer the thesis research questions. Criteria included whether the social media platform had an open API (making historical data accessible), whether the user demographics were roughly equal (making data more representative and comparable), and whether the collected data was in an easily usable format (reducing possible errors with analysis and comparison). Each social media was resolved against each suitability criteria, which was totalled at the end (using the same method as in the previous pilot studies). The social media platforms with the highest marks were therefore considered to be the most suitable for selection. The analysis matrix is shown in the figure below.

In conclusion, the social media platforms of Facebook, YouTube and Twitter were chosen as the most suitable for analysis. Although dissimilar to each other, the literature has indicated that variations between platforms may contribute to a better understanding of disaster case studies by acting as multiple lenses. The platforms were identified by having a higher popularity than the other platforms that was comparable between the three, while meeting a majority of the analysis matrix criteria. While it may have been possible to compare data from all of the platforms in the short-list to produce an even more detailed understanding of case study analyses, this method was discounted given the time constraints of the thesis, as well as the complex and extensive methodological steps required to do so. Similarly, selecting fewer platforms for analysis was discounted as comparisons between data may not have been as insightful or original, which are required to answer the research questions.

	Pinterest	Google+	Twitter	LinkedIn	YouTube	Reddit	VK	Facebook	Flickr	Vine
Is there a roughly equal gender balance of users?	Y	Y	Y	Y	Y	Y	N	Y	Y	N
Are a majority of user age brackets represented on the social media?	Y	Y	Y	Y	Y	N	N	Y	Y	N
Is the social media used in English speaking countries?	Y	Y	Y	Y	Y	N	N	Y	Y	Y
Are there no (or few) political or social limitations to using the social media in particular countries?	Y	N	Y	Y	N	N	N	Y	Y	N
Are there no (or few) structural limitations on the social media content an individual may produce?	N	Y	N	Y	N	N	N	Y	N	N
Is the data format that the social media content is collected in easy to clean and analyse?	N	Y	N	Y	Y	Y	Y	Y	N	N
Is the data collected from a search on this site in a managable size for analysis?	N	Y	Y	Y	Y	Y	Y	Y	Y	Y
Has social media content from this site yet to be commonly used in disaster management?	N	N	N	N	N	Y	Y	Y	N	Y
Is the social media used in a wide range of countries globally?	Y	Y	Y	Y	Y	Y	N	Y	Y	N
Does the social media have an open API?	Y	Y	Y	N	Y	N	Y	Y	Y	N
Have other similar studies been able to scrape and use data from the social media?	N	Y	Y	N	N	N	N	Y	Y	N
Can the data collected be saved in multiple different formats easily?	N	Y	Y	N	Y	N	N	Y	N	N
Are there no (or few) limitations to data collection? (i.e. Twitter firehose)	N	Y	N	N	Y	Y	N	Y	N	N
Are there any open datasets available sourced from the social media already?	N	Y	Y	N	N	N	N	N	N	N
If so, are any datasets free?	N	N	Y	N	N	N	N	N	N	N
Can scraping data from the social media be conducted for a specific timeframe?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Are there no (or few) limitations to scraping historical data from the social media?	Y	N	Y	Y	Y	Y	Y	Y	Y	Y
Have similar studies used data from the social media with few limitations?	N	Y	N	N	N	N	N	N	N	N
Tally	**8/18**	**14/18**	**16/18**	**8/18**	**15/18**	**10/18**	**6/18**	**15/18**	**10/18**	**5/18**

FIGURE 5.7: An Analysis Matrix Evaluating Social Media Platforms Against Suitability Criteria and Scoring them Accordingly

5.2 Selecting Case Studies for Analysis

5.2.1 Matrix Analysis for Case Studies

The literature review highlighted a number of criteria that should be taken into consideration for the selection of case studies for later analysis to demonstrate valuable insight, as well as answering the thesis research questions. Criteria such as the recency, scale, context, spoken language and impact of events has been demonstrated as being important as some case studies may be better suited for particular types of analysis. For example, for research analysing online crisis communications during rapid onset events, the selection of a case study which occurred within a lesser developed country (which is less likely to have a large proportion of the population with regular access to the Internet), and of a slow onset in nature, will not yield insightful results no matter how in depth analysis can be. To ensure these criteria were met for the thesis another analysis matrix was conducted to ascertain suitability of case studies.

To do this, a list of disasters which had occurred in the previous two years was created, using online resources and data such as ReliefWeb. The recency of disasters was chosen as literature indicated that the more recently a disaster has occurred, the higher the chances the event had of generating a range of data across different platforms which are easier to access historically. Further parameters for inclusion were the scale and magnitude of the event (where high magnitude was more relevant as it would likely generate more data), and the likelihood that the type of disaster would occur again in the same region (where high likelihood was more relevant as the subsequent analyses would continue to hold value to regional disaster management). From this list, events that occurred within an English-speaking country were then short-listed for analysis within the matrix.

The matrix for case study selection required a much larger range of suitability criteria than that of the previous matrix due to the multi-faceted nature of high magnitude disasters. Consequently, additional criteria such as social media availability and privacy/blocking laws were taken into account, as well as unpredictability for disaster response throughout the life-cycle phases. While a range of underling factors exist for any case, it was decided that these would represent original and insightful aspects of analysis unique to each case study. This, as a result, would demonstrate how the methodology can be applied to contrasting cases while still producing valuable results to the relevant disaster management structures. Cases were again ranked against the suitability criteria, with the highest tally representing the most suitable for selection.

The following figures show a summary of the analysis matrix, which has been shortened to only show cases that occurred within English-speaking countries for the years 2016 and 2017. This is due to the fact that the full matrix is complex and large - a copy of which can however be found in the appendix listing all cases that were evaluated against

the suitability criteria. The first figure shows disasters from 2016, and the second figure shows events from 2017. The results of the matrix concluded that two cases were the most suitable to answer the thesis research questions. These are the Kaikoura earthquake (New Zealand, 2016), and Hurricane Irma (Caribbean, USA and outlying Islands, 2017). Although fulfilling all of the suitability criteria, they additionally were contrasting types of disaster, location, and a range of underlying factors which would be more valuable in answering RQ3 and RQ4.

Analysis Axis	Hurricane Harvey (2017)	Hurricane Irma (2017)	Hurricane Maria (2017)	California Wildfires (2017)	Hurricane Matthew (2016)	Louisiana Flooding (2016)	Kaikoura Earthquake (2016)	California Wildfires (2016)	Tennessee Wildfires (2016)
Did the disaster occur in an English speaking country?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Was the disaster considered a high magnitude event?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Is there evidence of Facebook, YouTube and Twitter use throughout the disaster?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Are all social media sites unblocked in the country?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Did the disaster occur within the previous two years?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Did a range of individuals from different backgrounds use social media throughout?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Has a state of emergency been lifted after the disaster?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Is there a lack of academic research about the disaster to date?	No	Yes	No	No	No	No	No	No	Yes
Did the disaster cause mortality?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Did the disaster cause damages?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Did the disaster affect transport links?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Is there evidence of geographical underlying factors?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Is there evidence of demographic underlying factors?	Yes	Yes	No	No	Yes	No	No	No	No
Is there evidence of political underlying factors?	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	No
Is there evidence of economic underling factors?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Were evacuations conducted during the disaster?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Does the country have an exisiting disaster management strategy in place?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
If so, does this include social media in their incorporation?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Were international humanitarian aid organisations required to respond to the disaster?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No
Did the disaster cause long term affects for the country?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Has the country experienced this type of hazard before?	Yes	Yes	Yes	Yes	Yes	Yes (smaller)	Yes	Yes	Yes (smaller
Is the country likely to experience this type of hazard again?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Are any re-occuring hazards likely to be frequent? (in less than 100 years)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Were any aspects of the pre-disaster phase considered unpredictable?	No	Yes	No	Yes	No	Yes	Yes	Yes	Yes
Were any aspects of the during-disaster phase considered unpredictable?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Were any aspects of the post-disaster phase considered unpredictable?	No	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes
Is there evidence of crisis communications throughout the disaster?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Would analysis of the case represent original academic insight?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Would analysis of the case allows for the complete answering of the thesis RQs?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Tally/29	**26**	**29**	**27**	**26**	**27**	**26**	**29**	**27**	**26**

FIGURE 5.8: A Summary of the Analysis Matrix for Case Study Selection

5.3 Data Collection

Facebook, YouTube and Twitter have previously been selected for data collection for the case studies. Given their structural differences, each will require a separate method of data collection which will be outlined in the following section. In addition to the use of quantitative methods, the literature suggested that due to Facebook's privacy laws any openly available data on the site may not have the same level of richness as on the other sites (Zimmer, 2010). This is due to the fact that individuals may set their personal profiles to a private setting, affecting the amount and type of data available (Zimmer, 2010). To ensure that the research questions are answered in detail, it was decided that the edition of qualitative interviews may circumnavigate some of the data issues with Facebook data collection. This would target individuals previously identified on open groups and pages and allow them to express their use of the platform in their own words, thus avoiding the need to access private accounts (Zimmer, 2010).The method for this will be discussed at the end of this section.

5.3.1 Quantitative Methods

5.3.1.1 Twitter Data

The University of Southampton's Web Observatory set-up was used for Twitter data collection. Using this, the researcher is able to search for a string of text or hashtags used in tweets. The set-up then collects relevant tweets and stores them in a database that the researcher may then download, along with a range of other meta-data such as geolocation, hashtags count, and time published. To collect tweets, a list of search terms was determined for each case study. These used key words, phrases and hashtags regarding each disaster. The set-up was then used to search for each string of terms, setting the inclusion parameters to only include tweets that featured a minimum of two of the defined search terms. This was designed to collect tweets that directly discussed the disaster case, thus avoiding any unnecessary analysis of tweets that were tangential to the context. The time parameters set for each case study differed due to the differences in the type of hazard. For the Kaikoura earthquake, which was a rapid-onset disaster that had little prediction available, tweet collection began on the day of the event. For Hurricane Irma, which developed over several weeks in a course across the Atlantic ocean, tweet collection began before the storm system made first landfall, therefore including prediction and warning messages.

The search string for the Kaikoura earthquake is as follows:

Collect tweet IF term: "New Zealand" OR "Kaikoura" AND "earthquake" OR "tsunami"

The search string for Hurricane Irma is as follows:

Collect tweet IF term: "Hurricane Irma" OR "Hurricane" AND "Irma"

The total tweets stored for the Kaikoura earthquake was roughly 34,000, and for Hurricane Irma was roughly 3.1 million. The differences in size can be attributed to the scale of the disasters: Hurricane Irma affected more than twenty countries and islands, whereas the Kaikoura earthquake was limited to New Zealand. However, due to the time parameters of the thesis, manual content analysis of datasets of this scale by the researcher was infeasible. To address this, while still being able to demonstrate social media change over time, a systematic sub-sampling method was devised and employed on the Twitter datasets shown in the figure below. In this process, tweets in each dataset were ordered chronologically by date of publication. Starting at the beginning of the case study (which different for each) a sample of tweets was taken for a full 24-hour period, and stored as an individual dataset. These smaller datasets are referred to as subsamples, and were collected on seven-day intervals until the case study data collection ended (defined as when the state of national emergency had been revoked for each case respectively). A visualisation of the subsample creation process can be found in chapter 4. The dates of data collection and subsamples will be detailed in each case study chapter.

5.3.1.2 YouTube Data

The Google Chrome plugin called "Scraper" was used to collect raw YouTube data. This is a free data mining tool which can scrape online sites and consolidate data into a spreadsheet. To source data, terms were used as search strings to identify the most relevant YouTube videos for each case study. The same combination of search terms as the Twitter method above was employed for each event respectively. The list of video results produced by each search was then ordered by the highest number of views, rather than the date of publication described in the Twitter method above. This is due to the fact that YouTube users do not use the platform in the same way as Twitter: videos, as the site's main content, take longer to produce due to format and unlimited data size compared to the instantaneous nature of capped tweets or Facebook posts (Giglietto, Rossi, and Bennato, 2012). Furthermore, the popularity of a YouTube video is measured through number of views, in combination with its approval rating (a function that any viewer can log to the video by clicking a thumbs-up or thumbs-down symbol) (Giglietto, Rossi, and Bennato, 2012). This method therefore acknowledges that the number of views for videos may have changed over time, and that videos published at an earlier date may be considered more popular for this reason (Giglietto, Rossi, and Bennato, 2012).

The top 100 videos most watched were then scraped and stored into a spreadsheet accessible by the researcher. The Website crawler "Screaming Frog" was used to crawl the video URLs to fetch metadata. Such data includes video URL, video title, meta descriptions, video duration, number of views, video keywords, video tags, in-links, out-links and external outlinks. The list of comments on each YouTube video was also collected, as well as a written transcription of the video audio using the subtitles function provided by YouTube. Data in multiple formats is one of the unique characteristics of YouTube, and so a decision was made to preserve this by conducting analysis using all forms, rather than just video content alone. Furthermore, the relationship between each of the different types of data may too be insightful, given that social interactions occur within the comments, and directed towards the content creators also (Giglietto, Rossi, and Bennato, 2012). Due to the range of data types and the time parameters of the thesis, the top 10 videos of the scraped 100 were used in data analysis for each case study. This limit was chosen as commonly the most popular videos on the site tend to focus on a handful of key aspects which then gain momentum with viewers (Figueiredo, Benevenuto, and Almeida, 2011). This means that if too many videos are assessed it is likely that a small amount of themes will have more weight in the analysis stages. This is further evidenced by literature using multimedia data in case studies, who argue that too much complex non-authoritative data may skew the outcomes of integrated disaster assessments (Schnebele, Cervone, and N. Waters, 2014). Data was collected at the time time of final Twitter subsample, in the post-disaster phase.

5.3.1.3 Facebook Data

The tool "Netvizz" was used to collect publicly available Facebook data. This is a free research tool which extracts publicly available data from the Facebook platform for groups and pages which are not closed. The tool works by searching for the same search strings as listed in the Twitter and YouTube methods above, producing a list of pages and groups which feature a minimum of two terms. Unlike the previous methods, data cannot be ordered by time parameters as often groups and pages themselves are created at different points in time which may not be linked to the specific disaster directly. Therefore, manual identification of suitable data was argued a necessary step to ensure high quality of data (Rieder and Bernhard, 2013). For example, the Facebook group "New Zealand Earthquake Watch" fits the parameters of the search string, however was created several years before the Kaikoura earthquake occurred. Consequently, on groups and pages that were scraped using the tool, manual searching was employed by the researcher to search for data within the previously defined time parameters. All applicable data was then gathered in a spreadsheet.

Personal judgement of the researcher was used to produce a short-list of the most relevant Facebook groups and pages for analysis. This took into consideration the volume of

relevant discussion, how many active members were involved, and whether there was evidence that the individuals active on the page/groups had personally experienced the disaster. A summary of each short-list will be presented during each case study chapter detailing number of groups and pages analysed. It is important to note however that Netvizz does not allow for the collection of personal account data, which means that the actions of an individual on a page or group cannot be contextualised with relation to someone's usual activity on Facebook (Rieder and Bernhard, 2013). Given that individuals may act differently during periods of crisis - as was evidenced by the literature review - the context of qualitative data is important to produce a more detailed answer for RQ2 and RQ3. Therefore, it was concluded that the edition of semi-structured interviews with individuals who used the short-listed pages and groups would likely be valuable: firstly in explaining quantitative data scraped from the site, and secondly in providing individual experiences that were not accessible through personal Facebook accounts.

5.3.2 Qualitative Methods

5.3.2.1 Semi-Structured Interviews

Following Facebook data collection, a strategy for semi-structured interviews was devised informed by literature such as Kallio (2016). Potential participants were initially sourced through the short-lists of groups and pages outlined in the section above. In this, the researcher used personal judgement to identify accounts that were active on the sites during the time parameters of each case study. Activity was determined by high levels of engagement with posts i.e. through liking and sharing, and high level of content creation i.e. by posting and commenting (Mochon et al., 2017). Individuals of interest were then approached by a direct message from the researcher, via Facebook, explaining the research and requesting an interview (Kallio et al., 2016). Inclusion criteria was for an individual to be aged 18 years and over, be of sound mind, and have experienced one of the case study disasters either virtually (by engaging with the event on social media) or personally (by being physically there). Snowball sampling was then used, where interviewees recommended other participants with similar levels of engagement on the platform. It is important to note however that this kind of sampling was not representative of the country's population, and so interviewees are not proportional to either the virtual demographic of Facebook users, nor the real-world demographic of the populations affected (Diefenbach, 2009).

While conducting qualitative interviews with Facebook users, many recommended speaking with other individuals who did not use the platform, but who were relevant to the research. It became apparent throughout snowball sampling that a range of other individuals held valuable opinions regarding the case studies who did not use social media

at all, for example emergency responders and government employees. In following with methods of preserving the richness of data, it was therefore decided that pursuing interviews with non-users of social media was valuable (Baker and Edwards, 2012). Snowball sampling consequently expanded to include other appropriate individuals who originated from different backgrounds and vocations. Not only did this allow for a greater richness of qualitative data, it also provided a comparison between the users and non-users of social media during disasters (Bryman, 2017) – a evaluation that has been encouraged by disaster literature. The full details of interviewee backgrounds and assigned IDs for each case study can be found in the appendix. Each interview dataset is summarised within each case study chapter.

Interviews we designed to be semi-structured in order to allow the researcher to pursue topics of interest if they became apparent during interview (Kallio et al., 2016). Despite this there were a number of questions that were consistently asked to all participants, such as "Please can you comment on your use of social media during the case study". This allowed any individual, regardless of their level of social media engagement, to answer. The interviewer was then able to follow particular themes or experiences by asking questions tailored to the interviewees answers (Kallio et al., 2016). Each interview lasted between twenty minutes and one hour in length. All interviews were conducted either via Skype (a freely accessible service for communication which allows messages and video calls), or in-person. An audio recording was taken of each interview and later transcribed, the processing of which will be detailed in the following section of this chapter. A summary of the headline questions asked during each interview is listed below: these form the basis of the semi-structured questions which the researcher then elaborated on. The ethics application numbers for this research can be found in the appendix:

1. Please explain which social media sites you accessed during the disaster?

2. Please explain why you used these sites? (or did not) Where did you find most information throughout the disaster?

3. Were you aware of the disaster before it occurred (i.e. the pre-disaster phase). If so, please can you explain whether you accessed social media because of this?

4. Were you aware of the disaster as it unfolded (i.e. the during disaster phase). If so, please can you explain whether you accessed social media because of this?

5. Were you aware of the disaster after it occurred (i.e. the post-disaster phase). If so, please can you explain whether you accessed social media because of this?

6. Can you elaborate on the content of the sites that you used, and what you think their primary purpose was to yourself? Do you think this was the same for others in the event?

7. Were there any particular functions that you personally liked or disliked?

8. Do you access social media in an every-day setting? If not, please can you explain why?

9. Can you explain what happened during the disaster from your point of view, what were your personal experiences?

10. Given that the disaster which occurred may happen again, are you likely to access social media in future events? How do you think their use could be improved?

5.4 Methods of Data Processing and Analysis

5.4.1 Processing and Analysing Social Media Data

The processing of data originating from the platforms Facebook, YouTube and Twitter again required different methodological steps given the variations in both platform and data format. For Facebook, methods of data cleaning took place on the generated list of groups and pages found by Netvizz. This used the personal judgement of the researcher, informed by literature such as Baxter (2012), to identify the most appropriate groups and pages for analysis in order to create a short-list for each case study. Furthermore, the posts, comments and interactions collected from the short-listed groups and pages were removed if they had formatting errors such as being blank or being written in another language.

For YouTube data, methods of data cleaning were employed by discounting videos that had been removed since publication, or that were presented in a different language. This was same for the comments made on the short-list of videos. Should a video be removed from the short-list, the next most popular video from the wider 100 scraped videos was then able to move up to ensure there was enough data for insightful analysis. For Twitter, methods of data cleaning were employed on each of the subsamples created, which were informed by literature such as Van den Broeck (2005). In this, tweets were identified and removed from the subsamples if they were anomalous, based on the judgement of the researcher. Anomalous was defined as not being coherent, being unrelated to the case study, having no written content, or featuring a majority of content written in another language (Van den Broeck et al., 2005).

Data collected from the platforms Facebook, YouTube and Twitter was analysed in two main ways. Firstly, a quantitative method was used in which python scripts were written. These automatically analysed the data. and provided basic analytics of each platform, including the most active accounts, the most popular hashtags or keywords, and the most re-tweeted/upvoted/liked information in each of the datasets. Secondly, a qualitative method was used where manual content analysis was performed by the

researcher on each of the datasets, in combination with personal judgement (informed by the literature review). This indicated emergent themes within the data, such as crisis communications, as well as variations between the data formats and types. Finally, the conceptual framework was applied to the datasets which will be outlined at the end of this section.

5.4.2 Processing and Analysing Interview Data

For each interview conducted, an audio recording was taken and a written transcription created. Transcriptions were assigned an anonymous ID, in a format that differed for each case study to avoid confusion (McLellan, MacQueen, and Neidig, 2003). For the Kaikoura earthquake IDs were numerical, whereas for hurricane Irma they were alphabetical. This was done to preserve the anonymity of participants, while still allowing context through background information (McLellan, MacQueen, and Neidig, 2003), for example the interviewees age, vocation and general disaster experiences were noted in the interview summaries linked to the assigned IDs (but not enough to reveal the identity of the participant). A reductive method was used on interview transcripts to reduce raw data to key themes, informed by methods such as Folkestad (2008). These were then able to explain and support the findings of the wider social media data, combining a deductive approach with an explanatory one (Folkestad, 2008).

5.4.3 Applying the Conceptual Framework

The conceptual framework that was previously created and validated earlier on in this thesis was then applied to the social media data from Facebook, YouTube and Twitter. This was done systematically, whereby data content was read, assessed, and then assigned the relevant framework categories manually by the researcher. A spreadsheet of categories was kept for each of the datasets, which formed the basis for modelling social media content change over time. The suggested application sequence outlined in Chapter 2, creating the conceptual framework, was used in parallel. This used an analysis of existing social risk assessments and governmental protocols of each case study country to provide an extended dimension of understanding. Each of these will be outlined and discussed in the following results chapters.

5.5 Chapter Summary

The methodology has sought to devise a process for answering the thesis research questions, while taking into account a plethora of issues highlighted by both the literature review and the pilot studies. It has concluded that the platforms of Facebook, YouTube

and Twitter will together form a suitable lens for the analysis of disaster case studies. Furthermore, it has concluded that the cases of the Kaikoura earthquake (2016), and hurricane Irma (2017) are the most appropriate events for analysis given the research criteria. These cases feature contrasting hazard types, locations and demographics which may further evidence the applicability of the methodology to future case studies. A novel methodological approach has been justified which combines both quantitative and qualitative steps to circumnavigate issues such as Facebook's privacy laws, and draws upon a range of data in a unique mixed-methods approach. By doing this, an insightful and valuable assessment of disaster case studies can be conducted which answer the overall research questions, as well as providing detailed answers for the smaller RQs. The remainder of this thesis presents the results of both case studies, beginning with the Kaikoura earthquake in the following chapter.

Chapter 6

The Kaikoura Earthquake

In the previous chapter the methodological approach was explained. This sought to set up a means to answer RQs 1-4 and to build upon the findings of the earlier pilot studies. In this chapter, the first case study results will be presented: that of the Kaikoura earthquake, which happened in New Zealand 2016. It was chosen for scoring highly in the selection process (section 5.8) which included factors such as occurring in an English speaking country, being a high magnitude event, and taking place recently. Furthermore, given the high Web accessibility of the country, the disaster was heavily discussed across a range of social media platforms making it potentially valuable for analysis. Research presented in this chapter has been published in Gray et al. (2017a) and (2017b).

This chapter will begin by introducing case-specific terminology needed for understanding earthquakes. Then, as part of the results, a chronological overview of the event will be presented. Following this, the background of the disaster will be discussed, emphasising the motivations for studying the event in more detail. Underlying issues will be presented in the four main areas of geographical, demographic, political and economic factors, as well as outlining the current nature of disaster response in the area. Following this, themes from the data have been synthesised across the applications of social media during the disaster life-cycle phases (RQ1). This is presented sequentially, breaking down the data from both social media and interviews to illustrate how social media content changed during the event, as well as why interviewees believed this was the case (RQ2). The results explain the scope of Facebook, YouTube and Twitter for the purposes of resiliency, response, recovery and risk reduction (RQ3). Finally, the chapter concludes with a summary of the results, and an introduction to the next case study.

6.1 Case-Specific Terminology

Earthquake - According to the United States Geological Survey (USGS), earthquakes are rapid onset events which involve a change or shift in the earth's crust. They release a huge amount of energy which results in the violent shaking of the ground, thus potentially resulting in damages and mortality. The epicentre or hypocentre of an earthquake (the point at which the earthquake begins) releases seismic waves which radiate outwards. Earthquakes are commonly caused by shifts in plate tectonics, volcanic activity, or man-made hazards such as mining or fracking.

Plate Tectonics - Using NOAA's (2018) definitions, plate tectonics are the physical structure of the Earth. The top layer – the crust – is divided up into a series of tectonic plates which float on the molten under layers. These plates move and shift constantly, and collide with others. The boundary between tectonic plates can be divergent (where the plates pull apart from on another), convergent (where the plates impact against one another), and transformative (where two plates slide past one another in parallel).

Fault Lines - Using the USGS definition (2018), faults are fractures in the Earth's crust, commonly found along tectonic plate boundaries. They vary in size and depth, and are dependent on the movements of tectonic plates. Faults can either be normal (where two parts of the crust pull apart from one another, commonly found at divergent plate boundaries), reverse (where one part of the crust is thrust on top of another, commonly found at convergent plate boundaries), or strike-slip (where two parts of crust slide past one another horizontally).

The Richter Scale - Using the USGS definition (2018), the Richter scale is the scale used for measuring the magnitude of earthquakes. The method uses a seismograph where more destructive earthquakes produce larger oscillations. The scale ranges from 0 – 10 in magnitude and is exponential i.e. each number in the scale there is some thirty times more energy released than in the previous magnitude. Most earthquakes measuring below 2 go unnoticed by humans, whereas the most destructive quakes typically are 5.5 and above.

6.2 Motivations and Background

In recent years the fault lines of New Zealand have seen increased frequency in their seismic activities, with just under 33,000 earthquakes recorded in 2016 alone (Langridge et al., 2016). The largest of these was the Kaikoura earthquake which recorded a magnitude of 7.8 on the Richter scale on the 14th of November, 2016 (Duputel and Rivera, 2017), and has been labelled by seismologists as the "most complex earthquake on record" (Shi et al., 2017). It's epicentre was on the South Island of New Zealand at a depth

of roughly 9 miles, which caused ruptures that began 9 miles north-east of Culverden and 37 miles south-west of the town of Kaikoura. The ruptures occurred in an intricate sequence across multiple fault lines that triggered a series of intense aftershocks (Van Dissen and Little, 2017; Shi et al., 2017). Unusually, the initial fault occurred on a line that was not classified as major which meant that the disaster was largely unpredicted (Shi et al., 2017; Duputel and Rivera, 2017). This makes the case study valuable for analysis as the complexity and unpredictability of the disaster tested the preparedness resilience, response and recovery of communities in ways that had not been experienced in decades. This makes understanding the event and its management in more detail valuable for future events, especially given the certainty of more seismic hazards.

The rural nature of communities in New Zealand, too, makes the Kaikoura earthquake interesting for analysis. The country has a population of 4.6 million citizens, however a population density of just 15-17 people per square kilometre (**NZstats2018**). The country is considered sparsely populated by OECD standards, as well as having low population density given its area(**NZstats2018**). This, combined with the country's high level of population with access to the internet (86%) (**NZstats2018**), makes the use of social media and digital technologies a viable and relied upon method of communication and information dissemination (Hartnett, 2017). (Hartnett, 2017) go on to explain that rates of digital literacy are increasing rapidly due to this, with the younger generation recording multiple devices able to access the internet within the home, fewer digital divide factors affecting accessibility, and a new social emphasis being placed on the internet as a tool rather than a leisure activity.

There is little published material that take into consideration the demographical, political and economic underlying factors of the Kaikoura earthquake (as of 2017) (Gray, Mark J Weal, and Martin, 2017). Instead, a majority of literature focuses on the extreme physical complexity of the earthquake itself. Particularly in country that is so prone to seismic hazards, and one that utilises the internet so highly, there is a growing need for more disaster management strategies to take into consideration social media and digital technologies as tools for future events. Due to the higher levels of isolation that the New Zealand population faces, there is a need to understand what the changing role of social media and digital technologies is within rural communities and households (D. Johnston, J. Becker, and Paton, 2012). During crises, too, the role needs to be evaluated in the context of New Zealand's unique settings and characteristics: this is especially important given the launch of several national warning and preparedness systems released in the past five years (D. Johnston, J. Becker, and Paton, 2012).

The following sections aim to contextualise the case study in more detail. This will draw upon information gathered through interviews as well as from wider literature and reports on the area. A summary of the interviews are presented in table 6.1 below which have been assigned anonymous IDs. IDs will be referred to throughout the chapter corresponding to information from certain interviews, and using a numerical format. Then,

a chronology of the case study is presented which illustrates the types of hazards that occurred and when. The following sections with then scope the underlying geographical, demographical, political and economic issues that shaped the use and users of social media throughout the disaster, naturally leading onto the main body of the results.

Interviewee	Brief Overview	Assigned ID
Member of the public	Female in mid 40s who is a resident of the Kaikoura area and works in a local café.	1
-	Female in early 50s who is a resident of Kaikoura and works in a local museum.	2
-	Male in early 50s who is a resident of the Kaikoura area and works in retail.	3
-	Male in early 60s who was a resident at the time of the event, and is retired.	4
Tourist	Female in late 30s who was traveling in the Kaikoura area at the time of the event.	5
Tourist	Male in late 30s who was traveling in the Kaikoura area at the time of the event.	6
The Kaikoura District Council	Male in early 40s who works for the district council, which is the local government for the Kaikoura district of New Zealand.	7
The Kaikoura Marine Reserve	Male in mid 30s who works for the Kaikoura Marine Reserve, who manage and study the unique ecosystem of the area.	8
The Kaikoura Response and Recovery Organisation	Male in late 30s who works for Kaikoura response and recovery organisation, who provide asset management and transport link repairs in the region.	9

Table 6.1: An Overview of the Interviewees from the Kaikoura Earthquake, Detailing Basic Contextual Information and Their Assigned IDs.

6.2.1 A Chronology of the Disaster

The main hazard of this case study is that of a 7.8 magnitude earthquake which hit the Kaikoura region of New Zealand on the 14th November, 2016. Alongside this, there were a range of other hazards caused by the initial earthquake, which included multiple large aftershocks, land subsidence, and a tsunami. Given the variety of hazards and the time at which they were triggered, it is pertinent to understand the chronology of the disaster before any in depth analysis can be conducted. Similarly, a basic understanding of the disaster and other underlying factors are needed before more detailed comparisons of data can be discussed. Consequently, figure 6.1 below illustrates a chronology of the case study, before the remainder of this section discusses the geographical, demographical, political and economic factors present which shaped the outcomes of the disaster.

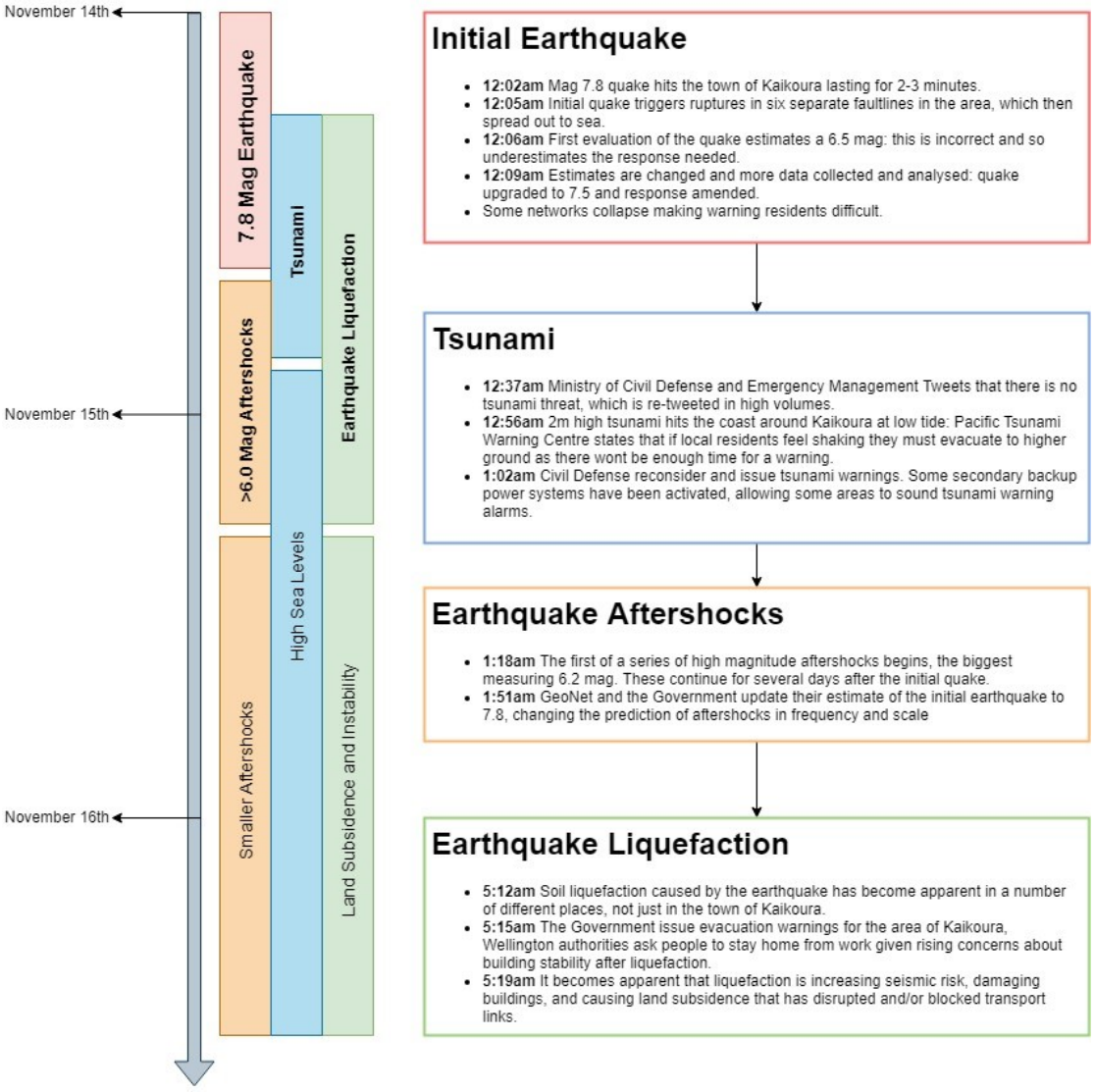


FIGURE 6.1: A Visualisation of the Overall Timeline of the Kaikoura Earthquake and Subsequent Hazards

6.2.2 Geographical Factors

New Zealand has a complicated and active tectonic setting, which means that the country is highly prone to earthquakes and other seismic hazards (Interviews 7, 9). The two islands themselves (North and South islands) are located along a major tectonic boundary between the Australian and Pacific plates in the Tasman Sea. The boundary is particularly active as it features several subduction zones, where in the North island the Pacific plate is being subducted below the Australian, whereas in the South island the Australian is being subducted underneath the Pacific (Interview 7). Shallow earthquakes happen in the South island where the benioff zone (a seismically active zone) dips steeply to the south-east. The subduction zones are connected by the Marlborough Fault System: a series of sub-parallel strike-slip faults that run northeast-southwest, and form the Alpine fault in the South island (figures below). This setting means that many communities are divided by, or built on top of, areas of land that are tectonically active. The region of Kaikoura region additionally boarders the Pacific ocean and features many unique marine ecosystems found nowhere else in the world (Interview 8).

Given the geographical situation, the earthquake resulted in several unique aspects. Firstly, communities within the region experienced further isolation given the initial collapse in networks after the earthquake (Interview 5, 6). Secondly, the force and complexity of the disaster caused huge land subsidence and landfalls, which blocked the roads and railway links in and out of the town (Interview 7). Not only did this prevent the use of such transport links for processes such as evacuations, the scale and severity of damage rendered the town isolated for a long period of time especially since the main settlement is located on a peninsula (illustrated in figures 6.2 and 6.3 below)(Interview 7). Damages required significant equipment and man-power to be able to repair the transport links, which to the present day are still ongoing (as of November 2018)(Interview 9). Finally, the earthquake caused a tsunami which travelled to surrounding stretches of the South Island, and then made its way North colliding with the major city of Wellington. This was a scenario that concerned emergency responders and disaster management authorities given that little tsunami modelling existed at the time of the disaster, and that this type of event may re-occur in the near future (Interview 9).

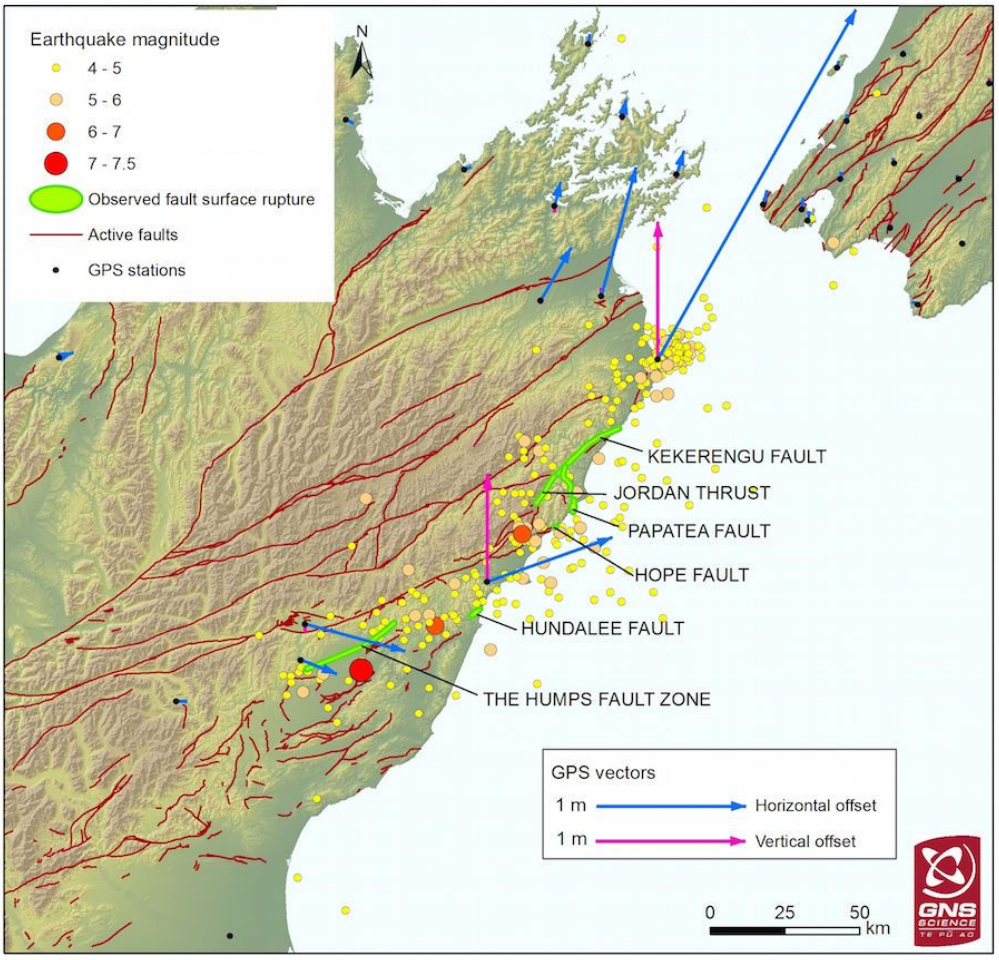


FIGURE 6.2: A Map of the Kaikoura Region on the South Island of New Zealand, with Highlighted Faultlines and Hazards. Source: GNS (2018)

FIGURE 6.3: A Map of the Main Kaikoura Settlement on a Peninsula of the South Island of New Zealand, Located Between Tectonic Hazards and the Pacific Ocean. Source: NASA Satellite Imaging (2018).

6.2.3 Demographical Factors

The population of the Kaikoura district is some 3,500 people, and represents less than 1% of the country's population (NZstats.gov, 2019). This, combined with its unique geographical setting, means that communities living in this district may be considered rural and isolated, especially given that the nearest city of Christchurch is roughly a three hour drive away (Interview 7). However, due to the same unique factors the area has become popular for tourists and visitors both nationally and internationally. This is due to the wide range of recreational activities available (such as hiking, cycling, walking, surfing and fishing), as well as its picturesque location along a main coastal highway (Interviews 5, 6). Consequently, interviewees explained that during the earthquake it was not only the main township's inhabitants that were affected, it was in actuality a range of individuals: many of whom originated from other parts of the country or other countries, which complicated the evacuation and rehabilitation of the area (Interviews 5, 6, 7).

As well as featuring a high tourist demographic, the region is also subject to an unusually high number of researchers, scientists and practitioners. This is once again caused by the unique geographical setting and extraordinary ecosystems of the area which has become an international hub for marine research (Interview 8). An interviewee who is a marine biologists further explained that *"Kaikoura is a fantastic place for studying ecosystems and some of the rarest species in the world. Some of which aren't found anywhere else. Because of that there's a really high turnover of people that want to come out here and study it, or to be part of the big national conservation projects. Some people are funded by universities and places, some by governments, some as part of their job. Most people tend to stay short term, but there are those who stay longer or keep coming back"*. This illustrates that not only is the demographical composition of the area unusual for a small township, it also emphasises the importance of the area in disaster recovery and rebuilding.

6.2.4 Political Factors

In recent years there have been political factors which have shaped the outcomes of the Kaikoura earthquake. Interviewee 4, a retired individual who lived in the area for most of his life before moving to Christchurch, explained that he had seen many shifts in governance since the 1980s which seemed to be taking natural disasters into increasing account. He goes on to state that *"the government called it interactive governance at the time. They were hoping to create more dialogue between themselves and stakeholders and the public when it came to dealing with hazards"*. Certainly, literature sources support this, and additionally argue that "interactive governance" and "governance beyond the state" (where power is distributed outside of the country itself) make New Zealand's

political setting unique in the world. Interviewee 4 recounts that more recently a resource management act was passed that included provisions for public participation in the development of plans, both to enable democratic local decision-making to empower communities, as well as to promote the social, economic, environmental and cultural well-being of said communities (supported by literature such as Cheyne, 2015). The combination of these aspects have created the "New Zealand Model of Public Participation", which is considered at the pinnacle of government/public collaboration by many other countries (Cheyne, 2015).

This model has shaped the outcomes of disaster in New Zealand before: in particular the Canterbury earthquakes in 2011 which affected the city of Christchurch. The main quake measured 6.2 on the Richter scale, causing 185 deaths and an estimated $11 billion dollars in total damages - the most destructive disaster New Zealand has experienced (NZstats.gov, 2019). The aftermath of this event saw a steep rise in government/public collaborative efforts to benefit local communities given the political structure in place (Interview 4, 7). As a result, earthquake awareness and preparedness experienced a new wave of dialogue between parties, national attention, international investment, and highlighted a number of political failings. Interviewee 5, who had experienced this disaster, commented that *"they have become a lessons-learnt case for the country. I think its really shaped the outcome of earthquakes since. Everyone agreed that we can't let something that big happen again"*. This emphasises the steps that were taken by the government and non-governmental organisations who specialised in regional emergency response, to analyse the failings of the Christchurch earthquake and to improve upon them. This has in turn produced a unique setting for the Kaikoura earthquake: where resilience, response, recovery and risk reduction are at the forefront of the nation's consciousness, and at the focus of the political landscape.

6.2.5 Economic Factors

The recency and severity of the Canterbury earthquakes affected underlying economic factors for Kaikoura. Due to the scale of damage that Christchurch and the surrounding area experienced, which exceeded $11 billion, many of the recovery and rebuilding stages are still in process. This meant that for Kaikoura, disaster management processes were drastically affected by a lack of disposable capital. Interviewee 1, who is a resident of the town and owns a café, explained that *"obviously the government and other organisations sent people to come and manage the event and to help us get out. But it was what was after that was difficult to deal with. I mean, we didn't have functioning roads for months which for a town this small meant most of our local businesses really struggle. I mean I really struggled too, we mainly rely on tourists"*. This demonstrated that long-scale tasks which required a high amount of man-power, skilled workers and resources suffered given that the country wasn't able to allocate more funds to their development.

After the Kaikoura earthquake there was significant socio-economic backlash regarding a number of issues (Interviewees 1, 2, 3, 4). Housing and insurance in particular have been a long running theme which first began with communities and properties affected by the Canterbury earthquakes. This resulted in an ongoing national campaign for justice, which aims to put pressure on the government (see example in figure 6.4 below). For Kaikoura specifically, there has been criticisms voiced by citizens about the economic handling of the disaster, and the subsequent generation of capital needed in order to recover and rebuild. Firstly, there remain issues that were not settled from the previous disaster, which has raised a political debate as to which event should be prioritised (Interview 2, 7). Secondly, many properties and infrastructure have experienced defective repairs managed by insurers who have not been held accountable, which has slowed recovery and rebuilding efforts (Interview 4). Thirdly, many properties that were damaged were sold on under the pretence of being rebuilt or with damages explicitly stated. It was found however that this was not the case, and now many citizens have been unable to make or progress insurance claims (Interview 4).

FIGURE 6.4: An Example Poster from the National Campaign for Economic and Political Justice. Source: www.eqcfix.nz

6.2.6 National Disaster Response Structures

The final component for contextualising the Kaikoura earthquake is that of the official disaster response and management structure employed by the government, featuring other organisations and parties as/when deemed necessary. National crisis management follows the protocol illustrated in figure 6.5 below. Further to this, the Civil Defence Emergency Management (CDEM) framework (figure 6.6 below) is employed. These are designed to work in conjunction with one another, and to take into account developments with technology and applications. The Ministry of Civil Defence and Emergency Management (MCDEM) have also consistently invested in new methods and technology used in the Disaster Management, Preparedness and Reduction of the working group of the IOC-UNESCO Intergovernmental Coordination of the Pacific Tsunami Warning System.

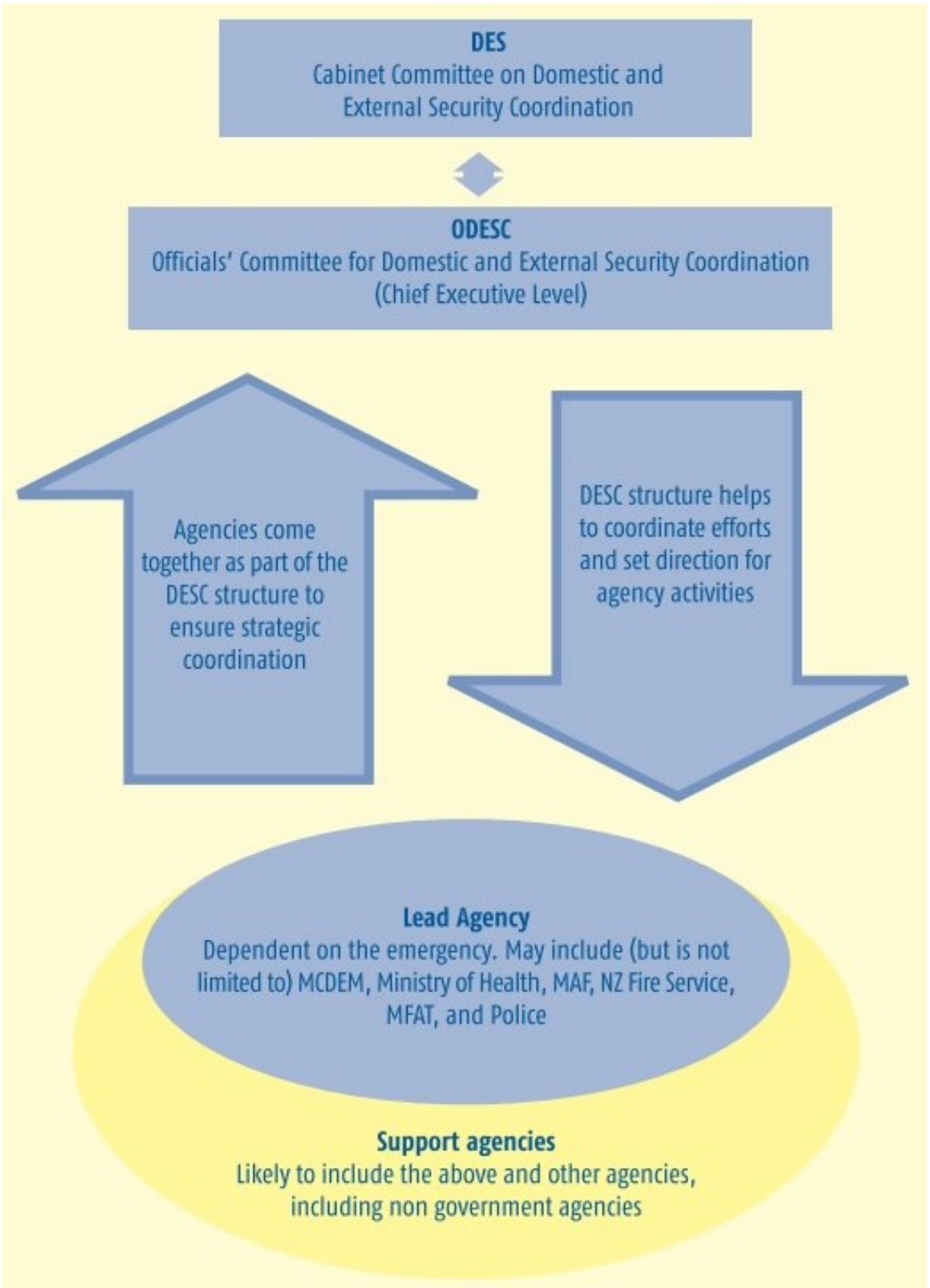


FIGURE 6.5: A Visualisation of New Zealand's National Crisis Management Structure. Source: Barker (2008).

Figure 6.6: A Visualisation of New Zealand's CDEM Framework used in Conjunction with Crisis Management Structure. Source: Barker (2008).

6.3 Results: The Role of Social Media during the Kaikoura Earthquake

The previous sections have provided information about the underlying factors which help to explain the case of the Kaikoura earthquake, and also provide a foundation to better answer RQs 1-4. Social media data was collected from the sites Facebook, YouTube and Twitter throughout the case study which are summarised in table 6.2 below. For each platform the process outlined in the methodology chapter was followed. For Twitter, roughly 34,000 tweets were collected. From this dataset 8 subsamples were created (unlike the 4 samples per pilot study). Samples that exceeded the Web Observatory daily hose were capped at 10,000 tweets. A breakdown of the Twitter subsample results can be found in table 6.3 below.

The top 100 most relevant videos published to YouTube throughout the disaster life-cycle were scraped. Instead of creating subsamples for these - which would be inappropriate given their different format - it was more logical to analyse the most popular 10 videos, determined by number of views. The comments thread of each video was additionally analysed, as this represented network interaction with the video content. A summary of the YouTube data can be found in table 6.4 below. Facebook data was also used, originating from open groups and pages created to discuss the event. For Facebook, a total of 82 pages and 11 groups were identified as being relevant to the disaster. These were short-listed to 7 pages and 2 groups for study. The criteria for selection was by being the most active groups and pages, determined by featuring the most qualitative content for analysis judged by the researcher. A summary of Facebook data can be found in table 6.5 below.

A series of qualitative interviews were conducted in order to avoid previously identified issues such as privacy and richness of qualitative data from the sites. 9 individuals were interviewed using a semi-structured technique, lasting between 20 minutes to one hour per interview. Individuals vary in background and vocation, a summary of which that includes the assigned anonymous IDs is listed in the appendix. A summary of the data sources used to inform this chapter is listed earlier on in this chapter in table 6.1, which additionally provides anonymous ID numbers and basic information of participants.

Data Origin	Total Data Volume	Shortlisted Data for Analysis
Twitter	34,000 Tweets	8 Subsamples (roughly 13,000 tweets)
YouTube	100 Videos and Comment Threads	10 Videos and Comment Threads
Facebook	82 Pages and 11 Groups	7 Pages and 2 Groups
Qualitative Interviews	N/A	9 Individuals

Table 6.2: A Table Summarising the Total Amount of Data Collected for the Kaikoura Earthquake, its Origin, and the Final Short-listed Data Analysed within this Chapter.

Kaikoura Twitter Subsamples	Subsample Collection Period	Total Data
Subsample 1	13th November 2016	10,000 Tweets
Subsample 2	20th November 2016	2,461 Tweets
Subsample 3	27th November 2016	70 Tweets
Subsample 4	4th December 2016	132 Tweets
Subsample 5	11th December 2016	82 Tweets
Subsample 6	18th December 2016	277 Tweets
Subsample 7	25th December 2016	42 Tweets
Subsample 8	1st January 2017	79 Tweets

Table 6.3: A Table Summarising the Twitter Subsamples for Kaikoura

Kaikoura YouTube Videos	Date Published	Number of Views
Landslide and Rockfall during Kaikoura Aftershock	16th December 2016	3.6 million
Papatea Fault and Raised Coast	21st November 2016	851,000
Live Video: 7.8 Earthquake House Shaking in Wellington	14th November 2016	629,247
New Zealand Earthquake Raised Seafloor 2 Meters	17th November 2016	207,158
New Zealand Earthquake Today: 7.8 Incredible Footage	13th November 2016	25,550
Man lands plane on SH1 to help family stranded by quake	14th November 2016	22,885
The Kaikoura Earthquake: What Happened and What does it Mean?	8th December 2016	22,331
Kaikoura Quake: The first 48 hours	16th November 2016	13,811
Quake moves house 10 to 15 metres	13th November 2016	10,843
Behind the scenes with HMNZS Canterbury at Kaikoura	16th November 2016	3,065

Table 6.4: A Table Summarising the YouTube Data for Kaikoura

Facebook Page/Group	Type
Kaikoura Earthquake Info Network	Open Group
New Zealand Earthquake Prediction	Open Group
New Zealand Earthquake Information & News	Open Page
Earthquake Early Warning System NZ	Open Page
Earthquake Forecast New Zealand	Open Page
GeoNet	Open Page
GNS Science	Open Page
New Zealand Earthquakes Today	Open Page
Earthquake Commission	Open Page

Table 6.5: A Table Summarising the Facebook Data for Kaikoura

6.4 Social Media for Resilience

6.4.1 National Warning Systems and the Canterbury Earthquakes

Given the recency and severity of the Canterbury earthquakes, preparedness had been improved on a national scale before the events at Kaikoura (Interview 7). This took the form of several national campaigns for earthquake awareness, and an increase in resources allocated to training programmes by the government, which are both components for national preparedness initiatives (gov.nz, 2018). In 2015, a new learning management system called Takatu was developed and implemented by CDEM with the support of stakeholders (Interview 2). This offers more than 100 active online courses which are free, support a wide range of learning materials for the population, as well as featuring aspects of social media such as hashtags (Interview 2, gov.nz). Further to this, a national tsunami preparedness drill and a series of educational information courses targeted at children, given that many schools suffered high damages previous earthquakes. The educational programmes, as explained by interviewees, represented a step forward in preparedness training that the country had not undertaken before (Interview 2). This was due to the fact that they were designed for a target audience, and so used child-friendly language, graphics and messages that were simple to understand and easy to share on social media (see examples in figure 6.7 and 6.8 below).

While many of the interviewees supported the progress made towards national preparedness, some noted that they themselves had not taken part in any recent drills or courses. Interviewees 5 and 6 explained that they had previously taken part in other drills, and thus felt that they remembered enough information to lower their risk in future events. Interviewee 5 stated that, as a tourist travelling around the area of Kaikoura at the time of the earthquake, *"we knew what we had to do in an emergency for our own city [Christchurch] having been through the Canterbury earthquakes, and done some of the training after that event... but Kaikoura was different. We were on the coast, and I guess we were in a different frame of mind because we were on vacation and cycling around the area. We weren't really cycling around thinking about where the nearest tsunami gathering point was, or how an earthquake would affect us. In that sense it really took us by surprise"*. This emphasises that despite an increasing utilisation of social media after a previous high magnitude event, there were clearly other underlying sociological issues that shaped the use of social media for individuals.

FIGURE 6.7: An Example of a National Educational Disaster Resilience Website Designed for Children Following the Canterbury Earthquakes. Source: whatstheplanstan.govt.nz

FIGURE 6.8: An Example of Tsunami and Earthquake Resilience Resources Hosted by the New Zealand Government Website. Source: civildefence.govt.nz

6.4.2 Community Earthquake Preparedness on Facebook

Despite an increase in national warning systems, drills, and educational campaigns, many interviewees stated that their primary source of information about hazards was in fact through traditional media such as news channels, and social media such as Facebook (Interviews 1, 3, 4, 5, 6). This was supported through the analysis of the groups and pages on Facebook, where the framework demonstrates that specific regional and local warnings scored highly in the early stages of the disaster (shown in figure 6.9 below). Interviewee 6, who was evacuated during the Kaikoura earthquake, explained that his use of the platform first began in the early stages of the disaster. He stated that *"We were told about [a Facebook group] by some other people who were being evacuated. I think they must have been following the regional news or updates on them for some years, either way they said a lot of information was shared on there. So, we looked it up, and you know they were right, there was a lot of information and debate, and surprisingly a sense of community even though I thought that surely not all of these people can't know each other in real-life. I guess that's the nature of social media though, right?"*.

The application of the conceptual framework to the social media datasets further verifies the differences in platform activity at the beginning of the disaster. By selecting framework categories that are generally associated with resilience and found in the pre-disaster phase we can track their volume across Twitter, YouTube and Facebook and compare the results from each (figure 6.9 below). This uses the examples of category number 3 "Provide and seek general disaster preparedness information", category 4 "Provide and receive national disaster preparedness information", and category 5 "Detect and warn of disasters and specific hazards locally" (a full copy of the framework can be found in chapter 3 or in the appendix). These represent the main actions undertaken for resilience and preparedness purposes in the pre-disaster phase moving into the during phase. Figure 6.9 illustrates that while both Twitter and Facebook feature the categories associated with building community resilience, it is Facebook that has an overall higher percentage spanning across all three categories. This was supported by interviewee 5, who noted *"We posted a message on the Facebook group asking if anyone had space in their vehicle to take us from Christchurch to Kaikoura. We had a positive response within hours. There was great sense of community online"*.

Interviewee 6 further explained that his use of Facebook developed as he learned to trust the groups and pages he became involved with. This was due to the fact that certain accounts were more active, and so *"I could see that this post was shared by the same person that mentioned information about something the other day, and they were right about it. So that made me learn to trust those people more, the more they posted and the more I followed the links"*. This was further evidenced by the range of both qualitative and quantitative information hosted on the shortlist of groups and pages which encompassed a range of different formats, including external news media

links, interactive maps, online resources, real-time monitoring systems for example GNS (particularly for earthquakes), and written information. An example of such information formats is illustrated in figure 6.10 below.

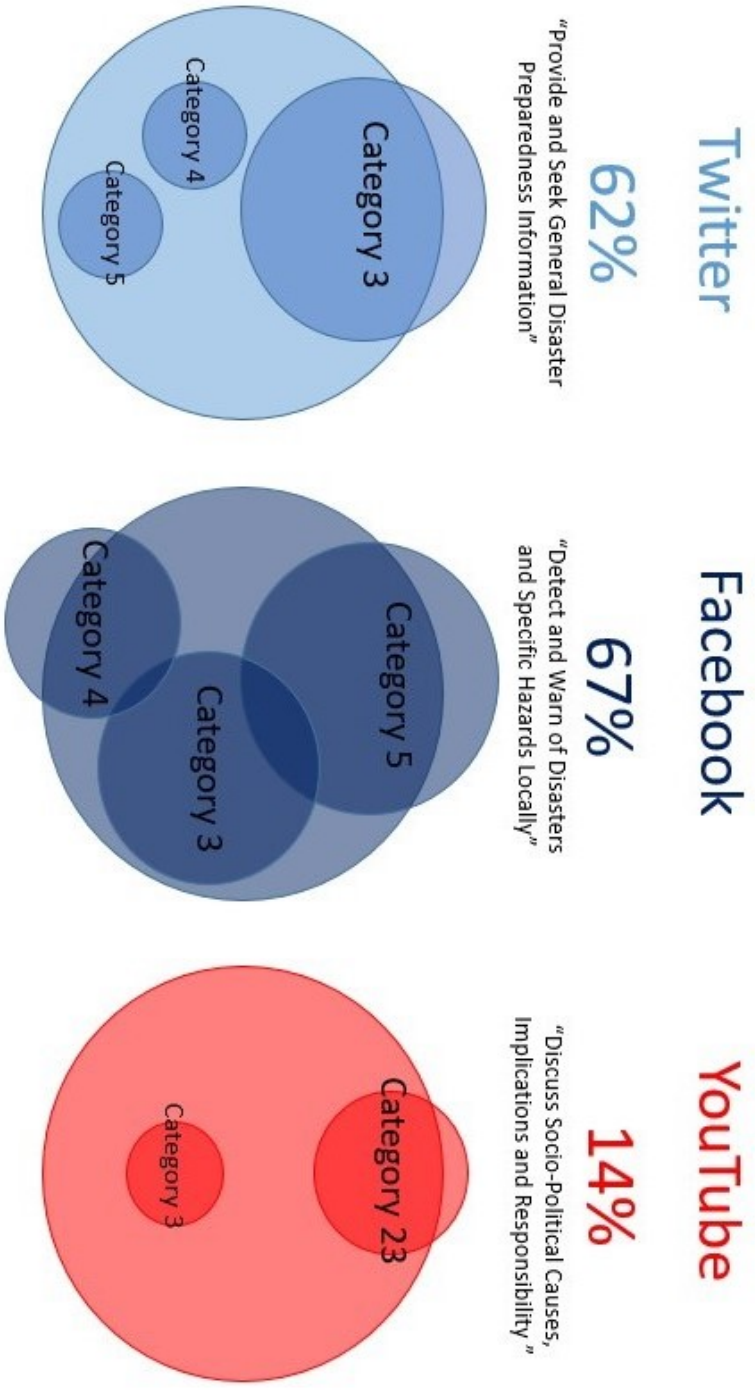


FIGURE 6.9: A Visualisation of Data Content for Categories 3, 4, and 5 of the Conceptual Framework for the Platforms Twitter, Facebook and YouTube.

A Key for Figure 6.9

No.	Framework Category
3	Provide and Seek General Disaster Preparedness Information
4	Provide and Receive General national and Regional Disaster Warnings
5	Detect and Warn of Disasters and Specific Hazards Locally
23	Discuss Socio-Political Causes, Implications and Responsibility

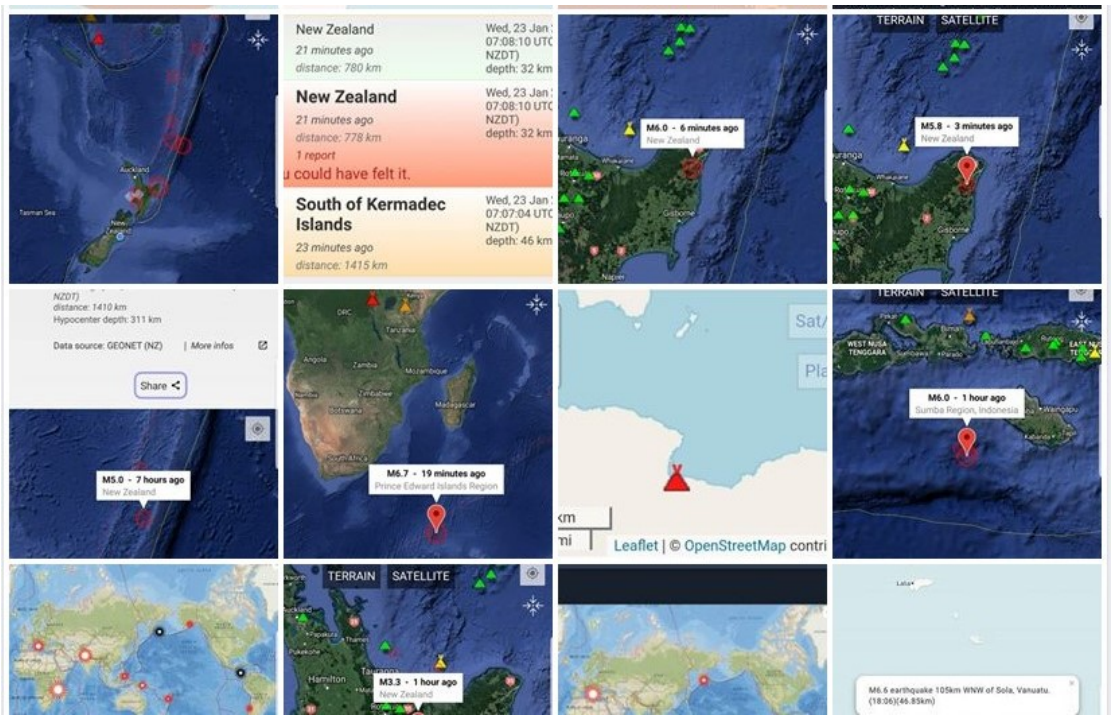


FIGURE 6.10: An Example of Hazard Information Shared in Facebook Groups, Demonstrating Variety of Data Type and Region-Specific Warnings. Source: New Zealand Earthquake Prediction

6.5 Social Media for Response

6.5.1 Detecting and Tracking Earthquake and Tsunami Trends on Twitter

The combination of varying data types are platform affordances within Facebook that are not available on both Twitter and YouTube, whose technological structure are extremely different. While Twitter results clearly show high engagement with accounts for information dissemination throughout the disaster life-cycle (for example @NZcivildefense and @GeoNet), a majority of its content was published as the events of the Kaikoura earthquake unfolded in real-time. This is demonstrated by the volume of tweets present in each of the subsamples, demonstrated in figure 6.11 below. This clearly shows that a majority of data was published in subsample 1, as the initial earthquake struck and immediate hazards unfolded. Unlike Facebook, a majority of this data was comprised of re-tweets rather than qualitative discussion.

Twitter data demonstrated that, as the literature strongly suggested, the platform can be used to track information and trends that occur throughout the disaster life-cycle phases. Notably, this was evidenced through the tracking of the term #earthquake: initially for the main quake, and then later for the subsequent aftershocks. This term was particularly traceable compared to other trends given that New Zealand has a number of accounts, both authoritative and scientific, that are dedicated to releasing earthquake information in real-time. These are reminiscent of the automated @FloodAlert tweets discussed towards the beginning of this thesis in the pilot study chapter. This can be demonstrated in figure 6.11 below that track the combination of three different hashtags, identified through different colours. These show that when a sharp rise in the popularity of all three terms coincides (indicated by the grey circles overlain on the trend lines), it is likely that an event has occurred in real-time. For example, the peaks of each terms at the beginning of the figure correspond to the initial earthquake and its triggering of a tsunami shortly afterwards.

However, event detection and tracking of trends led to issues of information reliability during Kaikoura. @GeoNet, the country's most popular Twitter hub on earthquake information, initially tweeted that the earthquake measured 6.5 on the Richter scale. Similarly, the Pacific Tsunami Warning Centre (@NWS_PTWC) who issue warnings for at-risk areas initially tweeted that there was no tsunami threat from the Kaikoura earthquake. Interviewee 1 stated *"we're used to quakes. We get small ones every day. If someone said there's been a magnitude 5 quake I would probably be sensible, but I wouldn't worry. If someone said there's going to be a 7 or 8, yeah I'd definitely be preparing a lot more. It doesn't sound like much but the difference is huge. And if Christchurch taught us anything its that damages and destruction and death rates can be huge even after quakes that aren't considered that big"*. Although both errors in judgement were

corrected within an hour of dissemination, this illustrates the importance of accurate and timely information, especially given the exponential scale that quakes are measured by and the velocity at which tweets may be published during disaster.

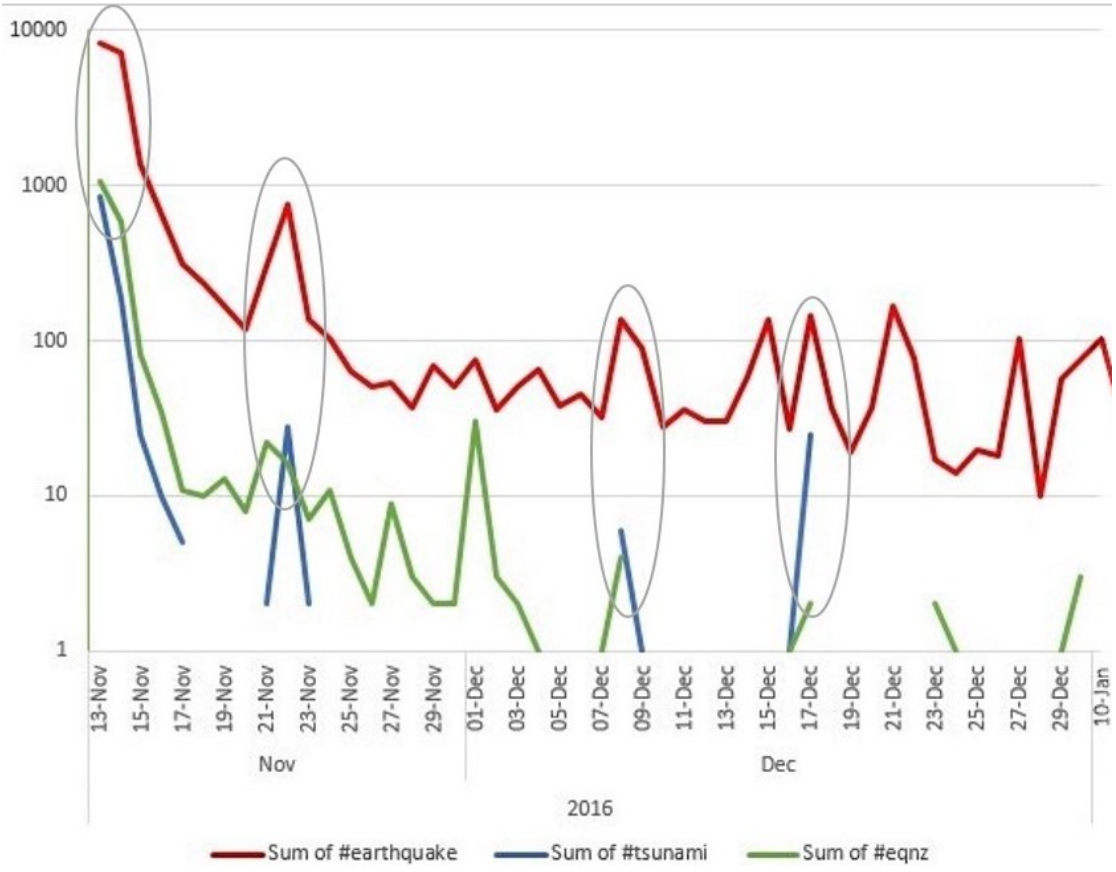


FIGURE 6.11: A Line Graph Visualising the Trend of Hashtags on Twitter throughout the Kaikoura Earthquake.

6.6 Social Media for Recovery

6.6.1 Documenting Impact through YouTube: Seeing is Believing

A majority of the top 10 YouTube videos about Kaikoura document the events as they unfolded, and were published within the first few days of the initial earthquake. These gained momentum (in terms of number of views, out-links and number of comments) in the during and post-disaster stages. It is likely that this is due to patterns of information spread which began locally, and then globally, as more individuals became aware of what was happening with the case. Interviewee 2 explained that *"I saw some of the impact that the earthquake had obviously because I was in the town at the time. But it wasn't until my grandson showed me a YouTube video of - I think it was of a house a few hours away - but it wasn't until he showed me that that I really realised how widespread the earthquake had been"*. This illustrates the importance that visualisations can have on social media given that content may easily be shared, that content is in most cases not geographically bounded, and accessibility is generally free. Similarly, the most popular videos in terms of views for the shortlist of YouTube videos all feature recordings of the earthquake impacts which may be considered shocking to citizens. The least viewed videos in the list consequently feature content that is not as extreme, for example documenting the movements of the ship used for evacuations. A contrast of these videos is shown in figure 6.12 below, taken from the most viewed (YouTube Video 1) and in figure 6.13 taken from the least viewed (YouTube Video 10).

Interviewee 8 further explains that he believes the documentation of the earthquake helped to raise awareness for the local ecosystems and species recovery. This was a primary concern for the high demographic of scientists and researchers based in the area, as during the initial quake the sea-floor shifted violently, and up to two meters in some places. This disrupted parts of the marine reserve and raised questions about the welfare of unique species in the area. Interviewee 8 goes on to argue that *"I think the videos have been really affective. Most people don't care about this one certain fish - or something to that affect - until you actually show them that fish. Seeing it, and seeing its environment, or rather how that environment has changed, I feel generated a lot more understanding of the situation that we had for the marine reserve after the earthquake. Even with the local residents"*. This emphasises that the format of videos may offer a paradigm of information unlike Twitter and Facebook, especially considering that an individual using the site knows the platform format. This is further evidenced by the dominance of categories 11 and 12 on YouTube which represent sharing, documenting and creating news coverage of the disaster shown in figure 6.14 below.

FIGURE 6.12: A Screenshot of the Most Viewed YouTube Video from the Shortlist about Kaikoura, Showing High Impact Rockslides. Source: YouTube Video 1

FIGURE 6.13: A Screenshot of the Least Viewed YouTube Video from the Shortlist about Kaikoura, Showing Non-Impactful Events. Source: YouTube Video 10

A Key for Figure 6.14

No.	Framework Category
10	Provide, Receive and Encourage Information Sharing in Multiple Formats
11	Document What is Happening during a Disaster Online and Offline
12	Create and Consume News Coverage of the Disaster
13	Provide and Receive Location Based Real-Time Warnings
14	Express Public and/or Individual Empowerment; Reassure Others
15	Raise and Develop Awareness; Donate and Receive Donations; List Ways to Help or Volunteer
19	Filter, Categorise and Critically Analyse Information

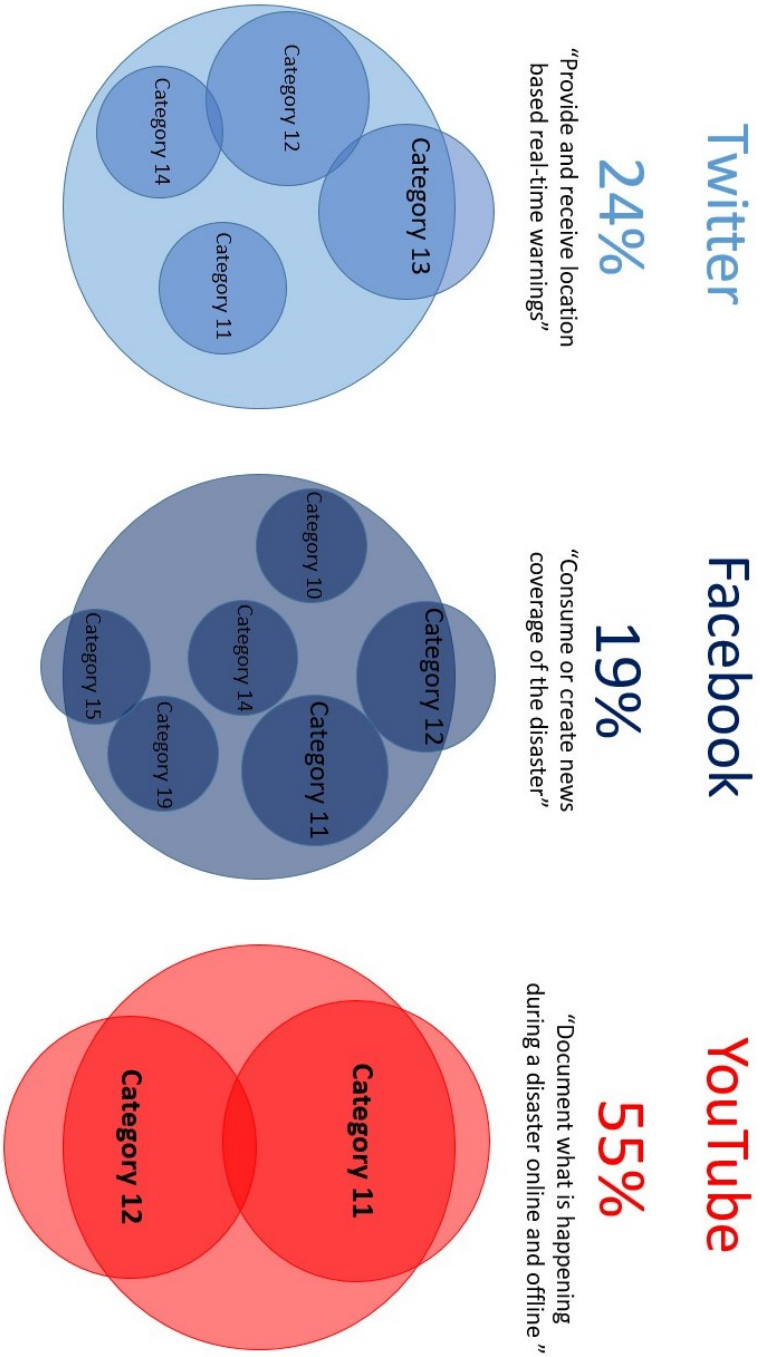


FIGURE 6.14: A Visualisation of Data Content for the Most Popular Categories of the Conceptual Framework for the Platforms Twitter, Facebook and YouTube in the During Disaster Phase of Kaikoura

6.6.2 Using Social Media as a Facilitator: Recovering Trust between Authorities and Citizens

Underlying political factors have in part contributed to a break down in trust between citizens and authorities, which preceded the events at Kaikoura (Interview 4). This, the interviewees explained, has been cause by a lack of governmental transparency that is particularly focused towards the processes of recovery (Interviews 3, 4, 6). Despite the governmental model for increased two-way communication between itself and citizens, there were high levels of post-disaster categories present in the social media data which seek to debate and understand responsibilities associated with recovery (shown in figure 6.16 below). This was highlighted earlier in the chapter in the case of home insurance and rebuilding. Interviewee 4 stated that *"many home owners are still waiting for the Canterbury earthquake claims to be sorted. Many more than that simply don't care any more or are too exhausted from trying to get progress. And at the same time the same problems are manifesting further north following Kaikoura. Transparency is one thing absent from eight years of home owners fighting for their rightful entitlements"*. The presence of category 23 across each of the platforms shown in figure 6.16 evidences this further, representing high levels of discussing socio-political causes and responsibility.

Certainly, this qualitative discourse can be evidenced on Facebook groups and pages (shown in figure 6.15 below), as well as in the media campaigns that were presented earlier on in this chapter by the earthquake commission (EQC). It can similarly be evidenced by the rise in groups and pages set-up on the site created in direct response to legal processes, for example "Earthquake Services Ltd.", as well as an increase in traditional news media which began to track total insurance claims made since the event. Further still, this discourse became evident on wider media such as blogs and in academic literature too, highlighting that this is an area of disaster management which the government have struggled to resolve time and again. In light of this, interviewees have reported that authorities have begun to acknowledge their failings from the Canterbury earthquakes, and have instead shown initiative towards rebuilding and recovering trust in response to Kaikoura. This was also evidenced by their re-posting and re-sharing of relevant earthquake information, highlighting how the lessons learnt from both Christchurch and Kaikoura are influencing improved approaches to the use of social media during future disasters. This may explain the high levels recorded for category 21 across each of the platforms in figure 6.16 (especially for YouTube), signifying the exchange of disaster recovery and rebuilding information as well as telling and hearing personal stories from both disasters.

The rebuilding of trust may be a long process however, and interviewee 4 commented that *"they seem to be making progress with Kaikoura claims now, it might just be because they don't want citizens to escalate any further on social media. Either way, there are still issues with the Canterbury claims. [Local government] recently set up a series of meetings*

to hear the public opinions in real-life, but those got postponed or cancelled and I think that caused a backlash on social media". In contrast, interviewee 7 postulated that *"I understand why people are concerned and we are obviously doing everything to make sure Kaikoura is better managed than Christchurch, and can rebuild faster and better. Since the Canterbury quakes we're trying to learn and take on board more feedback. Things like using social media to stay in contact with residents. We think forums and spaces to discuss issues might be a good idea considering that there is a record of the discussion and its available to all. It would essentially allow for virtual meetings, which could end up being valuable to both parties"*. This may further be evidenced by the presence of category 21 across each of the platforms in figure 6.16, especially in conjunction with the category 23 which seeks to discuss socio-political causes and responsibility.

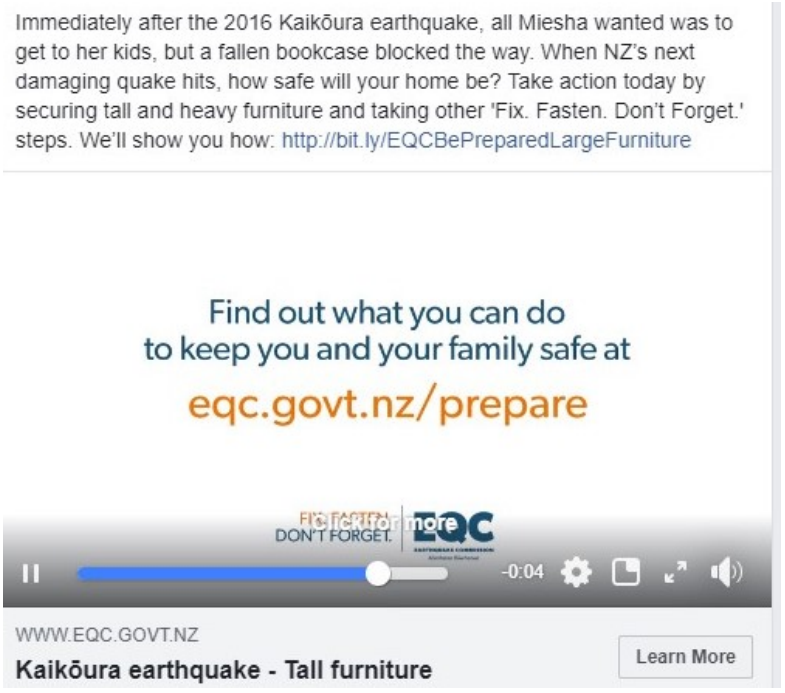


FIGURE 6.15: An Example of the Sharing and Posting of New Media for Recovery Purposes on Facebook Groups and Pages, Highlighting Lessons from Kaikoura

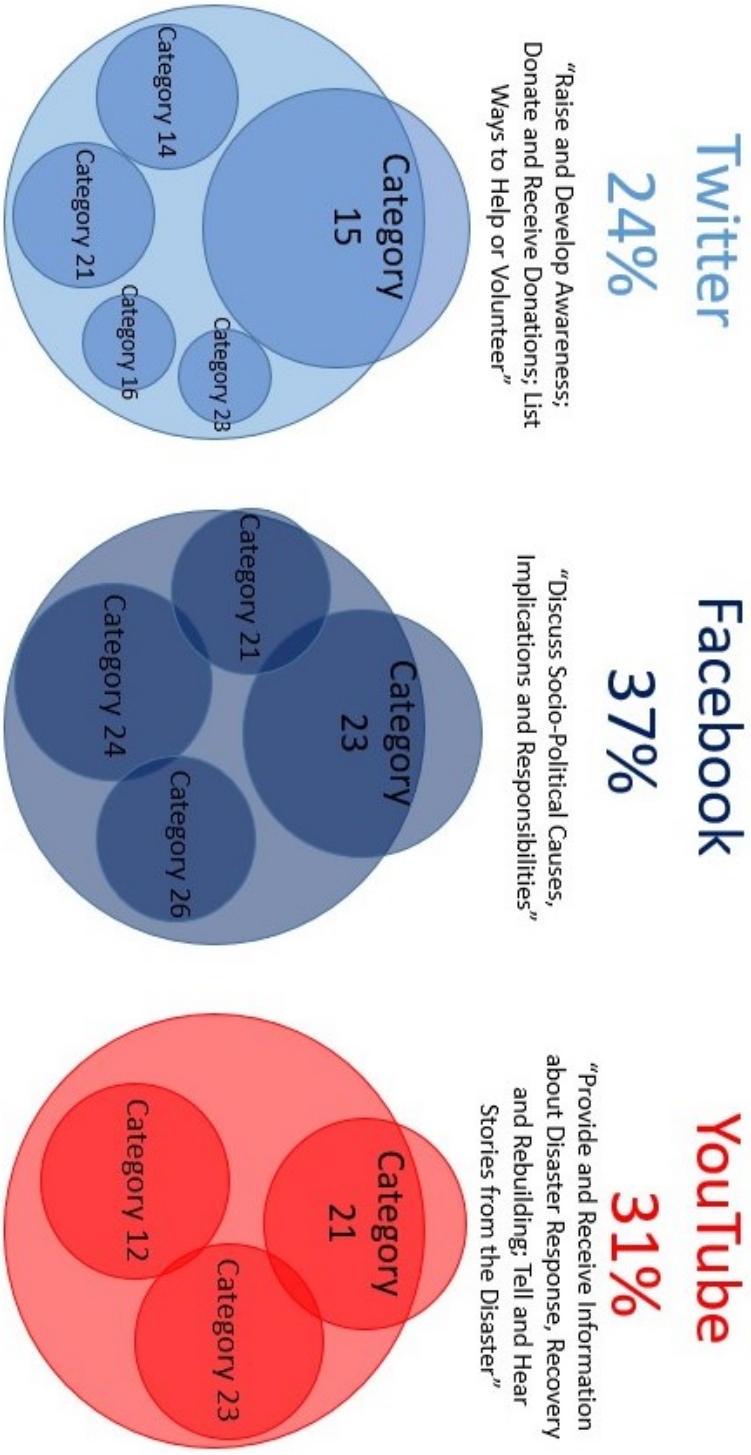


FIGURE 6.16: A Visualisation of Data Content for the Most Popular Categories of the Conceptual Framework for the Platforms Twitter, Facebook and YouTube in the Post-Disaster Phase of Kaikoura

6.7 Social Media for Risk Reduction

6.7.1 Crisis Communications Throughout

At the beginning of the disaster there was confusion relating to the exact scale and nature of the event, which was explained earlier on in the chapter. Following this, A2C communication using social media sought to check and update information quickly and accurately. Although this proved valuable in providing situational awareness for citizens, it still caused confusion as some individuals had not sought further information or had been able to access the corrected information (Interviews 1, 2), which are considerations that should be taken into account for future events. C2A communications during this period however mainly originated from the rest of the country, as well as globally. This is arguably due to the spread of information online, as previously theorised by the literature review and demonstrated in the presence of category 15 in figures 6.16: this category was also noted to rise in the pilot studies as information began to spread further.

C2C communications were apparent primarily on Facebook, but also in the form of confirming/spreading information in comments on YouTube videos and within tweets also. Interviewee 6 stated that *"during the evacuation process everyone was talking to one another about what they'd seen and what they'd experienced, sharing information about everything. My partner and I ended up going to the hospital because for some reason is was the only place that had WiFi. They were amazing about it and let as many people use it as possible, using it to let family know they were OK and so on. We were using it to let people know we were fine"*. This can be strongly evidenced by Facebook posts and comments throughout the disaster life-cycle phases given that the platform allows richer discourse than the others (i.e people are able to form conversations and debates within the online community). C2C communications took many forms as shown in the category content change over time throughout this chapter, which varied depending on real-life events. Examples of C2C communications are shown in figures 6.17, 6.18 and 6.19 below.

FIGURE 6.17: A Facebook Post Illustrating Global Community during the Kaikoura Earthquake

FIGURE 6.18: A Facebook Post Illustrating C2C Communications Requesting Help

FIGURE 6.19: A Facebook Post Illustrating C2C Communications Offering Help

In the during disaster phase, networks temporarily collapsed in the area (Interview 1, 5). During this time, interviewee 1 explains that *"volunteers and emergency responders started using megaphones and signs to let us know what was going on. They also started posting written things and updates on the notice board in the town centre until the networks came back, so people could go somewhere central and see for themselves what was going on. Before the evacuations they came around most peoples homes to check on them and let them know about the likely evacuations as well"*. This highlights that the use of offline community networks and methods of preserving those, used in conjunction with online methods in times of network functionality, were valuable in the disaster. This was supported in the social media data also, where authorities posted across a range of different platforms relevant updates on specific areas, and targeting certain demographics, i.e. residents of the town who were at the most risk. These too were evidenced online, demonstrated in figures 6.20 and 6.21 below.

In the post-disaster phase, there was increased evidence of both A2C and C2C communications once the networks had been repaired. During this phase, A2C was heavily focused on preventing further hazards and lowering the risk of individuals returning to the area after evacuation. Interviewee 9 stated that *"the company that I worked for started sharing the warnings and information that were originally put out by the government on Twitter and Facebook, and on the government website. We basically were there for rebuilding and recovery but we got a lot of local people asking us details about that. Where we could we pointed them to what the government had already said or published online. We tried to keep our online interactions as clear as possible and not to go against what the government was saying"*. While this illustrates the use of social media to support verified information, it also simultaneously highlights the lack of A2A communications evident on the platforms. Partly, this is due to the fact that many authorities, including the government, tend to use secure channels for direct communications. Partly, it is also due to the fact that there was only one interviewee who was in a position to comment on authority actioning, which means that the social media data (or lack thereof) cannot be qualitatively explained in detail. This highlights an aspect of using social media as a tool for disaster management which would benefit from further investigation and further explanatory data.

FIGURE 6.20: An Example of A2C Communication Shared Across Different Groups and Pages for the Disaster

FIGURE 6.21: An Example of A2C Communication Posted on Behalf of Authorities Addressing Insurance Concerns

6.8 Summary

This chapter has presented the results of the Kaikoura earthquake which occurred in New Zealand in 2016. It has detailed that the event was shaped by the outcomes of geographical, demographical, political and economic factors which in turn affected the uses and users of social media as a tool for disaster management. It has gone on to demonstrate that the social media platforms of Facebook, YouTube and Twitter were used extensively, both national and internationally (RQ1), and throughout each of the disaster life-cycle phases of the event RQ2). The use of qualitative interviews has further explained the results found in social media data, thus providing an understanding of the benefits, limitations and relationship between social media use and the case study (RQ3). As a result, original academic contribution has been made to the field of disaster management through the study, which has been documented in the papers Gray et al. (2017a, 2017b). The following chapter will focus on the second case study - that of hurricane Irma - following the same methodology and research objectives. The combination of the case study results may then be used to form proposed recommendations for the improved use of social media during disasters (RQ4) in chapter 8.

Chapter 7

Hurricane Irma

The previous chapter demonstrated how social media can be used throughout the disaster life-cycle phases of an event, by whom, and for a number of different purposes (RQ1). It has scoped how usage may change throughout the course of a disaster, forming an understanding of the role particular sites play (RQ2). Within these roles, it has become evident through the analysis that there are benefits and limitations to the use of social media during disasters (RQ3). This chapter seeks to build upon the findings of the previous chapter by presenting and analysing data from an additional case study. By doing this, RQ3 may be answered in more detail, and the underlying factors, as well as the benefits and limitations of social media platforms can be assessed and compared in more detail. This allows the study to begin to explain the complex relationship between social media and disasters, as well as the multi-faceted nature of the factors which shape their outcomes. Furthermore, this kind of comparison allows for the improvement and development of targeted methods of disaster management that are tailored to these particular factors (RQ4), which will be scoped and presented in the following chapter. Research presented in this chapter has been published in the papers Gray et al. (2018), (2018a) and (2019).

This chapter presents the case of hurricane Irma, which hit a range of island nations across the Caribbean, South America and North America in 2017 as part of the annual Atlantic hurricane season. It was chosen for scoring highly in the selection process which included criteria such as occurring in an English speaking country, being a high magnitude event, and taking place recently. It also represents a different type of hazard to the Kaikoura earthquake, which may offer another paradigm of understanding for social media use (RQ1). This chapter will begin by scoping the area of study and acknowledging differences in the set-up of this case study. Then it introduces case-specific terminology regarding hurricanes. Following this, the background of the disaster will be discussed, emphasising the motivations for studying the event in more detail. Then, as part of the results, a chronological overview of the event will be presented. Contextual underlying factors will be explained in the four main areas of geographical,

demographic, political and economic factors, as well as outlining the current nature of disaster response in the area. The results of data analysis are then detailed. Following this, themes from the data have been synthesised across the applications of social media during the disaster life-cycle phases (RQ2). This is presented sequentially, breaking down the data to illustrate how social media was used for resiliency, response, recovery and risk reduction on each platform (RQ3). Finally, the chapter concludes with a summary of the results and an introduction to the final chapter, where proposed recommendations for the future use of social media during disasters are discussed (RQ4).

7.1 Chapter Clarifications

As a range of countries were affected by hurricane Irma there is a need to further define the case study parameters before analysis. Given the global nature of social media, the only methodological step that was affected by this is that of the semi-structured interviews. Due to the time constraints of this thesis and finite resources it was deemed infeasible for the researcher to collect interview data from all countries affected. Therefore, using personal judgement, it was decided that focusing the case study evaluation on one country that was affected by Irma would likely answer the research questions in a more detailed and concise manner. To select a country that was the most suitable for analysis, a final analysis matrix was conducted, following the same process as in the methodology. This sought to evaluate all of the countries affected by Irma against a number of suitability criteria, which considered the scale of mortality and damages, and the current state of recovery. A summary of the matrix is shown in table 7.1 below, showing that the country of Antigua and Barbuda was likely to be the most appropriate scope for study.

Interview data collection for this case study followed an amended method. Unlike the previous case study, interviews about hurricane Irma was collected as part of a research team for the project "The Recovery of Caribbean Communities from Hurricanes" (referred to as the RECCOH project), rather than by the researcher alone. The RECCOH project was funded by the HEIF stimulus fund and based within the University of Southampton, and formed as an interdisciplinary team that mirrored the objectives of this thesis (though specifically for the management of the Atlantic hurricane season, rather than of a range of disasters). The team was compiled of seven individuals, including the researcher, who was approached by the project as this thesis was studying the case of hurricane Irma prior to the project's formation. The project itself allowed the researcher to collect qualitative data through academic connections which would have been unavailable individually. Despite this, the collection of social media data across the platforms Facebook, YouTube and Twitter followed the same processes outlined previously in the methodology.

It is important to note several further acknowledgements regarding the differences in qualitative interview data for hurricane Irma. Firstly, interviews were conducted by a team of individuals which ranged between one and four interviewers. This required a separate ethics application which was approved by the University of Southampton, but differs from the original ethics application for the data collection for this thesis. Both application details can be found in the appendix, along with their specifications. While the nature of the data remained the same, an additional application was required given that more than one researcher would have access to anonymous data. Secondly, the total number of interviews for hurricane Irma is significantly higher than that of the Kaikoura earthquake. This is due to the fact that the RECCOH project worked in collaboration with the Antiguan High Commission, which allowed for governmental access to a range of organisations within Antigua and Barbuda that would have otherwise been unavailable for interview.

Analysis Axis	Antigua & Barbuda	St Martin	Turks and Caicos Islands	US Virgin Islands	Cuba	Puerto Rico	Florida, USA	The Bahamas
Did Irma cause mortality?	Yes	Yes	No	Yes	Yes	Yes	Yes	No
Did Irma cause damages?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Was there evidence of underlying geographical facotrs?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Was there evidence of underlying political factors?	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes
Was there evidence of underlying demographical factors?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Was there evidence of underlying economic factors?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Are there are any unique aspects about the country? E.g. ecosystems	Yes	Yes	Yes	Yes	No	Yes	No	Yes
Is Irma unstudied in the country?	Yes	Yes	Yes	Yes	No	Yes	No	No
Is English the primary language of the country?	Yes	No	Yes	Yes	No	No	Yes	Yes
Does a majority of the population have access to the Internet?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Is there evidence of social media use throughout Irma?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Is there still evidence of sustained damages and underlying factors?	Yes	Yes	No	No	No	No	No	No
Was Irma considered an extreme event for the country?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Is the country likely to experience hurricanes again?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Does the country experience a lack of resources for hurricane management?	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
Was Irma's path considered unpredictable?	Yes	No	No	No	No	No	No	No
Tally /16	**16**	**13**	**13**	**14**	**11**	**13**	**11**	**12**

TABLE 7.1: A Summary of the Analysis Matrix used to Determine which Country to Focus on for the Assessment of the Case Study

7.2 Case-Specific Terminology

Hurricanes - Hurricanes are travelling and rotating low-pressure weather systems that form over open oceans. Hurricanes originate in the Atlantic basin, which includes the Atlantic Ocean, Caribbean Sea, and Gulf of Mexico, the eastern North Pacific Ocean, and, less frequently, the central North Pacific Ocean. The sustained winds of a weather system is what defines its category. For a weather system to be considered a hurricane it must have sustained winds of 74mph and above.

Atlantic Hurricane Season - The Atlantic hurricane season is made up of all the storm systems that form in the Atlantic basin over a period of six months. It officially begins on June 1st and ends on November 30th, but systems have been known to form outside of these parameters. The season occurs due to the heating of the ocean in the summer months. The average stages and course of an Atlantic hurricane is show in figure 7.1 below. Hurricane Irma was one of the hurricanes within the 2017 Atlantic hurricane season.

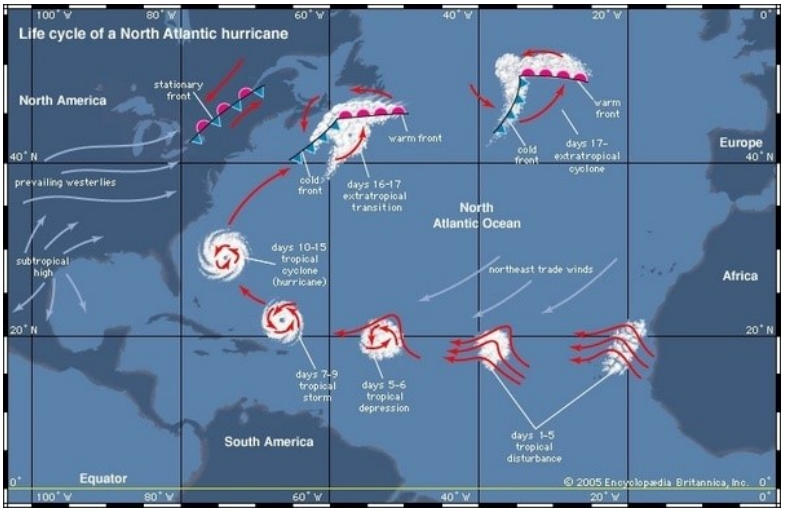


FIGURE 7.1: A Visualisation of the Atlantic Hurricane Cycle, Which Differs from other Areas of the World. Source: NOAA (2018).

National Hurricane Center - The National Hurricane Center (NHC) is located in Florida and provides a range of metrological information and warnings to the US and the Caribbean. The Hurricane Specialist Unit (HSU) maintains continuous monitoring of the Atlantic and North Pacific basins and passes on information to the World Meteorological Organization (WMO). The Tropical Analysis and Forecast Branch (TAFB) generates analyses, forecasts, satellite rainfall estimates, cyclone position tracking and intensity estimates year round. The Technology and Science Branch (TSB) develops tools and techniques for improved weather predictions, as well as statistical models. The Storm Surge Unit, as a subsection of the TSB, forecasts abnormal sea-level rise accompanying storms using modelling, which is used by emergency managers to predict evacuation measures and warnings. Finally, the Hurricane Liaison Team (HLT) are responsible for information exchange between the NHC, national weather services and emergency managers.

Saffir-Simpson Scale - The Saffir-Simpson scale is the classification systems for hurricanes, divided into five categories. Categories are determined by sustained wind speeds and their potential damage to man-made structures. Category three and above is considered "major". In other areas of the world storm systems are referred to as cyclones, and use a different measurement scale.

Small Island Developing States - Small island developing states (SIDs) are a collection of small island countries that face a number of developmental issues. They feature small but increasing populations, isolated geography, limited local resources and subsequent dependence on international trade, vulnerability to natural disasters and other similar disruptions, and fragile ecosystems or unique environments. The terms SIDS was established in 1992 by identifying that their growth is dependent on level of communications available, energy and transport costs, international transport and trade fluctuations, investment in local infrastructures, and reduced opportunities to create economies of scale due to their small nature (Thompson, 2015).

7.3 Motivations and Background

The Atlantic hurricane season is an annual phenomenon which, in exceptional years, can cause total damages that exceed $65 billion for the entire Atlantic basin. Given its inevitable re-occurrence, and the vulnerability of many SIDs in the area, it is important to improve the management of the season in future years. Particularly for islands that feature unique resources such as coral reefs or endangered ecosystems, hurricanes are a regular threat. The islands of Antigua and Barbuda are located in the Atlantic Ocean where is merges with the Caribbean Sea, in an area referred to as the Leeward Isles (part of the Lesser Antilles). The case is particularly interesting due to the number of geographical, demographical, political and economic factors present: all of which

dictate how well the country, especially given its SIDS status, manages the season. The dependability of the season is reminiscent of seismic hazards in the sense that more disasters will occur in the coming years, which may be exacerbated by underlying factors such as climate change. In contrast to the previous case however, Antigua and Barbuda are considered a lesser developed country than New Zealand. This means that the country experiences a lack of available resources, skilled workers and societal infrastructures which impact the management of events. Despite this, the country has in recent years increased its investment in telecommunication and internet networks. Partly this has been fuelled by its isolated nature and the need to communicate and trade with the wider world better, and partly as a result of being influenced by globalisation.

There is little published material that defines the role of social media during hurricanes particularly located in SIDS. This is especially the case in the Caribbean where social media research tends to focus on environmental preservation and tourist management. For SIDS increasingly utilising social media, there is a need to evaluate the current place it holds within isolated island communities. This is principally important for those that are subjected to unique resourcing and income issues compared to more developed countries with similar geographical characteristics such as New Zealand or the United Kingdom. Furthermore, governmental policy, local services and infrastructure, and regional disaster management protocols need to be considered in the context of the beneficial services and applications that social media can offer. Not only do these considerations have value to Antigua and Barbuda, they may potentially act as a blueprint for other SIDS across the Caribbean. This makes Antigua and Barbuda an interesting and unique case study, where there has been little consolidation of lessons from hurricane Irma and the 2017 Atlantic hurricane season between the organisations who managed the disaster. The following section aims to contextualise the case study by explaining the chronology of events. It will then scope the underlying factors that shaped the use and users of social media throughout the disaster, naturally leading onto the main body of the results.

The following sections aim to contextualise the case study in more detail. This will draw upon information gathered through interviews as well as from wider literature and reports on the area. A summary of the interviews are presented in tables 7.2, 7.3 and 7.4 below which have been assigned anonymous IDs. IDs will be referred to throughout the chapter corresponding to information from certain interviews, and using an alphabetical format in order to differentiate clearly between the previous interviews conducted for the Kaikoura earthquake. Then, a chronology of the case study is presented which illustrates the types of hazards that occurred and when. The following sections with then scope the underlying geographical, demographical, political and economic issues that shaped the use and users of social media throughout the disaster, naturally leading onto the main body of the results.

Interviewee	Brief Overview	Assigned ID
The Barbudan Council (Group Interview)	The Council runs the internal affairs of Barbuda. Members are elected by the registered voters of Barbuda, with the Parliamentary Representative (MP) and the Senator, who is nominated by the Council, as ex-officio members. The council administers and regulates agriculture, forestry, public health, public utilities and roads as exclusive powers, and raises and collects revenue to meet expenses incurred in the performance of its functions.	A
Flow (Group Interview)	One of the major telephone and internet communication providers in Antigua and Barbuda.	B
The Ministry for Social Transformation (Group Interview)	A branch of the Ministry of Social Transformation of the government dedicated to supporting individuals and communities who are vulnerable in society.	C
The Ministry of Education (Group Interview)	A national education service for children and young people, from pre-school to post graduate level, which were responsible for the integration of hurricane evacuees into Antiguan social systems.	D
Local Business Owner (Individual Interviews)	Male in mid 40s who owns a company renting out boats and yachts on Antigua and Barbuda. These boats were used during the response and recovery stages of hurricane Irma.	E1
- As above	Male in late 50s who runs a hotel on Antigua who experienced hurricane Irma.	E2
-As above	Male in later 30s who owns a taxi company on Antigua who experienced hurricane Irma.	E3
Members of the Government of Antigua and Barbuda (Individual Interviews)	Male politician in late 50s employed by the Government of Antigua and Barbuda.	F1
- As above	Male politician in late 40s employed by the Government of Antigua and Barbuda.	F2
- As above	Female politician in mid 40s employed by the Government of Antigua and Barbuda.	F3
Retired Member of the Government (Individual Interview)	Retired male politician in early 60s previously employed by the Government of Antigua and Barbuda.	G
The Antigua and Barbuda Meteorological Centre (Group Interview)	The National Meteorological Centre for the Country.	H
Ministry of Agriculture, Lands, Fisheries and Barbuda Affairs (Group Interview)	A service for the application of modern and emerging practices designed to strengthen food security initiatives, efficient land use management and sustainable development of natural resources. Responsible for a series of hurricane-related response initiatives.	I
Red Cross Antigua (Individual Interview)	Male in mid 30s who works for the Antiguan branch of the Red Cross, which provides services in the areas of health, welfare, disaster relief, first aid and youth development.	J
The National Solid Waste Management Authority (Group Interview)	A service to provide residents with an integrated, cost effective solid waste management system that follows the guidelines of environmentally sound	K

TABLE 7.2: An Overview of the Interviewees from Hurricane Irma, Detailing Basic Contextual Information and Their Assigned IDs.

	principles. Responsible for hurricane debris clean-up efforts and organisational coordination for environmental issues.	
WTO and Ministry of Foreign Affairs (Individual Interview)	Female WTO Employee in late 30s working for the Ministry of Foreign Affairs	L
The National Office for Disasters (NODS) (Group Interview)	The governmental department responsible for the preparation, management, response and recovery of natural disasters.	M
ZDK Radio Station (Individual Interview)	Male in early 40s who works at ZDK: A local radio station available to the residents of Antigua and Barbuda. Responsible for hurricane information dissemination.	N1
ABS Radio Station (Individual Interview)	Male in late 40s who works at ABS: A local radio station available to the residents of Antigua and Barbuda. Responsible for hurricane information dissemination.	N2
The Observer Radio Station (Individual Interview)	Male in mid 40s who works at the Observer: A local radio station available to the residents of Antigua and Barbuda. Responsible for hurricane information dissemination.	N3
The WAITT Institute (Group Interview)	The Institute partners with governments committed to developing and implementing comprehensive, science- based, community-driven solutions for sustainable ocean management.	O
The University of the West Indies (Group Interview)	The main university of the Caribbean islands with four landed campuses, and many open campuses. Responsible for informing regions about disaster risk reduction. Group representatives from the islands of Barbados, Trinidad and Dominican Republic.	P
The Antigua Lions Organisation (Individual Interview)	Female in early 50s who works for the Antigua Lions, which are non-profit service organization helping people in Antigua & Barbuda and the surrounding communities.	Q
Antigua Public Utilities Authority (Group Interview)	A tripartite government statutory agency to ensure that consumers receive the best possible value in Telecommunications (including mobile & internet), Electricity and Water services.	R
Digicel Telecommunications (Group Interview)	One of the major telephone and internet communication providers in Antigua and Barbuda.	S
The High Commission for Antigua and Barbudan Affairs (Group Interview)	The High Commission for Antigua and Barbuda affairs.	T
Members of the Antiguan and Barbudan Public (Individual Interviews)	Female in early 20s who experienced hurricane Irma, who works as a waitress on Antigua.	U1
-	Male in early 30s who volunteered during hurricane Irma recovery, who works as social volunteer on Antigua.	U2
-	Female in mid 20s who experienced hurricane Irma and was evacuated from Barbuda to Antigua, who works as a hairdresser.	U3

TABLE 7.3: An Overview of the Interviewees from Hurricane Irma, Detailing Basic Contextual Information and Their Assigned IDs.

-	Female in early 20s who experienced hurricane Irma and was evacuated from Barbuda to Antigua, who works as a waitress.	U4
-	Male in late 50s who experience hurricane Irma, who works for a boat rental company on Antigua.	U5
-	Female in early 30s who experienced hurricane Irma, who works in a bank on Antigua.	U6
-	Male in early 30s who experienced hurricane Irma and was evacuated from Barbuda to Antigua, who works as a fisherman.	U7
-	Male in early 30s who experienced hurricane Irma and was evacuated from Barbuda to Antigua, who works as a tour guide.	U8
-	Female in early 20s who experienced hurricane Irma who works at a hotel on Antigua.	U9
-	Female in late 60s who experienced hurricane Irma, who is retired.	U10
-	Male in early 40s who experienced hurricane Irma, who works at a local church on Antigua.	U11
-	Female in mid 30s who volunteered during hurricane Irma recovery, who works as a social worker between the islands of Antigua and Barbuda.	U12
-	Female in mid 30s who volunteered during hurricane Irma recovery, who works as a chef on Antigua.	U13
-	Female in mid 30s who volunteered during hurricane Irma recovery, who works in a supermarket on Antigua.	U14
-	Male in early 20s who experienced hurricane Irma who works at a bar on Antigua.	U15
-	Female in late 20s who experienced hurricane Irma who works at a convenience store on Antigua.	U16
-	Male in early 50s who experienced hurricane Irma, who develops property on Antigua and Barbuda.	U17
-	Male in late 30s who experienced hurricane Irma, who works in a supermarket on Antigua.	U18
-	Female in late 30s who experienced hurricane Irma, who works at a hotel on Antigua.	U19
-	Female in early 50s who experienced hurricane Irma, who works as a church volunteer on Antigua.	U20

TABLE 7.4: An Overview of the Interviewees from Hurricane Irma, Detailing Basic Contextual Information and Their Assigned IDs.

7.3.1 A Chronology of the Disaster

As explained in the terminology, hurricane Irma affected the entire Atlantic region, and thus a number of different countries. Therefore, it is important to understand the progression of the storm throughout its cycle, especially given that it's path has a direct impact on its categorisation, i.e. by travelling over open water the storm system may increase its intensity, whereas travelling over land may decrease intensity. Figure 7.2 below tracks both the hurricane's course and its intensity. It focuses on Irma's landfall on Antigua and Barbuda which was previously scoped as the research area, and summarises the events that unfolded particularly for this case. The context of the timeline may therefore be used to inform the remainder of the chapter. The following sections discuss the geographical, demographical, political and economic factors present which shaped the outcomes of the disaster.

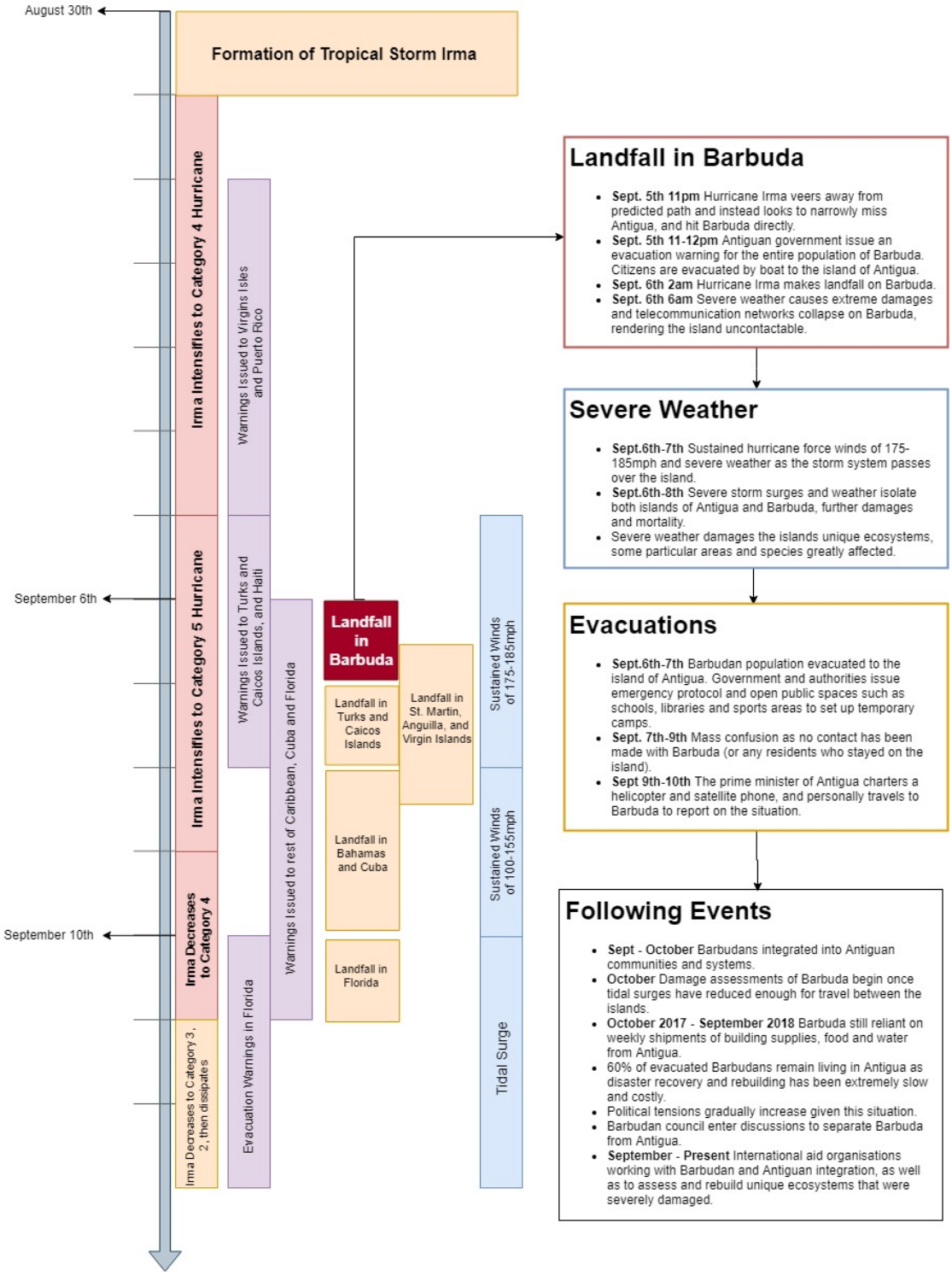


FIGURE 7.2: A Visualisation of the Overall Timeline of Hurricane Irma, Focusing on its Landfall on Antigua and Barbuda.

7.3.2 Geographical Factors

The geographical location of the islands have a number of effects on the way hurricanes may be responded to across the 4 R's. Primarily, the isolated nature of the islands means that one may only access them via air or sea. Severe weather caused by hurricanes therefore makes access to the country extremely difficult – as well as collaboration between the two islands which are separated by a stretch of ocean. Shipments and travel between the islands are predominantly formed of regular boat trips in the form of ferries and smaller vessels as these are cheaper than running a plane or helicopter, and Barbuda only has a small area suitable for landing aircraft on. While less costly, this method takes significantly longer, meaning that the average commute between the islands is longer than it would be via air. Interview I - as representatives of the department which coordinates resource allocation between the islands - argues that this is usually not a problem for commuting citizens or resource shipments in times of normality: it only becomes an issue after sustaining damages and mortality from hurricane Irma, combined with the break down in communications between departments and the islands themselves. They further argue that social media has been used interdepartmentally and inter-organisationally to aid with crisis communications (A2A), and in securing further resources from the public (A2C) to be sent for disaster relief.

The distance between the islands affects the delivery of resources from other areas, as well as between the islands themselves (illustrated in figure 7.3 below). The small geographical amount of land in Antigua and Barbuda means that farming and local produce is relatively low given the number of resident citizens. The islands, as a result, ship in a wide variety of food and other materials which are greatly affected by high seas and bad weather conditions caused by the hurricane season. Interviewee E1 explained that during hurricane Irma, his company along with many others, were chartered by the government to provide regular shipments of food, water, and tools for re-building. He further emphasises that these shipments remain extremely important to the island, as of July 2018 - nearly a year following the events of Irma - he was still shipping water on a weekly basis to the island. The topology, too, has played a role in the vulnerability of the country to hurricane hazards. Barbuda is extremely flat with little in the way of natural defences, and so was extremely susceptible to the hurricane winds of Irma. Antigua, while not as flat, features a wealth of ecologically rich coastline and unique ocean environments that were affected by rough seas and hurricane debris. Both of these affects cause damages not only to the population and local environments, but also extremely dent the island's tourism.

FIGURE 7.3: A Map of the Country Antigua and Barbuda with a Scale to Illustrate the Distance between Islands. Source: The Lonely Planet Maps (2019).

7.3.3 Demographical Factors

Antigua and Barbuda has a population estimated at 81,000 permanent citizens, which means that disaster management and response volunteers are often required to be sent from other surrounding islands, as well as the international community (Interviewee J). During hurricane Irma and throughout the remainder of the 2017 Atlantic hurricane season this heightened risk for the population as rough seas and strong winds prevented any travel between islands. This was particularly a problem for Antigua and Barbuda compared to other SIDS as their country is formed of both islands, both sustaining damages, but Barbuda being hit catastrophically. As a result, the population of Antigua was unable to make contact with Barbuda for several days after hurricane Irma made landfall and limited international aid was available (Interviews A, M, Q, S, R J). Following this, the smaller population meant that recovery and rebuilding efforts must be fronted by a reduced number of workers that do not have access to the same level of expert knowledge (Interviews K, D). This is due to the fact that many citizens with high skill-sets and education choose to move to larger neighbouring islands, the USA and Canada, or other locations around the world (Interviews E2, C, D).

Following Irma, demographical issues were noted after the evacuation of Barbudans to Antigua. Just under 2,000 citizens were re-homed on the main island, which initially required public spaces such as schools and centres to be re-purposed (Interviews C, Q, D). Following this, longer term rehabilitation was needed for citizens considering that Barbuda currently remains in a severely damaged state, with little re-building (Interviews C, Q, D). As of July 2018, some 200 citizens have taken up residence on Barbuda, with a further 100 or so volunteers and workers returning on a weekly basis to continue with repairs (Interview M). In light of this, many Barbudans feel that their sense of identity - which they feel is strongly connected to the island - is fading in their new living conditions on Antigua (Interview A, F3). Interviewee F3 commented *"Barbuda has had hurricanes before. People didn't move, and they survived the hurricane. In a matter of 6 months they were able to rebuild because they got the money. The problem this time is that when you moved them from Barbuda and brought them to Antigua, they just lost interest in their own life. They don't want to go home because it's still in a bad state"*. This highlights the sense of cultural division felt by individuals, as well as the continued impact that the Barbudan experience has on citizens.

Humanitarian aid organisations working closely with communities, for example the Red Cross, argue that demographical issues associated with the evacuation and subsequent integration of Barbudans is a complex negative outcome of the disaster (Interview F3, C, J). Interviewees from the Red Cross explain that they have since decided to take cultural and demographical factors into their management efforts in the post-disaster stages of Irma. This follows three main steps, in which social media has been used as a facilitator.

Firstly, the organisation have worked in collaboration with the government to set-up two-way communication centres within the community for feedback, extending invites on open pages and groups on Facebook (Interview J). Secondly, the organisation only take on volunteers from within Caribbean communities themselves to ensure that volunteers have a high level of contextual understanding with the underlying demographical issues (Interview J). Finally, organisations are collaborating with the department of Education to develop training programmes for schools where young Barbudans are now enrolled. This aims to reduce tensions from a bottom up approach, and targets Facebook in particular as that is the most popular platform for the younger generation (Interview D).

7.3.4 Political Factors

The demographical issues detailed above have in turn influenced some of the many underlying political factors exacerbated by hurricane Irma. Many Barbudans feel victimized by the manner in which the Antiguan government have responded to the disaster, and have expressed this through multiple media channels. Interviewee A, a member of the Barbudan council, stated that *"If you want to help it must come directly to us, the people of Barbuda. I have been speaking on the radio about this just about every day. There are crazy people over here [within the government], all they love is land and money"*. This illustrates just some of ways that traditional and social media have been leveraged by underlying political factors following Irma. The interviewee goes on to state that the Barbudan council are also disappointed with the political involvement of the United Nations (UN) in hurricane Irma recovery efforts. This, he theorises, is due to the fact that they have been manipulated by the Antiguan government, and so little money received for re-building has actually made its way onto the island. He concludes by stating that if the world wanted to help they must contact the council directly - which can be done through social media, too - again emphasising the utilisation of platforms for specific purposes.

Likewise, many Antiguans feel that their aid efforts have been undermined by Barbudans. Interviewee C commented that *"Barbudans are behaving as if we have done nothing. That is the part that I cannot understand. That you know we were helping you and you say to the whole world that we are not doing anything"*. This once again highlights how both sides of a political debate have used social media as an international stage. Furthermore, both sides of the argument have been vocal within local communities, as well as through wider media such as radio broadcasts and TV interviews on the islands. In projecting this unrest to the rest of the world, many political parties - in particular that of the Barbudan council - hope to garner interest and support from other nations that goes beyond recovery and re-building efforts following hurricane Irma (Interviewee A). On a citizen-level, many individuals have in contrast to higher level politics sought

to get along with one another, and to integrate to the best of their ability (Interviewees J, Q, U2, U4). Despite this, there remain undertones of unrest which have in turn driven the creation of more extreme governmental policies, such as redefining the level of funding/resources to be allocated to Barbudan evacuees (Interviewee A, F1).

Political tensions are still present more than year after Irma, with little chance of being solved in the near future (Interviewee A). Individuals feel that the community is more divided as a result of political infighting and international smear campaigns going into following Atlantic hurricane seasons (Interviewees U1-20). Arguably this is major concern for the government in power, as resilience and preparedness demonstrably enhance a community's ability to cope with, and respond to, disasters. In light of the damages sustained by Irma, the government in power has stated that building back must be more resilient to avoid the same level of destruction in future events (Interviewees F1, F2, F3). This emphasises policies that support the improved construction of residential buildings, more sophisticated networks and communications systems, and increased resources delegated to disaster recovery teams, for example to departments such as waste management who are tasked with hurricane debris clean-up (Interviewees F1, C, K). The Barbudan council have argued *"We are going to try to separate regardless of what happens - if we have to eat grass we'll do it because it would be worth more than staying with Antigua"*(Interview A). This evidences the political turmoil still present, and expressed through media, which arguably will only become more tense throughout future hurricane seasons.

7.3.5 Economic Factors

Antigua and Barbuda have a fairly low annual GDP which is predominantly generated by tourism (Interviewee I, L). It has high levels of poverty that have a demonstrable link to increased risk to disasters within the Caribbean (Interviews I, L). This has a number of repercussions for disaster management throughout each of the disaster lifecycle phases of hurricanes (Interview I, M). In the pre-disaster stage there is a lack of sophisticated warning equipment, so the islands rely on weather reports and hurricane forecasts generated by the NHC (Interview H, M). While generally reliable, they provide information for the entirety of the Caribbean and Atlantic regions, making prediction and preparedness for Antigua and Barbuda difficult given the unpredictable nature of hurricanes (Interview H). This was a significant issue during the 2017 season as the storm systems detected by this method were more severe and varying than previously had been predicted (Interviews H, M). Particularly for the case of hurricane Irma, interviewees explained that its unpredictable veering off course to hit the island or Barbuda head on, when the initial forecast had warned that Antigua was directly in its path, was deeply concerning (Interviews F3, Q, H). A representative from the National Office for Disasters (NODs) argued that they are in the process of buying and maintaining better

forecasting equipment, as well as branching out to post advanced warnings on social media, following the impact of Irma (Interview M).

In the during-disaster phase, there is a lack of communications infrastructure that is build to withstand hurricanes. This is particularly the case on Barbuda as it has a much smaller population, and so has historically been allocated fewer resources from the government (Interview L). Partly, this is due to a lack of investment capital for more sophisticated equipment (Interviews F3, M), as well as a lack of building capital for reinforcing existing network connections built on the islands (Interview S). In the post-disaster phase, the isolated nature of the islands has meant that rebuilding and recovery materials must be shipped in from other areas (Interview M). The cost of this rises during the hurricane season as it is more difficult to ship, and other neighbouring islands are competing for the same resources (Interview M). As such, the islands have had to postpone recovery efforts in past seasons – including that of the 2017 season – due to a lack of available capital. A representative from the MET Office supported this argument, and further added that the service was applying to the government for more money which would be spent hiring and training social media strategists specifically for the distribution of information on Facebook and Twitter to begin with (Interview H). This however would depend on the level of funding made available by the government in future hurricane seasons.

Finally, there are considerable economic issues with the development and re-building of Barbuda. Interview I stated *"Businesses in Barbuda were just completely destroyed in the last hurricane. It's basically a fishing economy and they rely on the ocean for their livelihoods"*. While this affected the island's ability to bounce back, it also revealed more complex economic issues as Barbuda itself is communally owned land (Interviews F1, F3, A,). Interview I further explained that *"A lot of persons in Barbuda didn't buy insurance because of the poor situation, the land tenancy, which the government is currently trying to address in terms of now allowing freehold lands on Barbuda - which of course the council vehemently opposes. We believe that the level of destruction and the slow pace of recovery was because of the lack of proper business continuity and lack of insurance coverage"*. Interviewees A and F3 claim that the Antiguan government are waiting for investors to come to Barbuda to buy up land contracts as part of a partnership with the government. This is theorised to boost the damaged economy of the islands, as well as allowing disaster relief money to come through different channels. Interviewee F3 commented that *"The government collect enough money, but don't even have a proper account for it, know how much has been spent, or how much is left. There's no honesty about the spending of the money. When agencies approach [us] to give us funds for hurricane relief the Antiguan government discourage them"*. Not only does this highlight the continued economic issues following Irma, but also demonstrates how multiple underlying factors may interact with one another.

7.3.6 National Disaster Response Structures

Evidently there are a number of underlying factors that have shaped the outcome of Irma. To be able to make improvements to the management of future hurricane seasons (RQ4), we must first understand and analyse the current structures in place for hurricane management. While these varies across the different SIDS within the Caribbean, many of the core principles and policies are the same. Figure 7.4 summarises the Hurricanes Procedure Manual (HPM) published and distributed by the Caribbean Disaster Mitigation Project. In addition, it features relevant regional-specific information directly linked to Antigua and Barbuda taken from the Emergency Plan of Action (EPoA) published by the Red Cross, and the national crisis and communications plans published by the Antiguan and Barbudan government. This will be referred to in the following section.

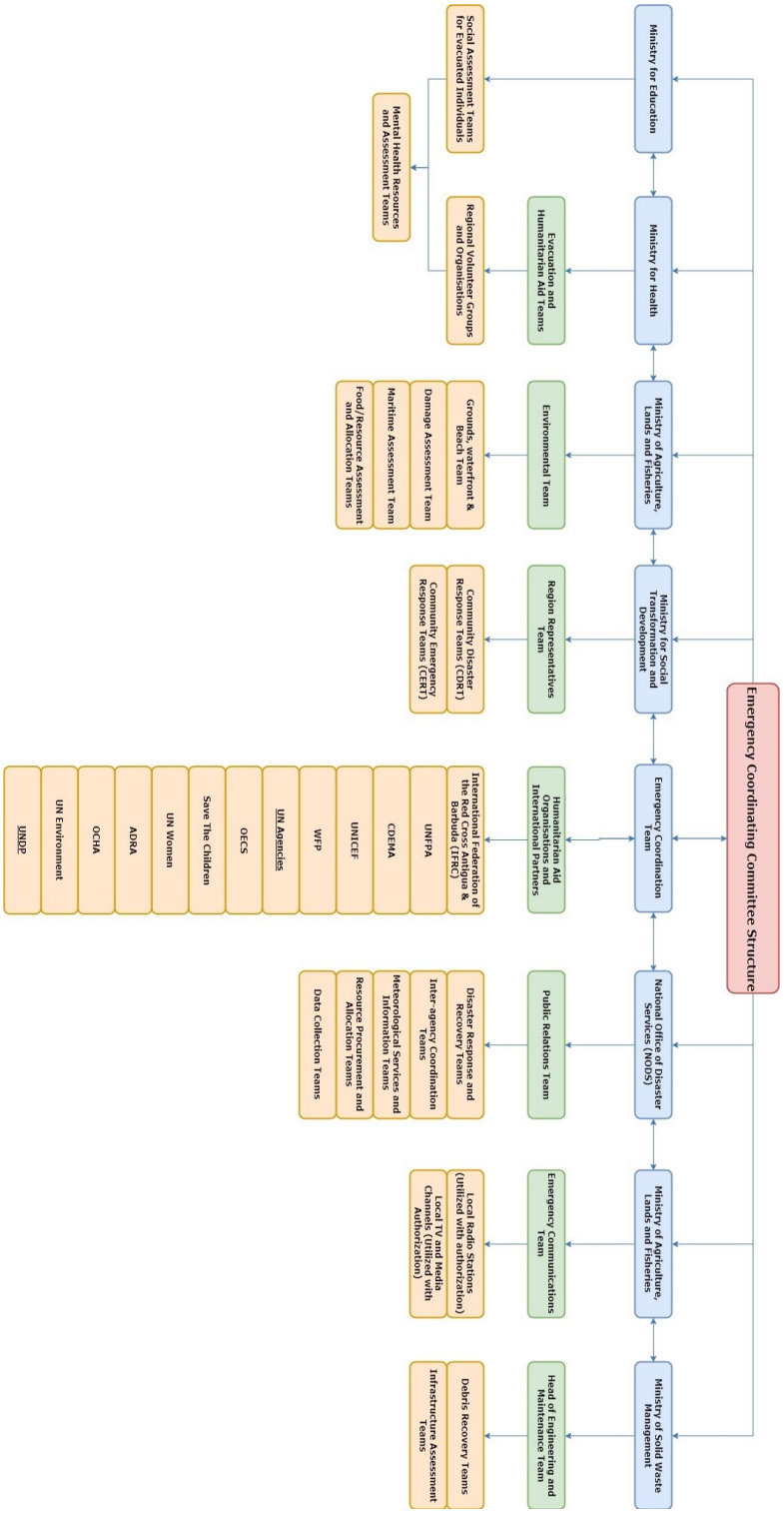


FIGURE 7.4: A Visualisation of the Emergency Coordinating Committee Structure for Antigua and Barbuda

7.4 Results: The Role of Social Media during Hurricane Irma

The previous sections have provided information about the underlying factors which help to explain the case of hurricane Irma, and also provide a foundation to better answer the RQs. Social media data was collected from the sites Facebook, YouTube and Twitter throughout the case study. For each platform the process outlined in the methodology chapter was followed, and a summary of the data sources can be found in table 7.5 below. For Twitter, roughly 3 million tweets were collected. The high volume of tweets may be explained by the nature of hurricanes themselves, which travel across large expanses and affect a number of different countries, as well as lasting for up to several weeks: this produces a higher volume of data than hazards which are more geographically and temporally bounded. Therefore, from this dataset 8 subsamples were created (unlike the 4 samples per pilot study). Samples that exceeded the Web Observatory daily hose were capped at 10,000 tweets. A breakdown of the subsample results can be found in table 7.6 below.

The top 100 most relevant videos published to YouTube throughout the disaster life-cycle were scraped. Instead of creating subsamples for these - which would be inappropriate given their different format - it was more logical to analyse the most popular 10 videos, determined by number of views. The comments thread of each video was additionally analysed, as this represented network interaction with the video content. A summary of the YouTube data can be found in table 7.7 below. Facebook data was also used, originating from open groups and pages created to discuss the event. For Facebook, a total of 22 pages and 86 groups were identified as being relevant to the disaster. These were short-listed to 5 pages and 3 groups for study. The criteria for the short-list was more specific than the short-list for the previous case study due to the fact that this study sought to analyse the case of Antigua and Barbuda alone, rather than its outcome for other countries. Therefore, only groups and pages regarding Antigua and Barbuda's experience with hurricane Irma was the first criteria for inclusion. This explains why despite the count of relevant groups being very high, only 3 were selected for analysis. The second criteria was the most active groups and pages, determined by featuring the most qualitative content for analysis judged by the researcher. A summary of the Facebook data can be found in table 7.8 below.

A series of qualitative interviews were conducted in order to avoid previously identified issues such as privacy and richness of qualitative data from the sites. More than 90 individuals were interviewed using a semi-structured technique, lasting between 20 minutes to one hour per interview. The volume of interview data was significantly higher than the previous case study due to the nature of the RECCOH project objectives outlined at the beginning of this chapter. The project sought to gather a large volume of qualitative data particularly from individuals with backgrounds in the government,

humanitarian aid organisations and international relations. As a result, many of the individuals that worked in teams or departments during hurricane Irma were interviewed in a group setting. This avoided the need to conduct many more individual interviews, while simultaneously understanding how teams, groups and communities responded to the event, as well as on an individual level.

Data Origin	Total Data Volume	Shortlisted Data for Analysis
Twitter	3,179,336 tweets	8 Subsamples (roughly 30,000 tweets)
YouTube	100 Videos and Comment Threads	10 Videos and Comment Threads
Facebook	22 Pages and 86 Groups	5 Pages and 3 Groups
Qualitative Interviews	N/A	90+ Individuals

TABLE 7.5: A Table Summarising the Total Amount of Data Collected for Hurricane Irma, its Origin, and the Final Short-listed Data Analysed within this Chapter

Irma Twitter Subsamples	Subsample Collection Period	Total Data
Subsample 1	1st September 2017	10,000 Tweets
Subsample 2	8th September 2017	10,000 Tweets
Subsample 3	15th September 2017	7,086 Tweets
Subsample 4	22nd September 2017	3,442 Tweets
Subsample 5	29th September 2017	2,017 Tweets
Subsample 6	6th October 2017	1,678 Tweets
Subsample 7	13th October 2017	1,177 Tweets
Subsample 8	20th October 2017	986 Tweets

TABLE 7.6: A Table Summarising the Twitter Subsamples for Irma

YouTube Video	**Date Published**	**Number of Views**
``Hurricane Irma: Barbuda, A Caribbean Paradise Lost - BBC News``	9th September 2017	125,634
``Barbuda Destroyed by Hurricane Irma Faces Jose Next - MSNBC ``	8th September 2017	74,721
``Hurricane Irma: Barbuda Barely Habitable - BBC News``	7th September 2017	49,504
``Barbuda has to Completely Rebuild After Hurricane Irma``	10th October 2017	37,632
``Reporter: Hurricane Has Cut Off Communication With Barbuda``	6th September 2017	30,352
``Barbuda: Fears of Land Grab After Hurricane``	8th November 2017	9,450
``Hurricane Irma Devastates Antigua and Barbuda``	7th September 2017	5,967
``Returning home to Barbuda a Year After Irma's Annihilation``	2nd September 2018	5,160
``Barbuda Island Paradise Wiped Out By Hurricane Irma``	1st December 2017	3,512
``Barbudans Arrive in Antigua After Hurricane``	13th September 2017	3,480

TABLE 7.7: A Table Summarising the YouTube Data for Irma

Facebook Page/Group	**Type**
Hurricane Irma Support Group	Open Group
Hurricane Irma Relief Fund for Barbuda Caribbean Neighbors	Open Group
Hurricane Irma Relief and Rescue Group	Open Group
Hurricane Irma Support Group	Open Group
Rescue Barbuda/Shelter Barbuda from Hurricane Irma	Open Group
Hurricane Irma Relief	Open Page
Hurricane Irma Claims	Open Page
Hurricane Irma Relief Team	Open Page

TABLE 7.8: A Table Summarising the Facebook Data for Irma

7.5 Social Media for Resilience

7.5.1 Old to New: Extending Community Preparedness onto Facebook

A majority of the country's resilience and preparedness efforts originate from the pre-disaster phase where, during the lead up to the hurricane season, a range of warning media is broadcast across the islands (Interviews R, S). These are predominantly broadcast on TV and radio channels, which the interviewees explained were their primary source of information for weather and seasonal updates, but have in recent years been expanding onto Facebook (Interviews R, S). These generalised broadcasts explain to citizens what they should do to reduce their risk before any hazards transpire, but generally are not region-specific to parts of the islands. Interviewee F3 explains that as someone who was previously involved in official preparedness efforts *"the government have the responsibility to prepare the public for the hurricane season. We had to do many meetings, lectures, campaigns, and consultancies. Even village to village talking to people, not just on the radio"*. This highlights that offline communications remain vital for the islands, but that many individuals are beginning to see more potential for social media.

Figures 7.5 and 7.6 below support the notion of expanding hurricane preparedness on social media. 7.5 is a graphic produced by CDEMA for general hurricane preparedness information hosted on their website as well as physically on posters. Employees of the University of the West Indies (who have grounded campuses across various islands within the Caribbean) explained that physical posters were distributed around the Caribbean nations (Interview P), as well as beginning to be shared by relevant local authorities onto Facebook pages and groups where figure 7.5 was located. Similarly, figure 7.6 shows an original TV broadcast media that was aired in the Caribbean area preparing the imminent landfall of Irma. Once again, the figure shows that the original media has been posted onto social media sites (in this instance Facebook), and has been shared by an authority account who help to manage the Atlantic hurricane season. While these figures evidence the expansion of hurricane preparedness information onto social media themselves, originating from more traditional media, they remain generalised to the entire Caribbean or to particular islands. A representative for a governmental department on Antigua and Barbuda stated that *"social media has a lot of potential, and I think it would really benefit us if we started prioritising it and becoming more specific with it"*. This was similarly corroborated by bodies who share generalised hurricane information such as the MET Office Antigua.

FIGURE 7.5: An Example of Hurricane Preparedness Information Produced for the Caribbean General Region by CDEMA

FIGURE 7.6: An Example of Hurricane Preparedness Information Media Produced by TV Media and Later Shared onto Facebook by Authorities

The expansion of hurricane information onto social media was also evidenced in the data collected from all three platforms in the pre-disaster phase of Irma. Figure 7.8 below demonstrates that there is evidence of early stage categories that focus on the sharing of regional and national warnings, with category 4 (providing and receiving general disaster information) being the most popular for both Twitter and Facebook. This subtly differs from the most popular categories recorded in Kaikoura which were more region and hazard specific (category 5). Further to this, category 7 was popular on Facebook during this time, which was absent from Kaikoura. This may be explained by previous contextual underlying factors discussed by the Department for Solid Waste Management (who are responsible for hurricane debris prevention, management and clean-up) who detailed that individuals use their hot-line, as well as social media, to notify authorities or services such as themselves before a hurricane hits. An example of their preparedness media is shown in figure 7.7 below, detailing a public service announcement prior to Irma reiterating risk-reducing information. Interview C explained that *"prevention is better than a cure. Preparedness. How do we get persons to be aware, be alert, and put themselves in a frame of mind, especially when disaster is going to come?"*. This again supports the statements made by the authority groups who are leading the transition for extending online preparedness information in more depth.

FIGURE 7.7: An Example of Hurricane Preparedness Information Media Produced by the Government and Shared via the Newspaper of the Observer and to Facebook Groups

A Key for Figure 7.8

No.	Framework Category
3	Provide and Seek General Disaster Preparedness Information
4	Provide and Receive General national and Regional Disaster Warnings
5	Detect and Warn of Disasters and Specific Hazards Locally
7	Send and Receive Requests for Help or Assistance
10	Provide, Receive and Encourage Information Sharing in Multiple Formats
14	Express Public and/or Individual Empowerment; Reassure Others

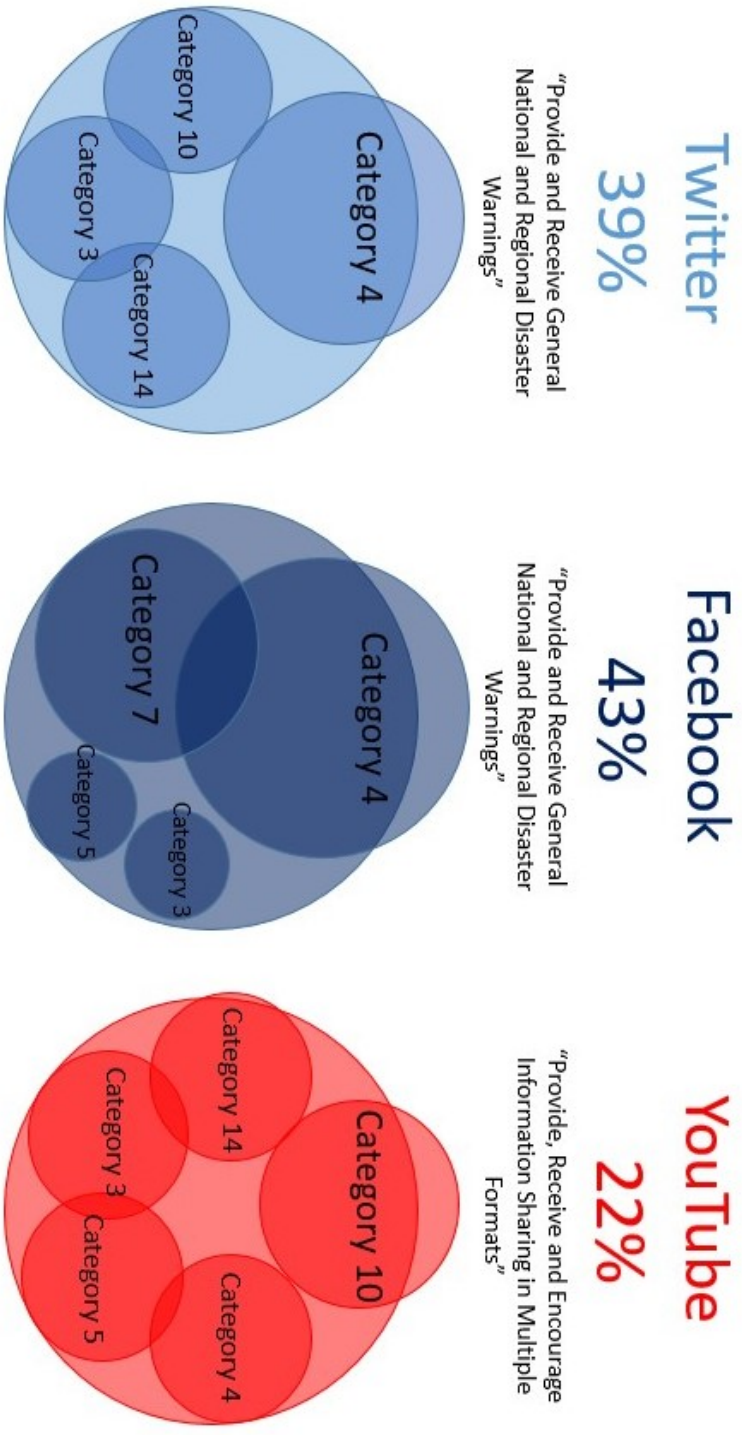


FIGURE 7.8: A Visualisation of Data Content for the Most Popular Categories of the Conceptual Framework for the Platforms Twitter, Facebook and YouTube in the Pre-Disaster Phase of Irma

While a majority of interviewees believed that the use of Facebook groups and pages could be beneficial, some expressed reservations about expanding onto the site. Firstly, they raised concerns over the number of users of social media within the country. They were aware that this number is rising exponentially with the construction of more sophisticated telecommunications, but emphasised that they needed to consider ways for islanders without Web access to reduce their risk in an equal manner (Interviews N1, N2, S, R). Secondly, on Facebook, groups and pages for community resilience and preparedness were set-up to focus on the entire season, rather than individual hurricanes alone. This implies that these spaces are commonly accessed as a channel to seek preparedness information, which is updated as and when the communities on the islands require it. Thirdly, some interviewees claimed that individuals simply don't want to be told how to be more prepared, given that they have experienced the hurricane season many times (Interviews F3, U7, J). Interviewee F3 states that *"People didn't want me to explain to them what they have to do to prepare themselves for the hurricane season, how to prepare their fish pots, their boats. We knew the hurricane was coming, but what did the government do in preparing Barbuda for it? They hadn't gotten over the first hurricane so they are never prepared for the next one"*.

7.5.1.1 Integrating the Roles of Old and New Media

While many interviewees openly praise the functionality of social media sites, particularly for the sharing of qualitative content that allows for the preservation of community ties, there are clear reservations when it comes to relying on platforms entirely. Interview C explained the problem further by suggesting social media may only be functional if it can be integrated with the traditional methods of communication which have existed on the islands for generations. They go on to state that during the department's response to Irma, *"you put out warnings on Facebook and media and I'm saying that people aren't listening. So I decided to go out. I went to schools and told them to listen and to get a group together. It was amazing because everything was flooding the media and news, and then you go out there and there are still pockets of people that don't know anything"*. This highlights that there is still dissonance between online and offline methods of communication and information seeking - a phenomenon which was well documented in the literature review for lesser developed countries with a lower access to the Internet.

While integrating methods clearly has a lot of potential, many interviewees argued that better protocols and methods for using social media were necessary for future hurricane seasons. Interview K explained that *"in Antigua we talk on the radio a lot, so I think that's the most effective method of communication in terms of the wider population. Then of course we need to reach specific demographics which we are exploring through Twitter and Facebook and so on. This looks at certain age groups, non-English speaking residents and other kinds of demographic"*. This highlights the need for integration

of methods, and for protocols that authorities and organisations may follow to ensure warnings are consistently and effectively communicated. Interview E illustrates this by stating that *"not many people use Twitter sensibly, not here"*. This may be noted too in the dominance of more generalised framework categories for information sharing (category 4) in figure 7.8 above, as opposed to more specific categories (such as 5).

Some organisations are instead setting up their own protocols for effective integration. Interview J explained that *"us and our beneficiaries do a lot of social media. A lot of Facebook, Instagram and most of our radio stations are now on Facebook live. Every time we do anything we reach out to the community, we use social media, we use the radio stations too and that goes to their social media"*. This raises questions about the responsibility of information dissemination in the pre-disaster phase across all types of media. Technically, it is the responsibility of governmental departments to plan in advance for such eventualities, but in actuality representatives from the Department of Social Transformation stated *"when we talk about preparedness and resilience, sometimes we're not even prepared for the eventualities like evacuating the whole island. What do we do in a case like that? We've never had a plan for that"*. This represents a key area for creating proposed recommendations to improve the use of social media as a tool for disaster management in future events (RQ4).

7.6 Social Media for Response

7.6.1 Online and Offline Data for Situational Awareness

Hurricane Irma made landfall on Antigua and Barbuda on the 6th of September. Shortly after, all communications with the island of Barbuda were lost due to the high winds, stormy seas and extreme weather conditions destroying the telecommunications networks on the island and blocking physical accesses. Interviewee D explained *"we didn't know if anyone over on Barbuda was alive until the prime minister got there and then came back in a helicopter with a report. For 12 hours there was nothing. No VHF communications or anything. The prime minister had to borrow a satellite phone. So that's why I was using Facebook to tell people what was going on"*. This evidences the importance of integrating both online and offline disaster management methods - especially to generate a situational understanding of what was happening during the event. It additionally supported literature which claimed earlier on in this thesis that system approaches combined with human cognition is valuable in understanding situational awareness. This was further demonstrated in data collected from the platforms shown in figure 7.9 below. In this, categories clearly differed across the platforms, which may be explained by the variations in network access across the islands. On Twitter, category 17 was popular which discussed disaster response, rescue and evacuation information: this naturally reflected the emergency evacuation of Barbuda where accounts were mainly re-tweeting

updates from media and authority accounts. On Facebook, network outages resulted in qualitative discussion of which information people had access to, and subsequently why this differed between online and offline. YouTube remained a tool for the dissemination of media and news coverage of the disaster.

A Key for Figure 7.9

No.	Framework Category
11	Document What is Happening during a Disaster Online and Offline
12	Create and Consume News Coverage of the Disaster
14	Express Public and/or Individual Empowerment; Reassure Others
15	Raise and Develop Awareness; Donate and Receive Donations; List Ways to Help or Volunteer
17	Provide and Receive Specific Disaster Response, Rescue and Evacuation Information
20	Understanding How Online and Offline Situations Differ
21	Provide and Receive Information Regarding Response and Recovery; Tell and Hear Personal Stories

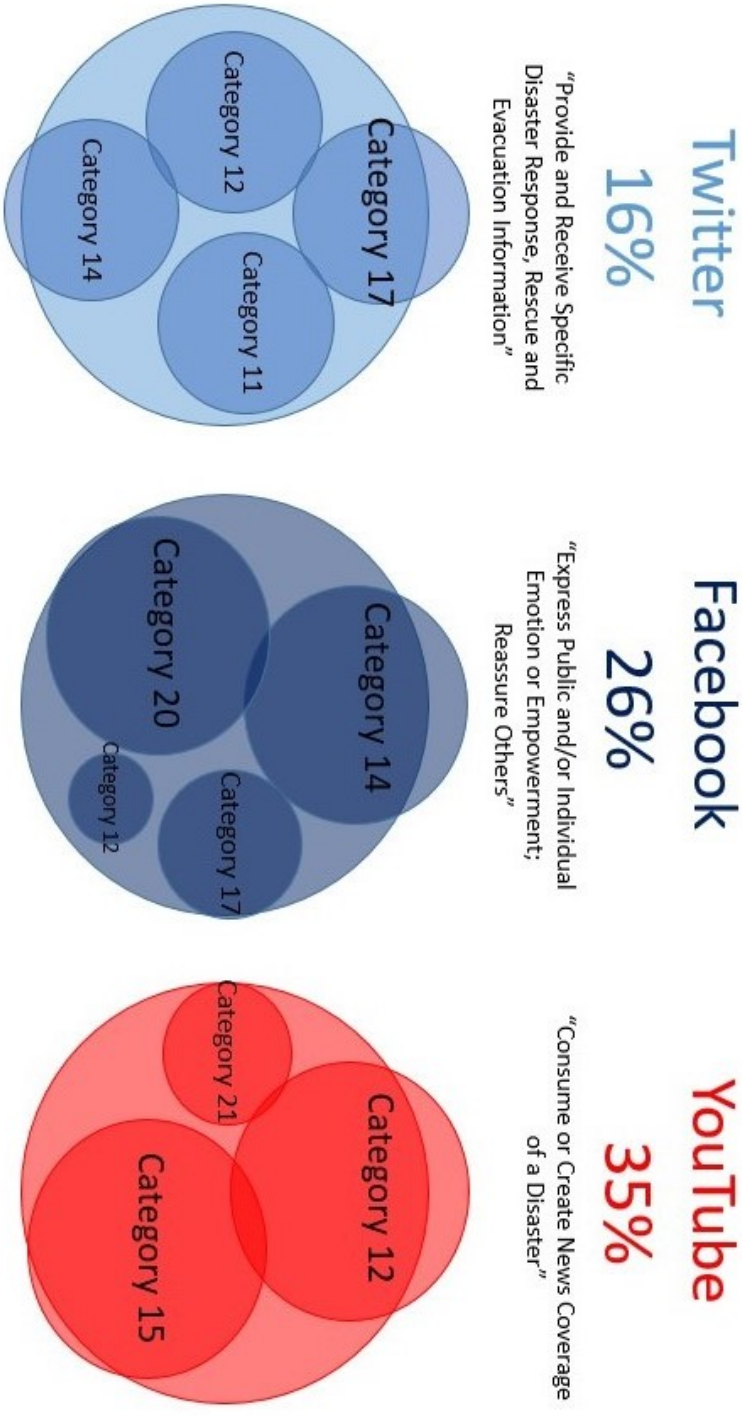


FIGURE 7.9: A Visualisation of Data Content for the Most Popular Categories of the Conceptual Framework for the Platforms Twitter, Facebook and YouTube in the During Disaster Phase of Irma

Despite the breakdown in communications, may of the interviewees explained that due to the plethora of underlying factors that the islands face, they are fairly used to having power outages for short durations of time within the hurricane season (Interviewees U2, U8, N1, N2, M). This familiarity, some argued, was one of the main reasons that the islands have a high resiliency to hurricanes (Interview U2, E1). During Irma however response was on a scale not previously seen before, where the breakdown in communications affected all disaster management authorities and across each of the different types of crisis communications (Interview M). In response to this, many government departments and organisations began to use whatever resources available to generate an idea of what was actually happening before prioritising responses: this again may explain why category 17 was high in Twitter data in figure 7.9 above due to the large volume of re-tweets. Several representatives from such responders explained that the combination of online and offline information was vital in underpinning this initiative, Interview J detailed that *"a lot of people are very active before the disaster. During, its government policy to cut power off. So people would tend to be on Facebook on their mobiles. We're still a bit active then but not as much because, obviously, we want to preserve battery power. Post-hurricane its more door to door and reaching radio stations. We have seen cases, especially in Barbuda after Irma, where the electricity seems to be a big issue, so that's why we keep doing door to door and go out in the community to know what is happening offline"*; Interview C *"even on the night of the hurricane we were out. People would ride out in the storm or try and contact us if they needed to go to a shelter. So we used phones and did physical visits"*.

Responders also highlighted the importance of offline community networks during hurricane Irma for situational awareness. In addition to radio broadcasts (which have previously been identified as important), there are also pre-existing social structures that are utilised for many aspects od disaster response. The Department of Education explained that the school systems are a good way to disseminate information, as children will then inform their wider families about what they're told (Interview E). Similarly, the Ministry for Social Transformation illustrates village social structures as networks of relational and cognitive capital, where the use of appointed village volunteers may act as offline information sources for certain areas (Interview C). An employee of a local church emphasises that the churches are extensively used during disaster response for the islands, not only for the social structures and information that can be passed through them, but also for immediate response shelters and resource storage (Interview U11). Interview K further details that *"in our society the church is as important as the schools and radio for disaster response. They have their own communities and are heavily involved. But with technology and development of our island, and more people using social media, we recognise the need for expanding information online especially through social media, and so that's what we're trying to do"*.

7.6.2 Social Media as a "Lifeline"

During the landfall of Irma, power outages and network collapse meant that the Internet was inaccessible for some 12 hours for certain parts of the islands. Local residents explained that during this part of the hurricane - which many had experienced before - *"we all listen to the radio once the storm has hit. You have no idea what's going on out there but you hear the winds and the sounds. People ring in if the phones aren't down and share their own stories and its comforting you know - its comforting to hear that you're not alone"* (Interview U17). Residents went on to explain that as soon as the Internet was available again, or someone was able to use their phone, people began to consider using social media as an extension of the radio networks as they felt that it was faster. The Ministry for Social Transformation stated that *"cell phones were more affective. WhatsApp especially and calling and Facebook, they were more affective at getting a message out rather than the radio because there were fewer people to contact"* (Interview C). They further argue that for their department particularly, given the nature of their disaster response work in providing communities with help, they felt that social media was beginning to be used more by individuals seeking help also. They stated *"we started getting messages through Facebook and WhatsApp from random people who we didn't know, telling us about this or that situation, and you know that we were needed to help out there. I think maybe someone must have had one of our team's contact details and decided to use it and to pass it on to other people. So in the end we started using those communications as points to respond to, treating them like lifelines"*.

The high use of Facebook as a means for requesting help may be attributed to the platform structure, which allows for more detailed posts, responses and comments. Requests for help can be evidence by figure 7.10 below, which shows a variety of links and videos that were posted to the site. Older citizens who claim to use the platform less extensively theorised that Facebook is beginning to be popular with the younger generation, meaning that it will be used more in coming years (Interview U10). Representatives from a national telecommunications provider postulate that this is because of the level of qualitative expression that Facebook allows compared to the other sites, which is more reminiscent of face-to-face community ties. This in turn has led to local organisations, charities and volunteer groups to begin exploring the allowances of Facebook for themselves. A representative from Antigua Lions, a non-profit organisation helping at-risk individuals in communities, clarified that while their group responds to disasters in a sociological way, they are now beginning to take into account other channels which citizens are utilising to request help. They stated that *"the whole country came together as Barbudans. The whole country. Hundreds of people took people into their homes. Fed them, took care of them, not just the government. The government didn't do anything right away. It was the people who took in the people. We focus on the people, and so we need to know what sites and information the people are using"* (Interview Q).

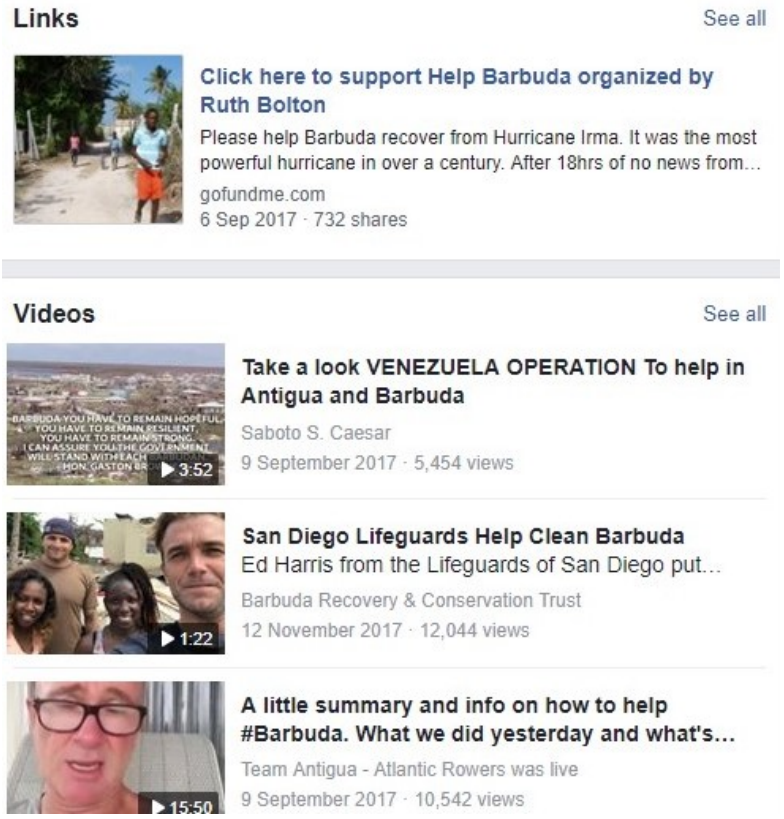


FIGURE 7.10: A Series of Examples of Different Organisations, Groups and Citizens Using Facebook as a Lifeline for Barbuda Disaster Response

7.7 Social Media for Recovery

7.7.1 The Power of Personal Appeals on New Media

Utilising social media for requesting help and resources, as demonstrated in the previous section, also extended into the post-disaster stages of hurricane Irma. This was illustrated by a local business owner whose boat rental service was used in the recovery phase of the event. He explained that *"I went to Barbuda and when I came back I did a Facebook live video just to the people what was going on and what we needed in Barbuda, and that went viral. It was featured in a lot of the British press and I think it had like 80,000 views or something within two days. Mainly because I teared up at the end of it because the lady who lost her child, she came and talked to us. And we were going back to Antigua to nice houses and nice dry beds, and those people were all out sleeping in the rough. So, I use a lot of social media. The thing is, what was really messed up is that the government is really bad at social media. The TV stations and stuff are really good at disseminating information online. Most of their news broadcasts now are on their Facebook page every night - you can watch it better that way. Its just very, very well done. But the government? They were so bad after the hurricane, for six months after they were terrible at communication, and they're still bad. Anyway, because I did this broadcast about Barbuda I was getting friend requests from Barbudans living around the world, telling me that every day they were searching for information and wanting to know what happened. To this day I still say the information given by the government on social media has been terrible"* (Interview E). This was further evidenced not only by the presence of the videos online, but also by it's being featured on global media (The Sun, a British news media) evidenced in figure 7.11 below. This demonstrates how an emotional personal appeal can spread quickly through networks as was claimed by the literature review earlier on in this thesis.

The business owner went on to state that it was not only citizens who used social media for requesting help. Both himself, and a range of other business, charities and organisations began to utilise the service on the behalf of recovery efforts as they felt that they could offer relief to Barbuda themselves (shown in figure 7.10 above). He further explained that *"it was interesting how social media helped with funding really immediately. Whenever we'd want stuff we'd put it out on Facebook groups and have everybody share it. Its a small community so it worked really well and because I've used social media for so long I have a lot of followers. Not many people here use Facebook sensibly for disasters so when one of the few who do use it well actually call for something, then people start sharing it a lot. For example I put out that we were going to Dominica like we did with Barbuda and we need more water supplies for it - and I ended up having like four boatloads of water kegs because people had responded to it on Facebook. You take a few emotionally looking photos and videos and whatever else and you can really manipulate people to help, you know? We did a lot of that for Barbuda, because we felt there wasn't*

enough being done". This can similarly be found in the content of YouTube, which, during the recovery phase, began to evidence more "shocking" video content showing the lives and struggles of evacuees, demonstrated in figure 7.12 below.

'The wind pulled the child from its mother's arms': Man recounts moment two-year-old was killed as Barbuda survivors say they used ropes to tether themselves when Irma struck like a 'horror movie'

- Volunteer [redacted] was one of the first people to arrive on Barbuda after storm
- He said a woman told him a child was 'pulled from her arms' by powerful winds
- Fuller broke down in tears as he told his sad story of the devastation on the island
- Comes as others describe the hurricane as like 'something out of a horror movie'

By IAIN BURNS FOR MAILONLINE
PUBLISHED: 09:15, 8 September 2017 | **UPDATED:** 13:15, 8 September 2017

FIGURE 7.11: A News Article About the Facebook Personal Appeal of Interviewee E which Spread to International Media Sites

Barbudans arrive in Antigua after hurricane

FIGURE 7.12: An Example of Media Following the Evacuees of Barbuda Published on YouTube

7.7.2 Interoperability, Initiatives and International Collaboration

Evidently, the power of personal appeals on social media played a significant role in the recovery of communities from hurricane Irma. Additionally, national appeals showed that their use of social media in light of interoperability failings was valuable for Irma recovery efforts also (figure 7.13 below). In particular, the Ministry for Social Transformation explained that due to a lack of communications and unavailable resources, they were forced to take the initiative and to fulfil governmental roles of recovery outside their department's jurisdiction. They document that in the aftermath of the event usual methods of interoperability were greatly affected, which meant that all resource allocations, evacuations, and rehabilitations of citizens from Barbuda to Antigua has to use traditional administration such as pens and paper, rather than digitised software. They commented that *"there were no structured mechanisms in place so we just had to receive citizens. Check them in, write down medical issues, names, everything was just quick thinking at the time. Eventually we put out local and national calls on Facebook because we needed to organise issues like food - so many people were bringing us food that we had too much of one thing and not of another"* (Interview C). Given the likelihood of systems, communications and networks collapsing during disasters - especially caused by an annual season - this highlights that there is a clear need for better protocols, more robust interoperability testing, and better disaster recovery planning for Antigua and Barbuda.

Broader national and international appeals were also evident which were orchestrated by the government and large humanitarian aid organisations. Examples of this were again shared primarily on Facebook, illustrated in figures 7.13, 7.14 and 7.15 below and targeted specifically at national and international communities respectively. Representatives from the Red Cross clarified their international policy with regards to hurricanes in the Caribbean, stating that *"when someone is impacted by hurricane, the closest Red Cross will come to aid immediately. That being said, when we were impacted, Dominica, Montserrat and St Lucia came to our aide. But then immediately after Dominica was impacted too, so we had to kind of fend for ourselves. We kind of shuffled around between the islands, exchanging resources all of the time and staying very well in touch. Because we know the communities well we can sometimes utilise the resources within the Caribbean because of cultural context - its very difficult for me to bring someone from, say, Australia and try to explain to them how Barbudans operate, It would take me weeks to do that... So really we try to only use human resources from the area, and make sure we do training programs throughout the year so we, too, know all the other volunteers"*. The cultural differences of the islands was also noted by the business owner who made personal appeals on Facebook, who reported that Barbudans from around the world would personally contact him simply because they saw his Facebook content, *"they wanted information from someone who is actually here and who understands what is going on"*.

FIGURE 7.13: An Example of National Appeals Posted on Facebook Groups

FIGURE 7.14: An Example of International Appeals Posted on Facebook Groups

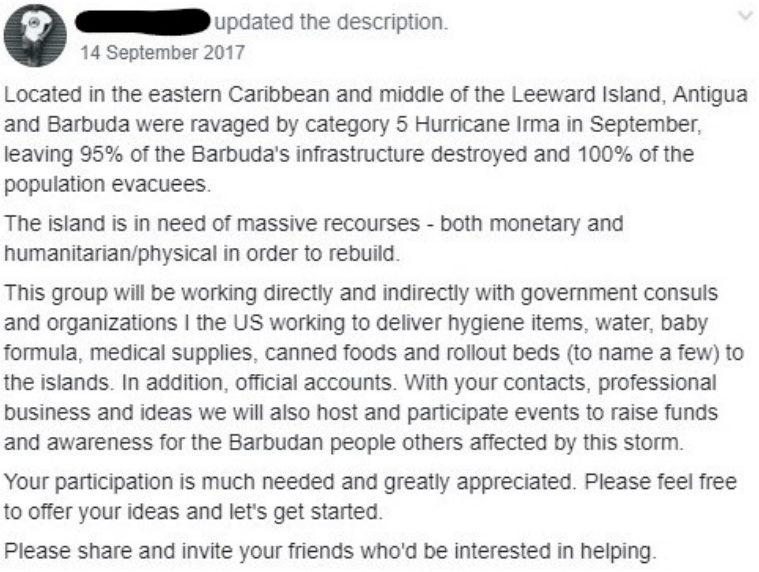


FIGURE 7.15: An Example of International Appeals Posted on Facebook Groups

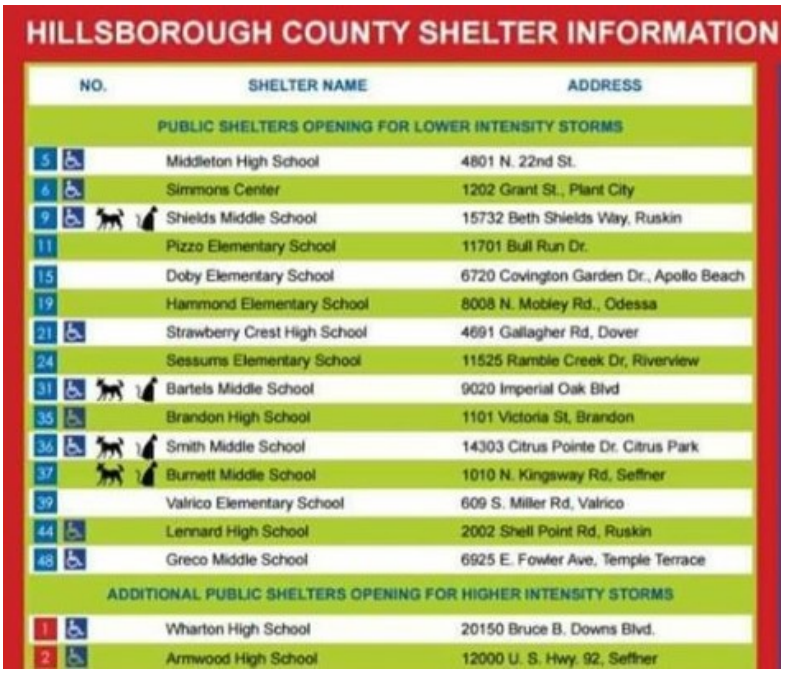
In light of the events of Irma, the Department for Agriculture and Fisheries expressed that international integration and collaboration must be improved for future hurricane seasons, given the issues with Irma response. They clarified that *"the UNDP has a long term programmatic intervention currently going in Barbuda. In the early recovery phase, which we are just about rounding up [as of September 2018], and then going into the medium and long term stages. We started right off of the back of the post-disaster needs assessment, conducted right after the hurricane and went straight into the early recovery phase with funding from the government of China. That has addressed things like housing repairs. Now we're going into the medium to longer term resilience programming with funding from the government of India as well as the European Union (EU). We're then looking at expanding the resilience programs beyond housing repairs and going into certain areas like livelihoods, the blue economy, renewable energy and integrating all of these into a better program for the islands"* (Interview I).

Representing the approach of humanitarian aid organisations, the Red Cross stated that *"our operations have changed a lot in the way that we need to move forward, integrate and collaborate. We have now begun doing things like finance forecasting that we didn't have in place before. Putting together trade deals with different hardware stores, because we realised that the items we had immediately for hurricane response weren't sufficient - it highlighted areas of our disaster plan for recovery that it's important to double up on everything. We are heavily investing in communication equipment too, and an early warning system. CEDMA is funding the training, the use and the upkeep of the equipment. But the government of Antigua said, well you want to fund this but we don't have the funds to buy the equipment. So we, through Irma response, were able to finance the purchases of it, and it will be handled by NODs. But it will be maintained through CDEMA, so really its a collaboration between many groups to boost recovery, and to make sure we're more prepared next time"* (Interview J).

7.8 Social Media for Risk Reduction

Throughout all stages of hurricane Irma, it became apparent that there was a breakdown in A2A communications. In response to this, the Department for Agriculture and Fisheries stated that *"a lot was destroyed in the hurricane which meant there was not much communication between departments and even between the islands. There was talk after of laying an undersea fibre optic cable. Either way we need to strengthen the communications between the islands"* (Interview I). Representatives from the MET office explained that the national structure for communications in light of disaster followed certain steps, where NODS remains the central actor. They clarify that *"our information is put out on the website and maybe social media. There is also a million email lists for specific persons that we will email information out to. We provide information and the Disaster Office [NODS] will decide whether they need to open shelters, if they need to*

mobilise whatever resources. I think the way that the structure works is that the prime minister is actually the head of the disaster structure. So, the director would decide whether or not he needs to go to brief the prime minister with the cabinet" (Interview H). Consequently, many authorities and similar services have begun to host information on their own personal sites and services in an attempt to consistently allow citizens to have access to important information, an example of which is shown in figure 7.16 below for hurricane shelter points on the islands.



HILLSBOROUGH COUNTY SHELTER INFORMATION

NO.	SHELTER NAME	ADDRESS
PUBLIC SHELTERS OPENING FOR LOWER INTENSITY STORMS		
5	Middleton High School	4801 N. 22nd St.
6	Simmons Center	1202 Grant St., Plant City
9	Shields Middle School	15732 Beth Shields Way, Ruskin
11	Pizzo Elementary School	11701 Bull Run Dr.
15	Doby Elementary School	6720 Covington Garden Dr., Apollo Beach
19	Hammond Elementary School	8008 N. Mobley Rd., Odessa
21	Strawberry Crest High School	4691 Gallagher Rd, Dover
24	Sessums Elementary School	11525 Ramble Creek Dr, Riverview
31	Bartels Middle School	9020 Imperial Oak Blvd
35	Brandon High School	1101 Victoria St, Brandon
36	Smith Middle School	14303 Citrus Pointe Dr. Citrus Park
37	Burnett Middle School	1010 N. Kingsway Rd, Seffner
39	Valrico Elementary School	609 S. Miller Rd, Valrico
44	Lennard High School	2002 Shell Point Rd, Ruskin
48	Greco Middle School	6925 E. Fowler Ave, Temple Terrace
ADDITIONAL PUBLIC SHELTERS OPENING FOR HIGHER INTENSITY STORMS		
1	Wharton High School	20150 Bruce B. Downs Blvd.
2	Armwood High School	12000 U. S. Hwy. 92, Seffner

FIGURE 7.16: An Example of Authorities Hosting Information on Their Own Sites. Source: NODS website

The structure and protocols for national disaster response was undermined through a lack of communications. NODS, the department as the core of disaster management for the country, voiced in their own words what they felt had contributed to the breakdown in A2A communications. *"Even before the MET office publish any bulletin of any sort they have to tell us first, so that gives us the chance to communicate and ask questions, and get more information before its then put out to the public. Then we look at communications with the press, and other relevant departments. The main issue that we had throughout Irma was the breakdown in communications and the delay in assessments, partly because the hurricane didn't do as we expected it to, and partly because of the collapse in networks. We had to send out employees with walkie-talkies in the response phase to collect information in person. We had departments who didn't know where they were feeding information, and we didn't have a big enough team to process a lot of the information we received. A lot of our governmental discussions and approach and so on took place in person to avoid further confusion - these meetings are still happening in person to this day"* (Interview M). In contrast, there was a lack of evidence of A2A in the data collected from the social media platforms. This may be attributed to the

protocols followed by disaster responders, who tend to follow official channels of communication that cannot be found by scraping open social media data. This supports the notion that interviews with relevant individuals and groups are of value in explanatory methods that seek to understand social media, and particular their relationship with disaster management.

There was evidence of A2C communications across each of the social media platforms, but particularly on Twitter and Facebook. This again was voiced by a range of interviewees who represented authorities and organisations who were expanding their information onto online sites, as previously mentioned. The MET office argued that while they were slowly integrating more onto Twitter, they felt that in order to do this successfully they would need to hire a social media specialist specifically to ensure that A2C communications were of a high enough standard to reduce risk throughout disasters (Interview H). In hindsight of hurricane Irma, representatives commented that *"re-tweeting is - I mean if the information is solid - I think it does help underscore it to the public. The challenge is always monitoring what's coming out, and from other places, and the extent of that. That's something that we the organisation need to get better at"* (Interview H). This was issue identified by other authority groups, and even by NODS who stated that *"prior to the hurricane season we would set up public reminders on our website, which is up and down - I say that because we don't manage it's operation, that's done by government IT units not under our jurisdiction, even though its our site and disaster information comes through only us. So, we are stuck between a rock and a hard place"* (Interview M).

General dissatisfaction with A2C was noted in interviews with local citizens (Interviews E2, E3, G, U4, U7, U8), as well as by business owners who complained that *"the guys who are in charge don't know anything about social media. Nothing Whatsoever. Because they weren't using social media they didn't know what was going on"* (Interview E1). In response to this, some authorities have noted the need to improve their online output in conjunction with the offline. The MET office as an example of a service looking to expand more into online A2C, explained that their current method following Irma has changed. *"We have a hotline service and people can call in and ask for specific information. We also do TV broadcasts when we're invited. Last hurricane season [2017] we were pretty much unprepared until the main TV station ABS - who are our partners in getting information out - started doing more broadcasts. Last year we finally had someone at ABS who understood a bit more about climate and so that improved our relationship with them, and that them reflected in the information we could put out"* (Interview H). This highlights how underlying factors such as economics, as well as prior situational awareness of hurricanes, can impact risk reduction throughout an event.

Unrest was reported by volunteers and local business owners who had decided to help with recovery efforts, mentioned earlier in the chapter. *"NODS are charged with emergency preparedness stuff, but they were understaffed and underfunded and they aren't*

listening to us - and we're the ones going over there the most often. Communication was so bad"(Interview E1). They detailed that even when they received a response from an authority it would not feature much detail, would contrast an existing piece of information supplied by a different authority, or would be extremely time-critical (Interviews E1, E3). This, they argue, undermined their own recovery efforts and increased the risk of communities who were still waiting on vital post-disaster supplies and resources (Interviews E1, E3). While there was a general unrest recorded with C2A communications, many individuals noted that the use of social media was valuable for C2C. The Ministry for Social Transformation emphasised the importance of this by detailing that *"Barbudans had been living within a mile of one another for generations, and then after the evacuation they scattered. They were no longer able to just walk over to someone's house and communicate. That's why communication via social media became so important"* (Interview C).

The businesses and organisations involved in recovery, too, supported the use of social media for C2C, stating that *"Barbudans didn't update anyone with their phone numbers or anything so really social media was the only thing that they could have been gotten hold of through, considering that they've been dispersed in the evacuation. But the government still wasn't doing that, so we were doing it from person to person. Just asking people if they knew someone then to pass information along"* (Interview E1). Further to the C2C noted on Facebook, interviewees illustrated that this kind of communication happened through other means also. Interview U11, a local volunteer, explained that *"people talk through the networks of their village or church or radio station. Slowly its happening more on social media and even the churches and so on are using it. As a volunteer we use it to communicate between ourselves too, but mainly I use to talk to friends and family"*. Interview U8 similarly described that their use of social media was primarily concerns with their relationship with others, rather than for seeking further disaster information. They detailed that *"[I] still use WhatsApp to stay in contact with friends and family who have moved back to our island. It allows us to stay in contact and still feel close while we are still going through the process of re-building our lives"* (Interview U8).

7.9 Summary

This chapter has presented the results of hurricane Irma for the nation of Antigua and Barbuda in the 2017 Atlantic hurricane season. It has detailed that the event was shaped by the outcomes of geographical, demographical, political and economic factors which in turn affected the uses and users of social media as a tool for disaster management. It has gone on to demonstrate that the social media platforms of Facebook, YouTube and Twitter were used extensively, both national and internationally, throughout each of the disaster life-cycle phases of the event (RQ1 and RQ2). The use of qualitative

interviews has further explained the results found in social media data, thus providing an understanding of the benefits, limitations and relationship between social media use and the case study (RQ3). As a result, original academic contribution has been made to the field of disaster management through the study, which has been documented in the papers Gray et al. (2018, 2018a, 2019, 2019a).

The results gathered from this case and the previous one will then form the basis for the next chapter. In this, a discussion will be presented that focuses on the main themes that have emerged throughout the case studies. This will be conceptualised across the disaster life-cycle phases and social media's use for resiliency, response, recovery and risk reduction. Each of these sections will take into account findings from the literature review and study results to form proposed recommendations to improve social media as a tool for disaster management in future events (RQ4). The chapter will conclude by re-capping how this thesis has answered each of the RQs, presenting the study limitations, and finally concluding remarks.

Chapter 8

Discussion and Conclusions: Proposing Recommendations for the Use of Social Media in Future Events

The previous chapters have presented the results of each case study. For both of these, a novel methodological approach has been followed which has collected data from the social media sites of Facebook, YouTube and Twitter. Following this, the application of the conceptual framework (which was created earlier in this thesis) has been applied to the data, highlighting the users and uses of social media (RQ1), as well as the change in content throughout the disaster life-cycles of the cases (RQ3). The edition of qualitative interviews has sought to circumnavigate some of the issues with social media data, such as privacy laws and technological structures. These have supported the explanatory research design previously detailed, and have allowed individuals to further explain the role of social media during disasters. Research presented in this chapter has been published in the papers Gray et al. (2018), (2018a) and (2019)

The Kaikoura earthquake found that Facebook in particular played a valuable role in the exchange of information for online communities which later gained momentum in the during and post-disaster phases. It revealed that groups and pages were extensively used for a range of different types of information which were highly tailored to specific regions affected by the disaster, rather than for generalised national preparedness information alone. On Twitter, there were issues of information reliability as certain authority accounts initially misidentified the scale of the earthquake, which then propagated through the network due to the short length of tweets and re-tweets. On YouTube, particularly as events were unfolding and the rest of the world began to see the affect of the earthquake, visualisations of the event represented a new paradigm for generating

situational awareness. Underlying geographical, demographical, political, and economic factors were all found to shape the outcome of the disaster, a majority of which were caused by the previous Canterbury earthquakes in 2011.

Hurricane Irma, on the islands of Antigua and Barbuda, similarly found that Facebook groups and pages played a central role in the exchange of information, particularly for community resilience. Unlike Kaikoura, the platforms were gaining popularity during the Atlantic hurricane season with authorities looking to expand more to having an online presence. This meant that, in conjunction to the social media platforms, traditional media such as TV broadcasts and radio stations remained extremely important to communities during the hurricane. Due to a lack of hurricane-reinforced technology, many individuals explained that the combination of online and offline methods were necessary for the management of the disaster, which many authorities seek to improve in future events. Both Twitter and YouTube recorded a high volume of users and uses globally, driven by the fact that Irma affected the entire Atlantic basin. Similarly to Kaikoura, underlying geographical, demographical, political and economic factors were all found the shape the outcome of the hurricane for the nation of Antigua and Barbuda, particularly given its SIDS status.

The results from each of the case studies have been demonstrable of the current relationship between social media and disasters. However, in order to draw conclusions from their analysis, this thesis must first re-cap the RQs and overall statement in the following section. Then, the chapter will present a discussion centred around each of the uses of social media across the four R's of resilience, response, recovery and risk reduction. These will compare the results to previous examples highlighted in the literature review, explain the meaning of the findings, consider explanations for these. Using these as a basis, each section will present a proposed recommendation for the improved use of social media during future disasters (RQ4). Next, study limitations of the thesis are acknowledged. Then, the academic contributions of this research are reiterated which take three main forms: (1.) a novel methodological approach, (2.) improved understanding of disasters, and (3.) five proposed recommendations to improve the use of social media in future crises (as well as listing the published research papers throughout). Finally, a conclusion is presented which will summarise how each of the research questions have been addressed, thus accepting the overall thesis statement.

8.1 Re-capping the Thesis Research Questions

8.1.1 Thesis Statement

This thesis argues that social media as an example of new media, hold paramount importance to reduce risk in future disasters. It postulates that in order to lessen negative

impacts from future crises, the relationship between social media and disasters needs to be understood in more detail. This includes the current uses, users and applications of social media within disaster management, given the rapid socio-technical progression of a globalising world. It theorises that this knowledge will help to improve modern methods of disaster management, where complex underlying factors still shape the outcome of crises.

8.1.2 Research Questions

This thesis follows the notion that new media, in particular that of social media, holds paramount importance to reduce risk in future disasters. It argues that in order to lessen negative impacts from crises, the relationship between social media and disasters needs to be understood in more detail. This includes the current uses, users and applications of social media within disaster management, given the rapid socio-technical progression of a globalising world. It theorises that this knowledge will help to improve modern methods of disaster management, where complex underlying factors still shape the outcome of crises. The overarching question is:

> **"What is the current role of social media during natural disasters, and how might this be improved to reduce risk in future crises?"**

However, in order to assess the role of social media in a modern context, as well as its relationship with disaster management, a number of sub-questions have been formulated. These are as follows:

> **RQ1.** How are different social media platforms used during disasters, by whom, and to what purpose?
>
> **RQ2.** In what ways does the content of social media change throughout the disaster life-cycle phases, and why?
>
> **RQ3.** What are the benefits, limitations, and scope of selected social media during case studies, and how might the analysis and comparison of these provide valuable insight for future events?
>
> **RQ4.** How might original research and insight on selected case studies be used to formulate improved social media protocols or suggestions for disaster management?

Each of the RQs will be answered in the following section, which conceptualises the relationship between social media and disasters across the four R's of resilience, response, recovery and risk reduction. The next section will begin with social media for resilience purposes.

8.2 Discussing Social Media for Resilience

The use of Facebook groups and pages as a means of cultivating community preparedness and resilience was evident in both case studies. For Kaikoura, many groups and pages dedicated to monitoring seismic hazards pre-existed the disaster. This may indicate the presence of "relational communities", which Paton and Johnston (2017) argue is a beneficial consequence of using social media for shared concerns, where individuals seek further information as well as ways to learn from experiences. Certainly in the case of New Zealand, the outcomes of Kaikoura have been influenced by the previous Canterbury earthquakes in 2011, where national resilience has since demonstrably increased as a result of lessons learnt. This aligns with the findings of further studies such as Wenger (2002), who argue that communities of practice are more easily formed following a disaster, when information seeking by those affected filters into pre-disaster resiliency before any more future events occur. This was evidenced across all social media platforms by the series of comments, posts, media campaigns and visualisations which show that the outcomes of the Canterbury earthquakes were very much still a concern for communities in the present day.

While leveraging Facebook groups and pages for resiliency may represent the presence of "relational communities" in Kaikoura, it may also be explained by other theories. Cox and Perry (2011) for example argued that the higher the social capital of an area before disaster, the more power social media and community networks have in shaping the resilience and engagement levels that a community has. While interviewees who experienced Kaikoura stated that they believed social capital was high, they also explained that a majority of them didn't start using Facebook for resiliency purposed until the during to post-disaster phases. Another possible theory is that of Dufty (2012) who postulated that the speed of online communication during an event may too increase the level of resiliency that a community may have. Given that New Zealand has one of the highest national proportions of Internet access in the world, this may offer another valid explanation. However, it is one that may only be theorised as opposed to tested, as such measures are complex, costly and time consuming which goes beyond the scope of this thesis.

The use of Facebook groups and pages in the case of hurricane Irma may on the other hand be explained by a different set of factors. Although Antigua and Barbuda have experienced severe hurricanes before, their population has much lower access on average to social media compared to New Zealand. Therefore, the high resiliency of Facebook communities during Irma is more likely to be similar to the findings of studies such as Becker (2013) and Nakagawa (2004), who argue that exposure to risk throughout one's life increases an individual's level of resilience and preparedness. This was supported by interviewees who claimed to access Facebook throughout the entirety of the hurricane season, rather than picking it up in the during and post-disaster phases of Irma for lessons

learnt purposes. Furthermore, the high use of Facebook for community resilience may further evidence studies such as Norris (2008) which claim that communities are more homogeneous when coping with extreme events or crises.

Although Facebook use during Irma can be considered homogeneous, the findings of the case study indicate that unlike Norris's (2008) findings, there are more than four factors which may dictate community resilience (information and communication, community competence, social capital and economic development). In the reality of complex and high magnitude events it is Pfefferbaum's (2013) findings, which adds four additional considerations (connection and caring, resources, transformative potential and disaster management) which is a more accurate representation of community resilience. Differences across these additional considerations may explain some of the variations in disaster outcome experienced by each of the case study communities. Resources, for example, resulted in a much lower recovery and rebuilding rate in Antigua and Barbuda compared to that of New Zealand. Further results from both case studies identified more factors present which should be taken into future consideration such as Web accessibility and information reliability.

The accessibility that individuals have to the Internet was identified as a gap in the literature, as well as being emphasised throughout interviews as an important gateway for safety-critical information. Furthermore, the extension of information dissemination within online networks is another considerable factor, where information reliability, timing, credibility and speed of spread again dictate the capacity a community had to increase their resilience and preparedness. Geographical, demographical, political and economic factors were each found prominent in both case studies, and affected all types of social media data. Therefore, this thesis postulates that additional factors should be added to the findings of of Norris (2008) and Pfefferbaum (2013): that of Web accessibility, information reliability, geographical, demographical, political and economic factors. These evidently contribute to understanding community resiliency on social media, and may potentially be beneficial in enhancing it during future events, thus answering RQ4.

8.2.1 Proposed Recommendation 1: Developing Community Resilience for Future Events

In light of the findings from both case studies, a proposed recommendation for future events has been formed (RQ4) which focuses on the use of social media in developing community resiliency during disasters. This has been informed by the literature review, from case study data, and particularly that of the interview results. The recommendation is formed of one main step: (1.) Creating a range of downloadable resources.

Throughout both case studies interviewees highlighted the need for a range of resources tailored to each of the disaster phases. For New Zealand, despite already having a

range of resources (shown in chapter 6), interviewees explained that these were primarily designed for educational purposes and so were not applicable to the entire population. For Antigua and Barbuda, many authorities and organisations are at the beginning of expanding onto social media for disaster purposes. Consequently, few online resources exist that are tailored to the islands themselves and so the government tends to utilise generalised resources created by larger bodies such as the Caribbean Disaster Emergency Management Agency (CDEMA). In both case studies telecommunication networks and the Internet collapsed for a period of time, which made online information inaccessible for those located in affected regions. In this kind of situation, prior resiliency is of paramount importance to ensure that individuals know what to do to reduce the risk that they are exposed to (Pelling and Uitto, 2001; F. H. Norris et al., 2008).

Particularly for countries that utilise social media as a tool for disaster management there is a need to develop valuable resources for communities that both increase resiliency, while simultaneously not increasing risk. For example, an online tool may provide important information in crises, but if the networks collapse and it is no longer available it should not be the only tool an individual may rely on. This is evidenced by the literature review, where studies argue that Web accessibility is becoming more important in a globalising world and is an observable factor in reducing risk throughout disasters (Palen and Hughes, 2018; C.-M. Huang, Chan, and Hyder, 2010). Interviewees from authorities and organisations throughout both cases argued that they would like to host more online resources that are designed to increase community resiliency. This also supports literature examples such as Becker (2013) and Springgate (2011) who propose best practices for disaster educational resources.

Firstly, it would be beneficial for governments, authorities and organisations involved in disaster management efforts to compile a series of videos. These should be hosted in the same format across a range of social media platforms, which has the option of being tailored to the popularity of certain platforms in certain areas considering underlying factors such as geographical privacy laws. Videos should use a range of different types of visualisations to maintain interest on a topic that has a high community awareness already, as evidenced in the popularity of more shocking YouTube videos during the Kaikoura earthquake. Secondly, such resources should be aimed at different age brackets of the population so that underlying demographical factors, such as the digital divide, may be accounted for without affecting resiliency. Importantly, the core message of resources should remain the same despite the age bracket it has been designed for in order to avoid issues with information reliability during future events.

Thirdly, any resources created and hosted by authorities and organisations should have the option to be downloaded and stored in an offline format. This would both benefit resilience, while also not increasing risk should networks collapse during an event. Finally, collaboration between authorities and organisations involved in disaster management for a particular area is necessary to ensure that the same resources can be hosted by

different bodies, and across a range of sites. This would reduce the risks of making safety-critical decisions for the public, as no matter which hub they seek information from, they are guaranteed to have access to the same core message of correct information. These steps may additionally be tailored to a certain community by taking into account, or measuring, unique underlying factors. For example if they are identified as being at-risk from re-occurring events within a defined geographical area, or hosting videos in a second language such as Maori, considering the culture of an area.

8.3 Discussing Social Media for Response

In the case of the Kaikoura earthquake, Twitter was valuable in detecting and tracking hazard-specific trends during the response phase (i.e. for #tsunami trends following the initial earthquake). This functionality was strongly identified throughout the literature review, with many studies highlighting cases and methods for generating situational awareness. While examples such as Abdullah (2017) and Choi (2015) argued that automatic classification systems and algorithms of their devising were able to effectively track Twitter trends, it was also demonstrated in the case study results of this thesis that basic identification - minus the high levels of resources available to these studies - was possible using a simpler methodology. This supports the claim that Twitter has a beneficial technological structure and data format argued by key literature such as Reuter (2017), thus making it the most extensively studied platform for disaster management purposes (Robinson, Power, and Cameron, 2015; Imran, Castillo, et al., 2014).

Issues of information reliability were also illustrated by the incorrect tweeting of authority accounts during the response stage of Kaikoura. Studies such as Kedzie (2015) and Rudra (2016) theorise that unreliable information on the platform is likely caused by difficulties in accurate automated analyses. This is not probable given the lack of automation in the methodology of this thesis, therefore mis-information must be explained by other theories. Hughes and Palen (2012) identify a range of potential causes for compromising information reliability that include incorrectly citing original information, re-tweeting false information, emotional reactions to crises, anonymous profiles, genuine mistakes, marketing influences, and social pressures. This aligns with the analysis of Kaikoura tweets considering that the original mis-informed tweets were deleted after the accounts realised that the information was incorrect. The removal of false information was documented by literature such as Thomson (2012), but still faces problems on Twitter given the velocity and spread of re-tweets.

The differences in response between the cases of Kaikoura and Irma highlight the continued presence of the digital divide in present-day disasters (Van Dijk, 2006). This was evidenced through variations in population with access to the Internet, level of digital literacy, and levels of technology available to households. While Kaikoura experienced

information reliability issues on Twitter, Irma's general disaster warnings were predominantly broadcast on radio stations and TV broadcasts. This is a unique finding of this thesis, where there is little published documentation of the "unofficial" structure of information dissemination in SIDS during crises. Interviewees explained that relying on radio stations for updates was necessary given that networks and power collapses often during the annual hurricane season. This aligns with the claims of literature such as Sutton (2010), who documented that individuals will seek information through various channels during disaster if they feel that they require more situational awareness, especially if they feel at risk.

In the case of hurricane Irma information seeking for situational awareness was more heavily affected by power and network outages than Kaikoura. These were exacerbated by underling issues such as the flat geography of the islands and lack of local skilled engineer workers, resulting in a longer period before communications. Consequently, outages lasted for longer than in the case of Kaikoura, which authorities and responders explained caused them to rely on a combination of both online and offline resources to generate situational awareness instead. In Antigua and Barbuda communications for response (for A2A and A2C) mainly used walkie-talkies, VHF radio and satellite phones. Many interviewees, especially representatives from governmental departments, further explained that for SIDS, it was physical presence of volunteers and workers that were more valuable in helping communities during the disaster. This correlates with wider literature which argue that face-to-face communication should not be underestimated during crises (Jaeger et al., 2007). It also supports the findings of studies such as Jigyasu (2002) who emphasise the importance of local knowledge in reducing vulnerability.

Situational awareness for hurricane Irma highlighted the value of integrating online and offline methods for disaster response, which emulate the findings of studies such as Kapucu (2008). In this, community planning and coordination have high value in reducing risk during disaster, which rely upon affected communities having high levels of prior resilience. Similarly to Kapucu's (2008) results, elected volunteers within communities for Irma acted as intermediaries between responders, communities and authorities. While interviewees outlined the success of such volunteers in face-to-face situations, they also explained that a breakdown in communications combined with network outages undermined any further potential. Further to Kapucu's (2008) argument however, interviewees explained that due to the breakdown in communications their response went beyond their jurisdiction. This thesis therefore demonstrates that not only were local volunteers valuable in generating situational awareness, particularly for SIDS who face unique issues such as remoteness, but that responders and authorities alike have a drive to help their own communities despite limitations.

Continued and more explicit use of social media during crisis response was a theme of the interviews from both case studies. For New Zealand, this mainly took the form of more accurate generation of situational awareness, which reflected similar case studies

of more developed countries such as Tapia and Moore's (2012) analysis of social media use by the US government. For Antigua and Barbuda, it took the form of extending and integrating methods for response online, working alongside previously well-established offline methods such as radio networks. This reflected results of other similar case studies which evaluated disaster risk in SIDS, such as Pelling (2001) and Shultz (2016). They, too, highlight the disproportionally high level of risk from re-occurring hazards, lack of available resources, and a reliance on tourism which greatly affects SIDS ability to respond to disaster. Consequently, steps should be made to better integrate online and offline methods in complementary response planning considering SIDS increasing access to the Internet in the coming years.

8.3.1 Proposed Recommendations 2 and 3: Incorporating Online Volunteers and Social Media Specialists

In light of the findings from both case studies, a proposed recommendation for future events has been formed (RQ4) which focuses on the use of social media in supporting response during disasters. This has been informed by the literature review, from case study data, and particularly that of the interview results. The recommendation is formed of two steps: (2.) Integrating online and offline volunteer strategies, and (3.) Incorporating social media specialists into response strategies.

8.3.1.1 Proposal 2. Integrating Online and Offline Volunteer Strategies

During crises, communities often have elected volunteers who liaise between the public and authorities. In Antigua and Barbuda each village had one to three pre-designated volunteers who essentially were "on duty" throughout the annual hurricane season. These volunteers were in regular contact with authorities should any hurricane warnings be issued, and each were required to attend annual training on communications protocols. Due to the nature of communities in SIDS interviewees explained that everybody in a settlement knew their volunteers in a face-to-face setting, which they argue makes communications and trust easier during disaster. This corresponds to the notion of social capital as a beneficial aspect for disaster management outlined by studies such as Cox and Perry (2011) and Nakagawa (2004).

In New Zealand, the structure of deploying volunteers differed. While earthquakes are a common hazard in the region, these are not confined to a specific time-frame during the year like the annual Atlantic hurricane season. Instead, during crises it is representatives from authorities, responders and humanitarian aid organisations who form volunteers groups for response. Though this type of volunteer has a higher level of training given their background and/or vocation, it also means that they are not present in communities in a regular face-to-face capacity until a disaster occurs. This arguably represents lower

social capital than during Irma, but resulted in quicker rebuilding and recovery. It is probable then that the more extensive use of social media and online resources for forming relational communities are able to generate their own social capital. This is an interesting finding which supports literature such as Lu and Yang (2011) who identify high levels of social and cognitive capital in online communities following the Szechuan earthquake in China.

To incorporate the value that social media may offer communities during disaster response, it is suggested that volunteers should be elected for online networks, which is a notion that has been proposed by studies prior such as Reuter (2013). Online volunteers would combine with those in an offline setting to allow for the generation of both social and cognitive capital across both real-life and virtual spheres. The role would involve the monitoring of online channels disseminating information about an event, being an active part of virtual communities as a trusted source or "hub", and to report to authorities on the dynamics of online communities and their concerns. Training on degrees of centrality and enhancing their level of trust online may too be valuable for such volunteers, thus ensuring that their online actions utilise the structure of social media to its potential (Kim and Hastak, 2018). The process by which volunteers are elected would need to be dictated by the regional government, and the communication protocols pre-determined before an event. Once elected, online volunteers would become known to the local community in a similar way to real-life volunteers, only in an online context.

Online volunteers would however require a different set of skills to offline ones. They would need to maintain a high level of digital literacy to ensure that they can find, understand and report back information originating from a range of different online channels and resources. This type of training may vary based on a country's level of annual expenditure, and the percentage of individuals with access to the Internet within their jurisdiction. Governments would therefore need a detailed understanding of the geographical, demographical, political and economic underlying factors of an area that have the potential to shape social media use. Much like real-life volunteers, having a multitude of online volunteers would ensure better feedback to authorities in the event that volunteers may be incapacitated or killed during a disaster (Reuter, Heger, and Pipek, 2013). Subsequently, more sources of feedback would allow for comparison and cross-referencing, thus enhancing situational awareness both online and offline, as well as improving the reliability of information (Reuter, Heger, and Pipek, 2013).

8.3.1.2 Proposal 3. Incorporating Social Media Specialists into Response Strategies

While the option of online volunteers may increase situational awareness during an event, there remain limitations with the concept. Firstly, in some cases it is difficult to identify

mis-information online regardless of training. This is due to the fact that there are many factors which can affect information reliability, which have been previously explained in this chapter. Secondly, social media platforms themselves do no enforce standardised protocol for sharing information online during events. This means that online volunteers would need extensive training in different data formats, content, and platform structures which may be costly for authorities to run, and time-consuming for individuals who are unpaid for volunteering.

An option to avoid these limitations then is to hire and train social media specialists who would be employed by the governments, responders and humanitarian aid organisations involved in disasters (Palm, Polusny, and Follette, 2004; Lindsay, 2011; Briones et al., 2011). This proposal was strongly argued by interviewees who worked within bodies who respond to disasters themselves for several reasons. Firstly, employing specialists would alleviate the pressure of monitoring online channels from existing employees, allowing them to focus on other critical tasks. Secondly, specialists would be more aware of platform variations and context as part of their job specification, thus reducing the level of training needed. Thirdly, specialists would be able to design and implement departmental protocols for the creation and dissemination of disaster-related information. This would further allow the role to collaborate inter-organisationally with others for community and/or region specific strategy (H. K. O'Neill et al., 2014).

8.4 Discussing Social Media for Recovery

Throughout both case studies YouTube was documented as being valuable for visualisations. This may be due to the fact that the platform structure is extremely different from Facebook and Twitter, and is the only one of the three sites that has a primary focus on video content. For Kaikoura, the most popular videos involved shocking imagery of hazards linked to the initial earthquake, such as the tsunami, aftershocks and rock slides. This may represent the "shock factor" which is a phenomenon documented extensively in crises due to their impactful and devastating nature (Olteanu, Sarah Vieweg, and Castillo, 2015). This supports more generalised theories presented by literature such as Cottle (2014) who argues that social media has become a global stage which allows individuals from around the world to observe the unfolding of disasters.

It may also represent other social factors at play on platforms that are associated with generating high levels of attention as well as sharing. For example, Hughes and Palen (2012) postulate that there are any number of complex sociological phenomenon, subtle political flows, presence of online human behaviours and marketing campaigns that may influence the popularity of social media content. Despite the benefits documented by interviewees of YouTube videos in generating recovery attention, there is no conclusive evidence that explains why one video may be far more popular than another video,

especially if the content is fairly similar. This represents an interesting area for future work in measuring how the shock factor functions on different social media platforms, whether it can be measured accurately, and whether this represents a new paradigm in online human behaviours - an important consideration for the management of future events.

Beyond the use of YouTube, there were a variety of personal appeals noted across platforms for each case study. During Kaikoura, this was affected by underlying political factors which stemmed from the Canterbury earthquakes. It may be argued that the use of social media to reiterate political unrest to a global stage once again supports theories such as Cottle (2014), where different channels, made possible through globalisation, have been utilised to raise awareness of other issues. This was similarly noted during Irma through personal appeals on Facebook and Twitter, rather than YouTube alone. Alternatively, this may support theories such as the prominence of emotional sentiment. This is argued by studies such as Grassi (2011) as being a driver of information spread in online networks. While this is possible, semantic analysis as well as the big data sets needed for valid testing, are outside the scope of this thesis and may therefore only be speculated.

While personal appeals were apparent throughout both cases, the documented ones throughout Irma focused more on an international audience rather than a regional one. This was explained by interviewees as being necessary to generate more resources for recovery, to raise awareness of the political tensions of the country, and to request help from more developed areas. It may also have been caused by the wider geographical area affected by hurricanes, in comparison to the more contained area of the earthquake: naturally more people were affected personally by Irma's path, and so were more invested about finding and consuming information about the hurricane. In this sense social media was used as a tool to increase the transparency of actions and methods of recovery. This concept was evidenced in other studies of SIDS such as Kelman (2015) and Petzold (2015) who identify the use of social media for casting light on other issues that islands face, such as climate change and protecting the blue economy. It can be theorised then that international leveraging of social media may too be valuable in raising disaster awareness, particularly for SIDS.

8.4.1 Proposed Recommendation 4: Cultivating a "Lessons Learnt" Methodology

In light of the findings from both case studies, a proposed recommendation for future events has been formed (RQ4) which focuses on the use of social media in supporting recovery after disasters. This has been informed by the literature review, from case study data, and particularly that of the interview results. The recommendation is formed of

one main step: (4.) Cultivating a lessons learnt methodology from authorities and responders.

Interviewees explained that a wealth of lessons were learnt from the management of the disasters, especially in the case of Irma. However, they explained that there was no mechanism in place for the consolidation of such lessons, even for authorities and organisations who responded to the events. This was particularly the case between governmental departments who stated that they had had little to no qualitative discussion about ways to move forward after Irma outside of recovery options. Consequently, the important, unique and unexpected situations that occurred during the disaster essentially have not been recorded in a meaningful way that can be shared physically between responders and departments. This kind of information consolidation is usually imposed by internal structures, depending on the authority or organisation, and by the nature of the disaster itself.

Generally, after a disaster, a country conducts regional and national assessments of damage and impacts. This is dictated by cost, timeliness and availability of resources which may explain why for Antigua and Barbuda there has been a lack of departmental coordination. This means that low-cost solutions for future planning are valuable to cases in SIDS, where both coordination can be increased while vital resources may still be allocated to more pressing recovery issues. Although the lack of consolidation after the events became evident during the recovery stages of both cases, there is potential for proposing a mechanism that would benefit other stages of the life-cycle, particularly for pre-disaster resiliency. This takes the form of incorporating a lesson learnt methodological approach in the post-disaster phase of an event. This would require collaboration between all bodies involved, which may be complex for larger events. While literature documenting specific lessons that were learned is common in the field of disaster management, studies which propose methodological approaches for this are lacking.

Birkland (2006) outlines that lessons from disaster generally take the form of policy and agenda changes within governments. The study goes on to propose a theoretical framework of change used to breakdown the ways in which lessons learned can be identified and better understood. This, combined with basic internal measures within authorities and organisations - such as regular meetings to discuss findings and experiences - may form a valuable foundation for any group responding to disaster. This method would need to be tailored to the authority in question and take into account their own internal processes. It may also consider qualitative methods such as interviews with employees or volunteers as a valuable source of data. Finally, it should follow a systematic set-up whereby this methodological approach is routinely practised after a disaster to ensure better resiliency and response in future events.

8.5 Discussing Social Media for Risk Reduction

Crisis communications were evidenced throughout both cases, and across each of the four main categories previously identified by the literature by Reuter (2017). These are A2C, A2A, C2C and C2A communications. While studies such as Hughes (2012) argue that A2A communication is vital in reducing risk through-out all stages of the disaster life-cycle, it was this category which was the hardest to identify across the social media platforms. Partly, this may be explained by authorities following confidential protocol where inter-departmental and inter-agency communications must take place on secure channels. This is designed to avoid false information, information overload, or the leaking of sensitive information to the public during crises. Partly, this may also be explained by the different communications protocols in place depending on underlying factors such as political structures, or national disaster response structures which were outlined at the beginning of each case study.

In contrast to this, the social media data was able to confirm high levels of C2C, C2A and A2C communications present throughout each of the life-cycle phases, aligning with the findings of many examples within the literature such as Haddow and Haddow (2013). Unlike some of these examples, there was no clear phase tied to each type of communication however. This may be due to the fact that for rapid onset events such as earthquakes the duration of phases may vary, whereas for slower onset events there is more time and information in the earlier stages. The presence of each type of communication may on the other hand be explained by the methodology employed in this thesis, which relies on the application of the conceptual framework by the researcher. For future events, types of communication may be further corroborated by allowing cross-referencing from other methods (Olteanu, Sarah Vieweg, and Castillo, 2015), or the incorporation of automatic content analysis social media data (Pozzi et al., 2016).

Similarly to many examples within the literature, a breakdown in communications of varying types was noted throughout both case studies. Both Hughes and St.Denis (2014) and Gorp (2014) outline many barriers for communications for both authorities and citizens alike. For New Zealand, this primarily took the form of an initial network collapse, which was restored within a few days due to the high level of skilled technicians trained to cope with earthquake damages. Despite this, there were areas within the affected district that retained access to WiFi and/or other methods of communication such as the local hospital. Unlike Hughes and St.Denis (2014), the involvement of different authorities at different times throughout Kaikoura did not notably record significant troubles in communications.

In contrast to this, hurricane Irma recorded varying levels of communications and a significantly prolonged period of both network and power outages. As previously mentioned, this is attributed to a range of underlying factors which corroborate Gorp's (2014) argument that lesser developed countries suffering from unique factors have a

more tangible affect on crisis communications. It also supports the notion that SIDS face remoteness and resourcing challenges unique to their islands (Pelling and Uitto, 2001; Thompson, 2015). In addition to this, interviews revealed that national response structures had a more significant role to play in the breakdown of communications than was previously noted within literature. This was predominantly caused by confusion between the authorities and organisations responding the disaster, who were feeding information to NODS while the department itself was unaware of the full extent of its responsibilities. It may be possible that the lack of A2A recorded may have also been influenced by the country's reliance on radio stations for information dissemination.

Following the aftermath of Irma, an increase in A2A communications were highlighted by interviewees to establish better inter-agency coordination between NODS and other authorities. Furthermore, humanitarian aid organisations such as Red Cross Antigua had taken it upon themselves to conduct weekly meetings with governmental representatives more than a year after the landfall of the hurricane. This shows that even though A2A was not easily identifiable in the quantitative data from social media, it still took place following qualitative methods in a face-to-face setting. This is a unique finding of this thesis, which aligns with studies such as Kapucu (2011) who argue that qualitative methods have value not only in explaining social media data, but also in revealing the reality of disaster management structures themselves which may differ in real-life events.

8.5.1 Proposed Recommendation 5: Enhancing Communications Best Practices

In light of the findings from both case studies, a proposed recommendation for future events has been formed (RQ4) which focuses on the use of social media in reducing risk throughout disasters. This has been informed by the literature review, from case study data, and particularly that of the interview results. The recommendation is formed of one main step: (5.) Enhancing communications protocols.

Particularly in the case of SIDS who are generally more vulnerable to disasters given their combination of underlying factors and reduced availability of resources (Thompson, 2015), there is a need to establish more concrete protocols for disaster communications of all types throughout events. This should involve re-evaluating the current communications plan, and updating the contingency options to include other available methods considering the distance between the islands of Antigua and Barbuda. This remains applicable to other SIDS, who by their geographical nature tend to be more isolated. As evidenced during hurricane Irma, satellite phone and VHF radio systems were integral to crisis communications – but currently do not feature in the national emergency communications plan, nor are owned by any of the managing authorities.

Investment into these kinds of technology is argued by literature as being essential when networks collapse (Hagen et al., 2018), even if only selected authorities have access to them. Additionally, the network structure on the island of Barbuda must be re-evaluated and improved. The flatness of the island requires network technology must be built in such a way that is more durable throughout hurricanes to avoid immediate collapse. Contingency options, too, must be considered for the island rather than waiting for communications to be received from Antigua. This however requires a higher level of collaboration and communication which has been greatly affected by underlying political tensions between the islands.

Alongside this, the protocols for A2A communications must be improved and pre-defined before the onset of a disaster. Therefore, the government should select authorities to act as communicators during times of crisis, and to make sure this is known by all other authorities and organisations. Given the political climate this may require entering into negotiations as to how the select communicator should function, as well as determine what resources may be re-structured to support their efforts. Furthermore, another authority should be appointed as a communicator to other SIDs in the nearby area. Higher levels of communication between SIDs who are likely to be affected by the same hurricane season may result in the reduction of risk for all nations, and may help to better understand which areas need which resource at what time. This may additionally help alleviate issues with resource allocation, the assignment of volunteers, and making sure that required resources may be better provided on demand.

8.6 Study Limitations

This thesis has sought to understand the relationship of social media and disasters in the context of a globalising world. It has done this through the creation and application of novel methodological approach, which has created a unique conceptual framework and employed both qualitative and quantitative methods of data collection and analysis. The methodological approach has been conducted on two main case studies which differ from one another in various ways. This has answered the RQs stated earlier on in this chapter, and has confirmed the thesis statement by doing so. This holds value to disaster management methods in future events, but also highlights some of the main study limitations that were encountered. By identifying and further explaining these, future work may acknowledge and overcome such issues, benefiting the field further. This section therefore details the limitations that this thesis encountered. These may be broadly be broken into two categories, that of quantitative methods and that of qualitative methods.

8.6.1 Quantitative Methods

Quantitative methods of data collection were employed for the social media platforms of Facebook, YouTube and Twitter (for full details refer back to chapter 5). Since the collection of said data, there have been changes in both the set-up of methods, availability of data on sites, and certain privacy laws affecting sites. Firstly, Twitter is no longer capped at 140 characters in length for a standard tweet, with the service trial running a longer length of 280 in certain areas globally. This has implications for the richness of content that tweets may feature, as well as for the time needed in processing theoretically twice the amount of data. However, it is important to note that this has not been standardised for the entire platform, which means that data collected from the site may in some cases vary in length.

The thesis used the set-up of the University of Southampton's Web Observatory given its ease of access. While this offered valuable features, such as easily downloadable datasets, there are several issues with the set-up that may affect the nature of data collected. Firstly, the service is only available to students and/or members of the University itself. This means that the same collection may not be possible for others as the University pays a licensing fee to Twitter in order to access the historical API. I.e. for individuals who wish to query the historical API they either need to pay a fee to do so (up until a certain historical time-frame), or have their query capped by a firehose which limits data collection to between 1-10% of the full Twitter stream.

Secondly, due to the nature of rapid onset events, it is difficult to set-up data collection in advance. This was another attraction of using the Web Observatory set-up as the researcher was able to use published lists of hurricane, storm and other event naming conventions which were published by relevant disaster bodies. I.e NOAA annually publish hurricane names in advance of the Atlantic hurricane season, and then the storm systems are named sequentially. Therefore, the researcher was able to set-up Twitter API queries in advance for the list of names that had already been published, allowing data collection to begin automatically once the set-up detected enough tweets featuring the search terms (stated in chapter 5). This process may be more difficult without full access to the Web Observatory.

Thirdly, the Web Observatory has experienced variations in the level of content that it may legally collect. At the time of the pilot studies the University held a full license for the historical API, meaning that 100% of tweets could be collected for featuring a search term i.e. a full firehose. In the following case studies, for which data was collected during the following year, this had changed due to Twitter increasing their licensing fees. The University was unable to pay the full amount, so instead the Web Observatory ran a lower percentage firehose. This affected the datasets collected for both Kaikoura and Irma as the set-up automatically stopped collecting tweets for a 24 hour period if they exceeded 10,000. Despite this, 10,000 tweets was considered by both the researcher and

informing literature as still demonstrable of the full data set, while also reducing errors with the processing of big data (which would have been outside of the scope of this thesis).

Finally, despite the automated set-up made available through the University, pre-disaster data was difficult to collect both for the other social media platforms, as well as for different types of hazards that do not follow a systematic naming convention. Without access to historical APIs such data is expensive to obtain, and may also not be representative of full samples given the variations in privacy laws between sites. This is not only reflective of data issues for this thesis, but also highlights one of many reasons that disaster literature have documented difficulty accessing various data formats rather than just Twitter alone. Facebook in particular is renowned for having settings that stop individuals and companies alike from scraping data originating from profiles that have been set to private. Once an account has changed their settings to private, this means that only profiles that are friends with said account may see the information on their personal page.

This makes the use and motivations of using Facebook difficult to understand from an observational perspective, which was a driving factor in the novel methodological set-up of this thesis. This took the form of using the tool Netvizz, an open research tool that was previously explained in chapter 5. Netvizz was able to scrape data about publicly open pages and groups on Facebook. This essentially allowed the researcher to collect data that circumnavigated the platform's privacy laws. While it was able to collect valuable data it still wasn't able to collect information from personal profiles, or groups and pages that had their settings on private. Therefore, quantitative data sourced from the platform may still not be considered fully representational of all Facebook users, of all users who used the site to discuss the disaster case studies, of all groups and pages that featured relevant case study content, or indeed of the wider population of the case study communities.

Further to this, Facebook introduced new privacy laws, settings, stricter terms of use, and a new version of the API as of August 2018. This was triggered by a much bigger, international data scandal by Cambridge Analytica which caused a ripple effect across many other social media sites. Since this date, Netvizz has been on restricted accessibility to Facebook following the new public page content access protocols. While the developer of the tool has made progress with access to open data on the site since August 2018, there are a number of issues in replicating original collected through the tool. The developer has since published several blog articles with updated information of the tool, but warns that it will not have the same level of access as before. This is a necessary acknowledgement for understanding the nature of the groups and pages sourced prior to this, as well as a justification for the use of qualitative methods to further explain any data that was analysed.

The final platform, YouTube, similarly has unique issues that must be acknowledged in this section. The Google Chrome plugin scraper was used in conjunction with the tool Screaming Frog to scrape and collect videos and their metadata for featuring search terms (again, previously detailed in chapter 5). This was used as there are a lack of other options for scraping the platform effectively due to its technological structure. This method may still be used - as it has not been affected by the same changes in set-up as Facebook and Twitter - but acknowledgements must be made about the method of filtering videos by number of views. While this may indicate a level of popularity about a video, and subsequently a general opinion of individuals using the platform, the number of views recorded for videos naturally increases over time. This means that videos published earlier on in the disaster life-cycle of an event have an advantage over those published later., and are therefore more likely to show higher views.

8.6.2 Qualitative Methods

Quantitative methods were employed to help explain data collected from the social media platforms (refer to chapter 5 for details). This took the form of semi-structured interviews with individuals who had experienced the disaster case studies. As was previously acknowledged at the beginning of chapter 7, for hurricane Irma there were considerably more interviews than that of Kaikoura. This was due to the accessibility of the RECCOH project in securing interviews with a range of individuals and authorities that previously would have been unavailable. Therefore, it is important to note that the understanding generated from this case study can be considered to be more rich than that of Kaikoura not only in terms of volume, but also in terms of variation as interviewees had a wider range of vocations, backgrounds, and personal experiences of the event.

The interviews conducted for Irma took place physically in Antigua and Barbuda. This was easier for data collection as an audio recording of a face-to-face meeting is generally clearer than one taken of a phone or Skype call, due to technological anomalies or lapses in Internet/network connections. Therefore, the audio quality of interview transcripts were clearer than in the case of Kaikoura. Furthermore, the physical presence of the researcher in Irma interviews allowed a more intuitive analyses of interviewees by reading body language and expressions. This naturally allowed the interviews to follow interesting topics and themes that were harder to initially identify using Skype.

An overarching theme of this thesis is the presence of underlying geographical, demographical, political and economic factors in shaping the outcomes of disaster. These have been evidenced through quantitative and qualitative methods, and also through wider literature written about the case study areas. However, these factors encompass a plethora of micro factors within them which are both complex and difficult to measure. This means that any conclusions drawn about the exact affects of underling factors on social media usage may only be considered interpretation until standardised

measurements can be applied. While this would be highly valuable to the field of disaster management, it would require considerable resources, processing time, and a larger number of researchers that were not within the scope of this thesis.

8.7 Conclusions

This thesis concludes by accepting the statement that social media hold paramount importance to reduce risk in future disasters. It has demonstrated that understanding the relationship between social media and disasters in more detail is not only valuable for case studies, but also in reducing the negative impacts of future crises. It has shown this through a novel methodological approach that has scoped the users and uses of selected platforms (RQ1), as well as how and why site content changes over the disaster life-cycle phases (RQ2). Furthermore, it has demonstrated that disasters are unique events that are affected by complex interactions of geographical, demographical, political and economic underlying factors which have the potential to shape the effectiveness of social media as a tool for disaster management (RQ3). Using this information it has proposed five key recommendations, targeted for the use of social media during resiliency, response, recovery and risk reduction (RQ4). Therefore, it is argued that the contributions of this thesis will help to improve modern uses of social media in the field of disaster management, especially given the rapid socio-technical progression of a globalising world. Research presented throughout this thesis has been published in the papers Gray et al. (2016, 2016a, 2017, 2017a, 2017b, 2018, 2018a, 2019).

Further to answering the thesis statement, there are four RQs which have been addressed throughout this research (which were re-capped in section 8.1 at the beginning of this chapter). These will be summarised sequentially in the following sections of this conclusion. Each section will re-state the RQ, detail how it has been answered (in some cases pointing to previous chapters or sections of the thesis for further clarification), and summarise how this has allowed the thesis to accept the original statement. Following this, a summary of the main academic contributions of this thesis will be discussed. This is comprised of three main areas: (1.) a novel methodological approach, (2.) improved understanding of disasters, and (3.) five proposed recommendations to improve the use of social media in future crises. Finally, concluding remarks are presented which re-iterate the importance of this research and the continued need to improve tools for disaster management imminently.

8.7.1 RQ1. How are Different Social Media Platforms used during Disaster, by Whom, and to What Purpose?

Facebook was predominantly utilised for resiliency and preparedness purposes during the pre-disaster phase of both case studies. While many different types of user accessed the platform, C2C communication was the most popular type of information exchange on the groups and pages. This may be explained by communities seeking further information from online sources given the reoccurring risk of both seismic and meteorological hazards in the case study areas. This was demonstrated by the application of the conceptual framework, which highlighted that the site was in most cases used for proving and receiving general disaster preparedness information, providing and receiving national and regional disaster warnings, and detecting and warning of disasters and certain hazards locally. Full details of this may be found in chapter 6 section 6.5, and in chapter 7 section 7.6.

Twitter was more extensively used in the during phase of both case studies corresponding the real-life unfolding of the initial hazard in both cases. While many types of user accessed the platform, a combination of C2A and A2C communication was the most popular type of information exchange throughout the subsamples. This may be explained by the high presence of authorities, groups, and humanitarian aid organisations on the site, which disseminated updates and information as the events happened. This was demonstrated by the application of the framework which highlighted that documenting what was happening online and offline, consuming and creating news coverage the events, and developing awareness; sharing donations; listing ways to help were the most used functions of the site. Full details of this may be found in chapter 6 section 6.6, and chapter 7 section 7.7.

YouTube had high use throughout the during and post-disaster stages of both case studies as video content takes a longer time to publish than the formats of Facebook posts or tweets. A majority of communication took the form of C2C where individuals from around the globe watched events unfolding to better understand what was happening during the case studies, as well as to spread awareness and personal appeals to an international audience. This was illustrated by the application of the conceptual framework which showed that documenting what was happening online and offline, consuming and creating news coverage of the disaster, and discussing the socio-political causes, implications and responsibility were the dominating uses of the platform. Full details of this may be found in chapter 6 section 6.7, and in chapter 7 section 7.8.

Understanding how different platforms are used, by whom, and to what purpose holds significance to the field of disaster management. For resiliency purposes, outside of the scope of this thesis, this knowledge may be applied in improved targeted actioning planning by bodies who manage disasters. This has been theorised by literature as well as the outcomes of this thesis as a key component in preparedness. For response

purposes, this knowledge may help to supplement situational awareness for responders by providing information on the virtual world (as well as the differences between real-life and virtual events). For recovery purposes, this may be able to highlight online communities of interest to generate social and relational capital which have been proved valuable in bouncing back after disaster.

8.7.2 RQ2. In What Ways does the Content of Social Media Change Throughout the Disaster Life-cycle?

The creation and application of a conceptual framework to both case studies has identified that the users and uses of social media platforms change depending on the disaster life-cycle phases of an event. In the pre-event stage, resiliency and preparedness actions are generally the most popular. These include providing and receiving general disaster preparedness information as well as general national and regional disaster warnings, detecting and warning of disasters and hazards locally, and identifying the differences between the actual and potential uses of social media. These themes emerged throughout the disaster literature which informed categories within the conceptual framework, a copy of which may be found in chapter 3 section 3.3. The framework was then used to demonstrate content change throughout both cases studies where full results are detailed in chapter 6 section 6.4, and in chapter 7 section 7.5.

In the during event stage, the conceptual framework that the range of uses for social media increases. These include but are not limited to sending and receiving requests for help, informing others about ones condition/location, providing and receiving information in different formats, documenting what is happening online and offline, creating and consuming news coverage of the disaster, providing and receiving location-based real-time warnings, expressing emotion/empowerment, raising and developing awareness, informing and supporting existing disaster management strategies, providing and receiving rescue and evacuation information, seek mental and emotion support, and to tell and hear personal stories about the disaster. These themes were once again formed by disaster literature earlier on in this thesis (chapter 3), and full details illustrated in chapter 6 section 6.4, and in chapter 7 section 7.5.

In the post-event stage, the conceptual framework highlighted that the content of social media changes towards recovery purposes. These include discussing the socio-political causes and responsibility of an event, re-connecting with community members/loved ones, discussing the accessibility of social media themselves, and discussing the reliability of information on social media. Finally, it was found that some of the content of social media were present throughout the entire life-cycle which revealed that some aspects of social media use does not change depending on the phase. These include the consolidation of lessons learnt, evaluating the reliability of information, and the identification and containment of incorrect information. These themes were once again formed

by disaster literature earlier on in this thesis (chapter 3), and full details illustrated in chapter 6 section 6.4, and in chapter 7 section 7.5.

Understanding how social media content changes across the disaster life-cycle phases holds significance to the field of disaster management. Knowing this may allow bodies who manage crises to tailor information to time-frames and phases, thus reducing issues such as information overload. It may also have increasing value to disasters that are part of broader periods of crisis, for example storm and hurricane seasons, where hazards occur within quick succession of one another. In such situations, the timeliness of critical information is important and should not be undermined by the presence of information originating from different phases that has been created about a different hazard (evidenced in the pilot studies).

8.7.3 RQ3. What are the Benefits, Limitations, and Scope of Social Media during Case studies?

The results have demonstrated that there are a range of benefits and limitations for the use of Facebook, YouTube and Twitter as tools for disaster management. In particular, it has shown that the platforms themselves feature different user demographics, technological structures, and site allowances which make each unique. Consequently, each platform provides varying functionality during crises, different formats of data, and has a different relationship with disasters as well as to each of the other platforms themselves. The scope of the sites is in part dependent on the type of user (which was previously discussed in RQ1), and is in part dependent on the needs and expectations of said user from the site.

Facebook was found to be valuable in both case studies, particularly in the pre-disaster phases for resiliency and preparedness purposes. For full details refer back to sections 6.5.2 and 7.6.1. This was due to the platform affordances that allowed for rich discussion on the site in the form of posts, comments, likes and sharing. This variety of uses allowed individuals to express and engage with one another in a number of different ways that were not available on YouTube or Twitter. Groups and pages, too, were found to be unique to the platform. These allowed for online networks and communities to form that centred around each disaster, while not being geographically bounded, which essentially cultivated online social and relational capital. Groups and pages additionally enabled the sharing and hosting of a plethora of information in a number of different formats. This originated from other sources such as media produced by authorities, links to other websites or content created by users themselves.

While the site evidenced a wealth of qualitative data, accessing this remains problematic. As outlined in the methodology in chapter 5, the site features strict privacy laws which do not allow for data on personal profiles to be accessed, or from groups or pages

that have their settings set to closed access. This was noted in literature review also, and represents a problematic area for understanding the platforms role during disaster. Facebook themselves have in recent years acknowledged the importance the site has to individuals during disasters, and in response have developed their own functions in supporting disaster management (i.e. the safety check-in feature). Notionally the feature is valuable to users looking for certain information about loved ones, however the data it generates is only made available to certain large humanitarian aid organisations. Instead, the privacy limitations of the site need to be taken into account using other methods, for example by conducting interviews with individuals who explain their use of the platform personally.

Twitter was identified as one of the most extensively used sites throughout the literature review. A wealth of studies explained that this was for a number of different reasons which this thesis is able to support, for full details refer back to sections 6.6.1 and 7.7.1. Tweets are capped at 140 characters which allows content to be succinct but demonstrative. This is particularly valuable in disaster situations for generating situational awareness quickly. The ability of tweets to be re-tweeted allows information to be disseminated extremely quickly compared to Facebook and YouTube. The use of hashtags for trends allows for information, themes and developments to be tracked which again is valuable for generating situational awareness. Unlike Facebook, the site has fewer privacy restrictions and an API which allows queries, meaning that data is generally easier to collect. As one of the more popular platforms many authorities, humanitarian aid organisations and groups involved with disasters have personal accounts that allow for two-way communication throughout disasters.

While the site was used throughout each of the disaster life-cycle phases, this thesis noted that it was more extensively use in the during disaster phase for response purposes. This is due to the fact that tweets are quick to create or to re-tweet, as well as being utilised by automatic systems which create tweets if they detect a change in a hazard (i.e. for a flood alerts system). This can produced information as soon as it is recorded, however it may also lead to issues with the rapid spread of false or outdated information, which was demonstrated in the initial stages of Kaikoura. Compared to Facebook there are fewer functions available to users which means that data may only be succinct rather than elaborate. While this is beneficial for immediate time-critical information, it may also result in limiting the understanding of the context, underlying factors, or motivations of said information.

YouTube represented one of the lesser studied social media sites for disaster management purposes. It features several aspects which have been demonstrably valuable throughout the case studies, for full details refer back to sections 7.6.1 and 7.8.1. Primarily, due to the main format of the site being video, it contributes a visual insight into hazards and cases. This proved valuable in the recovery stages of both events, where actually seeing the developments of the disasters helped to raise awareness of the outcomes.

Furthermore, considering the shocking impacts of high magnitude events, visualisations captured the global audience who were able to witness video footage without being in the affected areas. Interviewees from both studies argued that this medium was additionally valuable in communicating emotional messages and appealing to the human nature of wider global communities.

The benefits of YouTube's video format featured limitations also. Primarily, this is due to the fact that many videos take time to edit and publish on the site, making it slower than both Facebook and Twitter in terms of information dissemination. Although the platform allows comments on videos, this does not often warrant two-way communication in the same way that direct tweets, messaging or commenting does on the other platforms. This means that the site is mainly used for information dissemination rather than being able to cultivate dynamic communities or high levels of exchange. Publishers of videos may too disable the ability to comment on videos, or to remove videos that have already been published. This further reduces the variety of uses that the platform has, meaning that many users who access the site do so with the primary intention of watching videos alone.

Understanding the scope of Facebook, YouTube and Twitter is significant to the field of disaster management for a number of ways. Firstly, there is a lack of literature that evaluates the use of Facebook and YouTube, therefore this may be used to inform other strategies or studies. Secondly, there is a need to tailor disaster information to particular sites to ensure that it may be used in the most effective ways possible, which this research supports. Thirdly, in terms of future work, there are many social media platforms which differ radically. The better the understanding of these and how they differ may help to inform management strategies in future events.

8.7.4 RQ4. How Might Findings be Used to Make Proposed Recommendations for Future Social Media Use?

The findings of social media analysis, combined with qualitative interviews, have allowed this thesis to create five proposed recommendations for the improvement of social media as a tool for disaster management in future events. These were explained in full earlier on in this chapter, and are re-capped in short below.

Proposal 1. recommends the creation of a range of downloadable resources, and is detailed earlier on in this chapter in section 8.2.1. This is aimed at the pre-disaster stage of a disaster where community resiliency and preparedness may be further improved. The proposal addresses the need for both online and offline content which may simultaneously provide valuable information for citizens, while also not increasing personal risk should social media become unavailable during an event.

Proposal 2. recommends the integration of online and offline volunteer strategies, and is detailed earlier on in this chapter in section 8.3.1.1. This is aimed the the during stage of a disaster where methods and actions of disaster response may be further improved. The proposal addresses the need for both online and offline volunteers who may together generate more detailed situational awareness of an event, being able to monitor information virtually and in the real-world. This lowers the risk of citizens who may only have access to online or offline volunteers.

Proposal 3. recommends incorporating social media specialists into response strategies, and is detailed earlier on this chapter in section 8.3.1.2. This is a further improvement to that of proposal 2 and is also aimed at the during event stage for disaster response. In contrast to proposal 2, 3 would require higher resources and funds to achieve. While the initial costs are higher than proposal 2, it would allow for better utilisation of social media as a tool for disaster management throughout events, reduce time pressures faced by responders using social media, and may potentially increase inter-agency coordination and collaboration.

Proposal 4. recommends developing a lessons learned methodology, and is detailed earlier on in this chapter in section 8.4.1. This is aimed at the post-disaster phase of an event where actions and methods are targeted towards recovery. This would allow for the consolidation of valuable management lessons between governmental departments, bodies and humanitarian aid organisations. These would then be made available to all bodies involved in disaster management to improve preparedness and resiliency for future events, and to lower potential risks identified.

Proposal 5. recommends methods of enhancing communications protocols, and is detailed earlier on in this chapter in section 8.5.1. This is aimed throughout all stages of the disaster life-cycle where methods can be improved to reduce general risk generated by failings in A2A, A2C, C2A and C2C communications. These would be targeted at each type of communication and each type of user to ensure that breakdowns in communications can be mitigated, and/or resolved more quickly.

8.7.5 Summarising the Academic Contributions of this Thesis

The research presented in this thesis and summarised in RQs 1 through 4 above contributes to the field of disaster management in three original ways. Firstly, a novel methodological contribution is made through the creation of a conceptual framework to ascertain the users and uses of social media in modern disasters, and to track how and why social media content may change over the course of an event. This has been applied to data collected from the platforms Facebook, YouTube and Twitter as well as to qualitative interviews. This forms a mixed-methods approach which provides a new paradigm on the use of sites during crises. This has practical applications to disaster

case studies for situational awareness of social media, conceptualised across the disaster life-cycle phases. The suggested application sequence for the framework is to integrate it with other existing frameworks employed by emergency responders, with the aim of supplementing the knowledge base before targeted actions take place. The integrated framework may then serve as a detailed general guide providing information on the unfolding of events, both online and offline, to be used for improved resource allocation, risk reduction, emergency response and hazard management. Alternatively, the framework may be integrated into the preliminary steps of social impact assessments (SIA) and social risk assessments (SRA) of crises. This would provide an extended dimension for predicting social impacts and uncertainties, taking into account unique aspects of communities. Furthermore, the framework may be employed by itself to generate insight into a case study or for generalised social media data.

The second original contribution of this thesis is through unique insight into the relationship between social media and disasters, as well as the nature of crises themselves. It does this by employing the novel methodological approach on two high-magnitude and highly contrasting disaster case studies: the Kaikoura earthquake (New Zealand, 2016), and hurricane Irma (Antigua and Barbuda, 2017). At the time of analysis little was published about these events making the results original and insightful, especially considering the re-currant nature of both earthquakes and hurricanes which require continued and improved management in coming years. By using social media as a lens for analysis the results have generated unique insight into each case, as well as highlighting the underlying geographical, demographical, political and economic factors which affect the complex outcomes of disaster. It has also demonstrated that variations in platforms utilisation are dependent on a plethora of issues, which may be conceptualised across the pre-disaster, during, post-disaster and throughout all stages phases of an event.

The outcomes of the first and second contributions have subsequently been able to form the third original contribution of this thesis. This takes the form of five proposed recommendations for the improvement of social media as a tool for disaster management in future events. These are (1.) the creation of a range of downloadable media content aimed at resiliency efforts; (2.) the integration of online and offline volunteer strategies targeted at response efforts; (3.) the incorporation of social media specialists into response strategies; (4.) developing a lessons learned method focused on improving recovery; and (5.) enhancing tailored communications protocols throughout all stages of an event. Alongside the three main contributions, this research has been published in a series of peer-reviewed conference proceedings and journal papers which have been acknowledged in declaration at the beginning of this thesis, and throughout the relevant chapters.

8.7.6 Concluding Remarks

This thesis began by emphasising the continued and pressing need to better understand disasters in a globalising world. The severity, frequency and unpredictability of events is increasing due to underlying factors such as climate change. With it so too are the risks posed to human populations by drivers such as changing environments, extreme weather, poverty, war and overpopulation. In 2016 alone New Zealand experienced more than 33,000 earthquakes. GeoNet, the country's geological hazard information centre summarised that *"we had geysers, eruptions, landslides, tsunami and a whole lot of earthquakes. The ground broke under our feet, and that is why we are calling this year the record breaker"*. The service went on to speculate the uncertainty of what this means for the country in coming years, given the damages and destruction still present both from the Canterbury earthquakes in 2011 and the Kaikoura earthquake in 2016, adding that *"you'd be hard pressed to find someone who wasn't impacted, in some way, by earthquakes in New Zealand"*.

Similarly, in the aftermath of the 2017 Atlantic hurricane season there are growing concerns about the nature of future seasons. As sea levels become warmer meteorologists and oceanographers fear that imminent storm systems will become subject to rapid intensification. This has been fuelled by the strength of Irma which recorded the first ever category 5+ hurricane - a new and alarming edition to the Saffir-Simpson scale of measurement. It has also resulted in higher frequencies of hurricanes within quick succession of one another, which pose a new threat for countries coping with the annual season in terms of sustained risk, vulnerabilities and SIDS status. Certainly, the inhabitants of Antigua and Barbuda have growing concerns for their welfare, particularly given the damages still evident on Barbuda more than a year after Irma. Interviewee U8, a resident of Antigua, stated that *"we fear for the next season. And the one after. This year we had a category 5+, but we also had several other 5s. We haven't seen that before, so yes that makes us worry. That makes us worry a lot"*.

Ultimately, crises cannot be stopped. The relationship between humans and disasters is long established, and will continue with the progression of the species. Instead, an emphasis should be placed on the four R's of resilience, response, recovery and risk reduction. Governments, humanitarian aid organisations, international collaborations and communities alike have paved the way forward in coping with risk, with roots stemming back to the very beginning of this relationship. In a modern context, new technologies, methods, services and features further add to the successes of risk reduction. Social media, as a tool that has some 2.77 billion global users, represents a new and important resource for disaster management: a claim which has some fifteen years of evidence from disaster literature to support, which this thesis itself contributes to. Social media users are projected to rise to 3.02 billion users by the year 2021. Consequently, now

more than ever these kinds of developments must be better understood to ensure our continued adaptation to risk from disasters.

> "In this dangerous world that we live in, where hatred and violence and natural disasters sometimes collide to almost overwhelm us, we each can help in some way." - Marsha Blackburn

Appendix A

Appendix

A.1 Research Ethics Applications

All details listed in this section refer to the ethics approval process for the University of Southampton data collection and storage.

A.1.1 iSurvey Questionnaire

Ethics ID 23005 - "Social Media Use During Disasters: A Survey". Category C type research. Committee approved on 13/07/2016.

A.1.2 Semi-Structured Interviews

Ethics ID 25383 - "Understanding and Evaluating the uses of Facebook during Disasters" for the Case of the Kaikoura earthquake. Category C type research. Committee approved on 11/02/2017.

Ethics ID 41351 - "The Atlantic Hurricane Season 2017: Context, Impacts and Long-term Recovery" for the case of hurricane Irma. Category C type research. Committee approved on 18/05/2018.

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