

Crisis Crowdsourcing in Government: Characterising efforts by North American Agencies to Inform Emergency Management Operations

by

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AUTHOR'S DECLARATION

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

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Abstract

Crowdsourcing is proven to be a useful communication platform during and in the direct aftermath of a disastrous event. While previous research in crisis crowdsourcing demonstrates its wide adoption for aiding response efforts, this research is generally limited to adoption by non-government organizations and members of the general public, and not government agencies. There is a gap in understanding the state of crowdsourcing by governments for emergency management. Additionally, there is a noticeable focus on the application of crowdsourcing in the response and recovery of a given disaster, with less attention paid to mitigation and preparedness. This research aims to classify the use of government crisis crowdsourcing in all phases of the disaster management cycle in Canada and the USA and identify the barriers and constraints faced by Canadian government agencies when adopting crisis crowdsourcing and social media for emergency management. Semi-structured interviews conducted with 22 government officials from Canada and the USA at the various levels of government in both countries reveal that crisis crowdsourced information has a place in all phases of the disaster management cycle, though direct crowdsourcing has yet to be applied in the pre-disaster phases. Participating federal agencies appear to be using crowdsourced information for mitigation and preparedness efforts, while the lower-tiered agencies are using crowdsourcing for direct response and recovery. A more in-depth analysis into the barriers and constraints faced by participating Canadian agencies looking to adopt crisis crowdsourcing or social media for emergency management reveals three general areas of concern that may be hindering crisis crowdsourcing efforts in Canada: organizational factors, demographic factors, and hazard risk. Based on these three general areas of concern, a readiness assessment scheme is presented to allow agencies to pinpoint the most prevalent barriers to their crowdsourcing efforts and to formulate plans to address these barriers.

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Dedication

I dedicate this thesis to my parents, without them I wouldn't be who I am or where I am today. Thank you for your endless support and encouragement, and for always believing in me.

Table of Contents

| | |
|--|-----|
| AUTHOR'S DECLARATION | ii |
| Abstract | iii |
| Acknowledgements | iv |
| Dedication | v |
| Table of Contents | vi |
| List of Figures | ix |
| List of Tables | xi |
| Chapter 1 Introduction | 1 |
| 1.1 Overview | 1 |
| 1.2 Research Purpose and Objectives | 4 |
| 1.2.1 Research Goal | 4 |
| 1.2.2 Objectives | 4 |
| 1.3 Research Scope | 4 |
| 1.4 Thesis Outline | 5 |
| Chapter 2 Characterising crisis crowdsourcing efforts by governments in North America: Informing all phases of the disaster management cycle | 7 |
| 2.1 Introduction | 7 |
| 2.2 Literature Review | 9 |
| 2.2.1 Crowdsourcing Models and Approaches | 9 |
| 2.2.2 Crisis Crowdsourcing | 11 |
| 2.2.3 Government Crowdsourcing | 15 |
| 2.2.4 Government Crisis Crowdsourcing | 16 |
| 2.3 Primary Research Methods | 22 |
| 2.4 Findings and Analysis | 26 |
| 2.4.1 Characterising crisis crowdsourcing by government agencies in Canada and the USA | 27 |
| 2.4.2 Crowdsourcing in the Disaster Management Cycle | 30 |
| Response and Recovery | 31 |
| Social Media and Passive Crowdsourcing | 31 |
| Active Geographic Crowdsourcing | 34 |
| Mitigation/Risk Reduction and Preparedness | 36 |
| Social Media and Passive Crowdsourcing | 36 |
| Active Crowdsourcing | 39 |
| The Complete Disaster Management Cycle | 47 |
| 2.5 Building a case for government crisis crowdsourcing | 49 |
| Transparency and Accountability | 50 |
| Government-Citizen Communication | 50 |
| Internal Communication | 51 |
| Enriching the Dataset | 51 |
| 2.6 Conclusions | 52 |
| Transition | 54 |

| | |
|---|-----|
| Chapter 3 Building a basis for the adoption of crisis crowdsourcing: Barriers and Constraints posed in the Canadian emergency management realm..... | 55 |
| 3.1 Introduction..... | 55 |
| 3.2 Literature Review..... | 57 |
| 3.2.1 Government Crisis Crowdsourcing | 57 |
| 3.2.2 Barriers and constraints of Government Crisis Crowdsourcing..... | 59 |
| Government Specific Barriers and constraints..... | 59 |
| Crisis Specific Barriers and constraints..... | 61 |
| Social Media for Emergency Management Barriers and Constraints | 63 |
| 3.3 Primary Methods | 65 |
| 3.4 Findings and Analysis | 67 |
| 3.4.1 Barriers and Constraints | 69 |
| Digital Divide | 70 |
| Credibility and Liability..... | 71 |
| Organizational Constraints & Policies..... | 72 |
| Resources | 74 |
| Privacy and Security..... | 76 |
| 3.4.2 Evaluating an Active Crowdsourcing Template..... | 77 |
| Login Credentials an Indicator of Openness to New Technology | 78 |
| The Importance of Credibility..... | 81 |
| 3.5 Crisis Crowdsourcing in the Canadian Emergency Management Realm | 81 |
| 3.5.1 Factors Impacting Crisis Crowdsourcing in Canada | 81 |
| Hazard Risk and Exposure..... | 82 |
| Feasibility | 85 |
| Culture and Demographics..... | 85 |
| 3.5.2 Classifying Canadian Emergency Management Crisis Crowdsourcing Readiness..... | 87 |
| Hazard Risk..... | 88 |
| Organizational Factors | 89 |
| Demographic Factors | 91 |
| Determining Crisis Crowdsourcing Readiness | 92 |
| 3.6 Easing the adoption of crisis crowdsourcing | 94 |
| 3.6.1 Follow a Bottom-Up Approach to Inform Policy Change..... | 94 |
| 3.6.2 Build Partnerships in Advance..... | 95 |
| 3.6.3 Build a Crisis Crowdsourcing Validation Toolbox | 98 |
| 3.7 Conclusions | 100 |
| Chapter 4 Concluding Remarks and Future Research | 101 |
| 4.1 Summary of Conclusions..... | 101 |
| 4.2 Recommendations..... | 102 |
| Start with a Limited Approach | 103 |
| Receive Mentorship from Experienced Agencies..... | 104 |
| Private Sector Support | 104 |
| 4.3 Key Research Contributions..... | 105 |
| 4.4 Future Research | 106 |
| Crowdsourcing for the Pre-Disaster Phases | 106 |
| Crisis Crowdsourcing: A Product of Hazard Risk..... | 106 |
| Citizen Drivers of Participation and Engagement..... | 107 |
| References..... | 109 |
| Appendix A List of Participants | 129 |

| | |
|--|-----|
| Appendix B Interview Script | 131 |
| Appendix C Interview Recruitment Materials | 135 |
| Recruitment Email..... | 135 |
| Information Letter..... | 136 |
| Consent Form..... | 138 |
| Feedback Letter..... | 139 |

List of Figures

| | |
|---|----|
| Figure 1. The Disaster Management Cycle and the four phases. The cycle is split into two general periods, the pre-disaster period with the mitigation/risk reduction and preparedness phases to minimise risk and impacts before an event, and the post-disaster period, in the immediate aftermath of an impactful event, the response phase is initiated. After the immediate response phases, efforts shift into the recovery phase. | 13 |
| Figure 2. Methods used by government agencies to collect information from the public for emergency management. | 26 |
| Figure 3. The online damage reporting form used by a county-level government in Florida..... | 35 |
| Figure 4. A screenshot of a recent earthquake alert detected by the USA federal agency’s specialized Twitter harvesting application. The alert provides an initial “heads up” to the public and to responders to prepare for a potential disaster..... | 38 |
| Figure 5. Examples of severe weather reports posted on Twitter for the Canadian federal agency in a recent severe weather event..... | 40 |
| Figure 6. A "shakemap" displaying the distribution of reported earthquakes and the derived intensity in 2015 (Source: USGS)..... | 42 |
| Figure 7. Upon feeling an earthquake, citizens can anonymously submit reports to the US federal government. Having the citizens fill out a very structured reporting form allows the agency to derive quantitative data from qualitative information..... | 43 |
| Figure 8. Citizens are presented with a before and after aerial image along a section of the coastline. The citizens are then asked to identify specific changes in the photos that may have resulted from Hurricane Sandy..... | 45 |
| Figure 9. Crisis crowdsourcing fits into all four phases of the disaster management cycle. In the pre-disaster phases, the crowdsourced information can be used to develop a long term picture of trends to enhance planning and prediction of events and can also be used to verify short term alerts and warnings. In the post-disaster phases, crowdsourcing enhances situational awareness and information situational reports that can be used to apply for disaster relief and aid from upper-tiered government agencies..... | 48 |
| Figure 10. The number of participating Canadian agencies that use each method of emergency information communication, broken down by level of government..... | 68 |

Figure 11. Percentage of participating Canadian agencies facing barriers and constraints with adopting crisis crowdsourcing and ICT practices..... 69

Figure 12. Distribution of the importance rankings of login credentials, where 0 represents “Not Important” and 6 represents “Most Important.” 79

Figure 13. Natural Disasters Risk Index (2010) from Verisk Maplecroft. Canada falls in the medium risk zone to natural disasters (Verisk Maplecroft, 2010b)..... 83

Figure 14. Historical trends in meteorological disasters in Canada show an increase since 1900 to 2014 (data from the Public Safety Canada Canadian Disaster Database). 84

Figure 15. The cost of reported natural disasters in Canada shows an upward trend since the early 1970's (data from the Centre for Research on the Epidemiology of Disasters International Disaster Database..... 84

Figure 16. The assessment framework is introduced as a two-step process, where the first step is completing a hazard risk assessment for the agency’s jurisdiction. If determined that there is no significant risk, then there is no need for crisis crowdsourcing. If there is a significant hazard risk, then the agency should further explore the options for crisis crowdsourcing. Assess the demographic and organizational factors is the next step in the process, and can help agencies identify specific barriers to crisis crowdsourcing adoption. 93

List of Tables

| | |
|---|----|
| Table 1. Summary of active crisis crowdsourcing applications implemented by government agencies..... | 18 |
| Table 2. Interview script themes..... | 23 |
| Table 3. Number of participants from each level of government in Canada and the USA. | 24 |
| Table 4. Official roles of participants from each level of government..... | 25 |
| Table 5. Summary of emergency crowdsourcing efforts used by participating agencies in Canada and the USA. *No data is available for state level governments in the USA because none could be recruited. | 27 |
| Table 6. Summary of benefits participants identified from using a crisis crowdsourcing model (Participants A, B, C, D, E, F, G, H, I, K, L, M, O, P, Q, R, S, T, 2015)..... | 49 |
| Table 7. Interview script themes..... | 66 |
| Table 8. The average importance of each feature proposed by the lead researcher for a hypothetical emergency crowdsourcing application. Importance was ranked from 0 (“not important”) to 6 (“most important”), see Legend..... | 78 |
| Table 9. Organizational factors contributing to a government agency's crisis crowdsourcing readiness..... | 89 |
| Table 10. Demographic factors that can influence a government agency's crisis crowdsourcing readiness..... | 91 |
| Table 11. Validation tools that should be added to emergency managers' social media monitoring toolbox..... | 98 |

Chapter 1

Introduction

1.1 Overview

Crowdsourcing, a product of the new generation World Wide Web (the Web 2.0), is increasingly being used in the emergency management realm. The most prominent crowdsourcing applications used in the emergency management realm (now referred to as crisis crowdsourcing applications) are launched and managed by non-governmental organizations (NGOs), such as Ushahidi (<https://www.ushahidi.com/>), Humanitarian OpenStreetMap Team (<https://hotosm.org/>), CrisisMappers (<http://crisismappers.net/>), and the Missing Maps Project (<http://www.missingmaps.org/>). Alternatively, many mashups created by private citizens tend to spontaneously emerge during an unfolding event, as is the case for “Scipionus” during the 2005 Hurricane Katrina disaster and the many map mashups relying on volunteered geographic information during the 2007-2009 Santa Barbara Wildfires (Goodchild, 2008; Roche, Propeck-Zimmermann, & Mericskay, 2011). This trend in the development of crisis crowdsourcing projects by NGO’s and private citizens has led researchers in this field to suggest that this is a reaction to the government’s failure to respond effectively during an unfolding crisis (Goodchild & Glennon, 2010; Johnson & Sieber, 2013). Moreover, many government agencies have been slow in launching their own crisis crowdsourcing applications (Meier, 2012; Roche et al., 2011). Even though governments are primarily responsible for managing the response and resources during an unfolding crisis, it appears that they are falling short in this regard, causing NGO’s and citizens to take control of their own situations and impacts resulting from the crisis.

Government agencies may not yet be convinced with the potential benefits that crisis crowdsourcing offers. There are valid concerns around the costs and risks of adopting crowdsourcing for government operations, and some additional, unique concerns with crisis crowdsourcing. The technological and human resources costs needed for developing and maintaining an application may be too consumptive or high for a long-term project, and managing the large volume of incoming information during an unfolding emergency introduces challenges with information overload and inadequate

staffing. Governments also risk revealing their own vulnerabilities and those of their citizens and infrastructure by adopting a crowdsourcing application and making the crowdsourced information accessible to the public. However, historic and recent examples prove that government agencies and citizens can benefit from the use of crisis crowdsourcing and social media for emergency management. Government agencies responsible for managing the 2005 Hurricane Katrina disaster were widely criticised for their inadequate management of the unfolding situation (Guion, Scammon, & Borders, 2007; Palen, Hiltz, & Liu, 2007). It is speculated in the literature that, as a result of this, online forums and web-mapping tools (e.g. Scipionus) emerged for citizens to coordinate their own response and recovery efforts (Palen et al., 2007; Roche et al., 2011). Over a decade later, the very recent Fort McMurray, Alberta wildfire disaster in May 2016, demonstrated the benefits that crowdsourcing and social media for emergency management provides government agencies. During the unfolding disaster, the Regional Municipality of Wood Buffalo maintained constant contact with citizens over Twitter. In doing so, the agency was able to provide immediate answers to citizens' urgent questions about what should be done and where to go, and was able to identify citizens in need of help and connect them with other citizens or responders who could provide the help they needed (Mertz, 2016; Normand, 2016).

Prior to the significant Fort McMurray wildfire disaster this past year, trends in the literature show that governments agencies in the United States of America (USA) have weighed the costs and benefits of crisis crowdsourcing and social media for emergency management. Federal agencies like the United States Geological Survey (USGS) and the Federal Emergency Management Agency (FEMA) have successfully launched multiple crowdsourcing applications related to emergency and disaster management. Much of the literature around government crisis crowdsourcing is focused on the applications launched by the USGS, such as Did You Feel It? and iCoast (S. Liu, 2014; Wald, Quitoriano, Dengler, & Dewey, 1999; Wald, Quitoriano, & Dewey, 2011). Additionally, as demonstrated during the Fort McMurray wildfire, social media has emerged as an alternative method of communication between government and citizens. Social media is being explored by many more government agencies than those adopting crowdsourcing and has proven to be an effective tool for bridging communication between emergency responders and citizens before, during, and after an unfolding situation (Hughes & Palen,

2012; Latonero & Shklovski, 2011; Newton, 2014; San Su, Wardell III, & Thorkildsen, 2013). However, the crisis crowdsourcing literature and most of the social media emergency communication literature is focused in the USA, with some recent studies emerging from Australia and Canada.

By engaging with citizens online, either through a crowdsourcing application or over social media the government is able to maintain contact with its citizens during a time when it is urgently needed. In turn, this shows the citizens that the government is responsive to their needs. Crowdsourcing and social media provide an opportunity for government agencies to connect with citizens in a novel way, by allowing citizens to share their lived experiences of a significant event (e.g. an earthquake), or to learn about hazards that they may not have been fully aware of (e.g. coastal hurricane damage). In this way, the government is showing their citizens that they care about the experiences of their citizens and about what happens to them. Thus, crisis crowdsourcing and social media for emergency management has the potential to increase citizens' trust in their government, especially during emergencies.

The primary focus in the crisis crowdsourcing literature has been on the non-governmental use for emergency response and recovery efforts. From the small body of literature that does include government use of crisis crowdsourcing, the focus has been on the USA. Thus, this research aims to address three gaps that exist in the literature: 1) classify the use of government crisis crowdsourcing in all phases of the disaster management cycle with a focus on government applications in North America, 2) identify the benefits of government crisis crowdsourcing and social media for emergency management 3) characterise crisis crowdsourcing efforts in Canada, and 4) identify barriers and constraints that Canadian government agencies face that may be hindering their efforts. While the primary focus of this study is on Canada, lessons learned in this context have implications for other jurisdictions. This research provides a stepping stone into understanding the role of crisis crowdsourcing in the Canadian emergency management realm specific to government agencies.

1.2 Research Purpose and Objectives

1.2.1 Research Goal

The goal of this research is to characterize the use of crisis crowdsourcing in Canada and the USA and provide recommendations to ease the adoption of this new technology by government agencies responsible for emergency management.

1.2.2 Objectives

Five objectives were formulated to meet the research goal:

1. Characterise the adoption of crisis crowdsourcing by the various levels of government in Canada and the USA.
2. Identify the ways in which crisis crowdsourcing can improve emergency management within government.
3. Determine the various ways in which crisis crowdsourcing feeds into all four phases of the disaster management cycle.
4. Identify the unique barriers and constraints that may be inhibiting the adoption of crisis crowdsourcing in Canadian government agencies and provide recommendations to overcome these barriers.
5. Create a readiness assessment framework for Canadian government agencies to pinpoint their unique barriers or constraints in adopting crisis crowdsourcing.

1.3 Research Scope

The scope of this research will focus primarily on the use of crowdsourcing for management of natural and technological hazards and disasters (e.g. hurricanes, severe weather, earthquakes, infrastructural failure, fire/explosion, transportation). The research excludes the use of crowdsourcing and information communication technologies for management and response of terrorism. Terrorism is an inherently complex issue that introduces new challenges around protecting personal safety and security online while a terrorist attack is unfolding. These complex issues are outside of the scope of this research.

1.4 Thesis Outline

This thesis explores the current state of crisis crowdsourcing practices in Canadian and American government emergency management agencies, with a specific focus on participating agencies in Canada. A review of the literature, along with the methodologies, findings and discussion are separated into two core chapters, and a concluding chapter. The thesis document follows the manuscript style option. As such, the findings are presented in two separate manuscripts, each of which fulfills the two core chapters. Each manuscript will be independently submitted to academic journals for publication.

In Chapter 2, a review of the literature characterises the United States of America (USA) as an innovative country in terms of government crisis crowdsourcing, and reveals that efforts in Canada are limited. In addition, the literature traces the emergence of social media which has provided an easy way for government agencies to connect with citizens in both times of crisis and of calm. Semi-structured interviews conducted with 22 government officials from Canada and the USA at the various levels of government in both countries provide a snapshot of the current state of government crisis crowdsourcing amongst participating agencies in North America. Ways in which crowdsourcing can feed into the four phases of the disaster management cycle (mitigation, preparedness, response, and recovery) are discussed.

A more in depth analysis of the current crisis crowdsourcing practices in Canada is provided in Chapter 3. The focus of this chapter is on the barriers and constraints that are present in the Canadian emergency management realm that may be inhibiting the adoption of crisis crowdsourcing. A broad overview of the previously identified barriers and constraints associated with crisis crowdsourcing is presented through a review of the literature. However, since the USA appears to be the only country heavily involved in government crisis crowdsourcing, these barriers and constraints are specific to the American emergency management realm. This provides a clear opportunity for the barriers and constraints in Canada to be identified and documented. Semi-structured interviews with 15 emergency management officials from all levels of government in Canada were conducted to characterize these unique barriers and constraints. The primary concerns that Canadian emergency management officials have with crisis

crowdsourcing are identified. Factors that constrain the adoption of crisis crowdsourcing by Canadian agencies are discussed. These factors are grouped into three areas of concern for which an assessment framework is provided. This readiness assessment framework allows agencies to assess their own readiness and easily identify barriers and constraints that are unique to them. Recommendations to ease the adoption of crisis crowdsourcing by Canadian government agencies are provided based on the constraints and barriers identified.

Chapter 4 includes a summary of the key findings and conclusions from Chapter 2 and 3. Future research directions are also highlighted.

Chapter 2

Characterising crisis crowdsourcing efforts by governments in North America: Informing all phases of the disaster management cycle

2.1 Introduction

In recent years, crowdsourcing and volunteered geographic information (VGI) have emerged as effective tools for communication between citizens, governments, businesses, and scientists. Governments at various levels have adopted crowdsourcing and/or VGI to engage with the public and build an open government, often referred to as Government 2.0. Governments use this technology to aid in decision making for changing or creating new policies and obtaining feedback on development plans. Crowdsourcing and VGI have also become essential to emergency response efforts, as citizens experiencing the crisis or disaster share information about current ground conditions. Emergency officials use this information for effective planning in their emergency operations. However many of these crowdsourcing efforts are led by non-governmental organizations (NGOs) and private citizens and it has been suggested that the emergence of these applications during a crisis are a response to partial government failings to act quickly and effectively (Johnson & Sieber, 2013). The focus in the literature has primarily been on the development and implementation of crowdsourcing applications by non-government agencies and public citizens in emergency response and recovery (Goodchild & Glennon, 2010; Meier, 2012; Roche et al., 2011). There is a gap in literature in understanding the state of crowdsourcing by governments for emergency management, and identifying the ways in which crowdsourcing can feed into the other disaster management phases, such as mitigation and preparedness. Alternatively, while the literature clearly describes the benefits that NGOs and citizens experience with crisis crowdsourcing, the literature is also lacking in identifying the unique benefits that government agencies may experience by adopting crisis crowdsourcing.

The objective of this thesis paper is to understand how crisis crowdsourcing can be applied in all phases of the disaster management cycle and to identify the benefits that crowdsourcing has for government emergency operations. It may be that governments are hesitant in adopting crisis crowdsourcing because they are not yet aware of, or convinced with, the benefits that these applications offer to their operations. This is

done firstly through an investigation of current crisis crowdsourcing practices in Canada and the United States of America (USA). The current state of government emergency management crowdsourcing in the USA and Canada is presented through a series of interviews with 22 officials from various levels of government, including federal meteorologists, seismologists, research oceanographers, as well as emergency managers at the municipal, county, and provincial levels. Interview results indicate that the participating agencies in the USA is more active in developing specialized crowdsourcing applications, while participating agencies in Canada are exploring the uses of social media for emergency management. While crisis crowdsourcing is often directly used in the post-disaster phases (i.e. response and recovery), the results reveal that the information produced from these applications can be used to further improve mitigation and preparedness efforts by allowing agencies to learn from the events and identify areas for improvement.

This research presents a deeper understanding of the current use of crowdsourcing practices by governments for emergency management. Furthermore, it is revealed that crisis crowdsourcing has a role in all four phases of the disaster management cycle. As existing literature has primarily been focused on the use of crisis crowdsourcing in response and recovery, this research offers a new perspective in how crisis crowdsourcing and its resulting information can be used for mitigation and preparedness. The benefits that crisis crowdsourcing offers to government agencies are also identified and described, which government agencies can consider when weighing the costs and benefits of adopting crisis crowdsourcing.

2.2 Literature Review

2.2.1 Crowdsourcing Models and Approaches

In the past decade crowdsourcing has become an effective tool for communicating with and gathering ideas from the general public. Many private companies have integrated crowdsourcing into their business models for improving their products, while researchers and scientists have started using crowdsourcing as a new method of data collection.

The definition of crowdsourcing is not completely agreed upon in the literature. John Howe, writer for Wired Magazine, first coined the term “crowdsourcing” in a paper he wrote for the magazine in 2006 in which he described it as “the new pool of cheap labor: everyday people using their spare cycles to create content, solve problems, even do corporate R&D [research and development]” (Howe, 2006). Many other definitions of crowdsourcing have since emerged. For example, Brabham describes crowdsourcing as a concept of “collective intelligence”, and the “wisdom of crowds” (Brabham, 2013a). Crowdsourcing is heavily reliant on the current generation of the World Wide Web¹ (Web 2.0) (Brabham, 2013a), thus it can be described as a “web-based ... model that harnesses the creative solutions of a distributed network of individuals” (Brabham, 2008).

Since the inception of crowdsourcing, many other characterizations and models of crowdsourcing have emerged based on how it is carried out, on the type of contributors, and on the type of information produced. Two approaches to crowdsourcing have been widely mentioned throughout the literature: active crowdsourcing and passive crowdsourcing (Loukis & Charalabidis, 2015; Tong, Cao, Zhang, Li, & Chen, 2014). Active crowdsourcing can be described as a form of crowdsourcing which involves requests being sent out to the “crowd” for ideas, solutions, or discussions to be produced. Alternatively, passive crowdsourcing refers to the voluntary creation of content over the

¹ It is recognised that pre-internet instances of crowdsourcing exist, such as the Audubon Christmas Bird Count (1900 - present) where volunteers explored local neighbourhoods and landscapes to identify and count bird species to monitor population trends (Butcher, Fuller, McAllister, & Geissler, 1990), and the Land Utilization Survey of Britain (1930's) where volunteers (primarily students) filled in maps based on local knowledge of the land use in their communities (Stamp, 1934). However, it is argued that while the fundamental characteristics of crowdsourcing have existed for decades, if not centuries, the full potential of crowdsourcing was not realized or exploited until the widespread use of the internet (Brabham, 2013a). Therefore, the focus of crowdsourcing in this study is on recent examples using the internet.

web by users without any request by an organization, which is then collected and exploited by a given organization (Charalabidis, Loukis, Androutsopoulou, Karkaletsis, & Triantafillou, 2014; Loukis & Charalabidis, 2015; Tong, Cao, Zhang, Li, & Chen, 2014).

In recent years, social media has become another platform for crowdsourcing. The emergence of social media, like crowdsourcing, is based on the development of Web 2.0 (Kaplan & Haenlein, 2010). Social media is an umbrella term that refers to online blogs, micro-blogs, social networking, forums, collaborative projects, and the sharing (i.e. uploading and disseminating) of photos and videos (Alexander, 2014; Bertot, Jaeger, & Grimes, 2012; Kaplan & Haenlein, 2010). The key difference between social media and traditional media (i.e. television, newspaper), is the interactive nature amongst users and producers of content. Traditional media is characterized by a one-to-many, unidirectional interaction between the users and producers, whereas social media has a many-to-many, multidirectional interaction between users (Bertot, Jaeger, & Grimes, 2012; Porter, 2008). The wide adoption of social media is described by Kaplan & Haenlein as a “revolutionary trend”, as it ranges from teenage to adult users world-wide (2010), and has contributed to the success of social media as a crowdsourcing platform.

The rich content that is voluntarily created and shared on social media platforms introduces a new model of crowdsourcing (Charalabidis et al., 2014; Loukis & Charalabidis, 2015; Singh, 2015). Loukis & Charalabidis characterized active and passive crowdsourcing based on the innovative ways in which information from social media is gathered and used (2015). Most crowdsourcing practices with social media involve the passive approach, as the nature of social media is to voluntarily create content or collaborate on projects without any incentive or drive from higher-up. This user generated content is readily available for the use and exploitation by any organization with access to it (Charalabidis et al., 2014; Kaplan & Haenlein, 2010; Loukis & Charalabidis, 2015). Social media can also be a platform for active crowdsourcing, in which an organization poses a problem or question on social media for the users to respond to (Liu, Lehdonvirta, Alexandrova, & Nakajima, 2012; Loukis & Charalabidis, 2015). The results from the social media query can then be aggregated and analysed using an automated system and supervised machine learning (Castillo, Mendoza, & Poblete, 2013; Y. Liu et al., 2012).

2.2.2 Crisis Crowdsourcing

Before delving into the mechanics of crisis crowdsourcing, an overview and clarification of the terminology must first be provided. The terms “disaster”, “emergency”, and “crisis” are often used interchangeably in the literature, with little differentiation between the three terms. However, there are some key differences in the scale and inherent nature of these terms, which have been clearly outlined by emergency management agencies themselves. For example, the Emergency Management Act for the Province of Alberta includes definitions for “disaster” and “emergency” and attempts to differentiate between the two terms. The province defines a disaster as “an event that results in serious harm to the safety, health or welfare of people or in widespread damage to property in serious harm to the safety” (Province of Alberta, 2013). The disaster management realm typically describes a disaster as the combination of a hazard and vulnerability to the hazard that exceeds the adaptive capacity of the impacted area and results in widespread impacts and losses of human life, property, infrastructure, the economy, the environment, etc. (UNISDR, 2007). Closely related to disasters are emergencies, which the province of Alberta defines as “an adverse situation requiring prompt response to save lives and protect property using existing resources and procedures” (Province of Alberta, 2013).

The key differences between a disaster and an emergency are the scale of the impacts and required response. Disasters often cross jurisdictional boundaries and disrupt the social and/or economic state of the impacted populations, and usually require coordinated response and support from “outside agencies” (Etkin & Dotto, 2010), whereas emergencies typically impact smaller populations, are usually contained within a jurisdictional boundary and only require routine response efforts from internal response agencies (Government of Alberta, 2010). Disasters are inherently emergencies, but emergencies can either become a disaster if not appropriately managed, or not become a disaster if successfully addressed.

The term “crisis” is not as clearly defined in the emergency management realm as “disaster” and “emergency”, and appear to be used in place of “disaster” (e.g. Alexander, 2014; Cameron, Power, Robinson, & Yin, 2012; S. Liu, 2014). However, it seems that some emergency management agencies consider crises at the smallest scale, with impacts of

an event focused on an individual or small population (LifeNet, n.d.), and the impacts are not always obvious or evident without further analysis (World Health Organization, 2016).

When a disaster or emergency strikes a location or population, quick and effective decision-making is of the utmost importance. Decision-making processes within the disaster management realm require a range of capabilities, including:

- Accurate prediction of a disaster, and evaluation of the potential impacts on the population and resources
- Generation and dissemination of timely warnings to authorities and populations in the affected region
- Mitigation/risk reduction of the disaster impacts
- Timely and coordinated response and recovery efforts during and after the disaster (Zhang, Zhou, & Nunamaker Jr, 2002)

All of these capabilities can be summarised in the disaster management phases: preparedness, mitigation/risk reduction, response, and recovery. Together these four phases build what is referred to as the disaster management cycle. The disaster management cycle is demonstrated in Figure 1.

During the response and recovery phases, timely and accurate information is crucial to the organisations involved. They must be able to collect, analyse, store, and communicate information about an unfolding event so that the best decisions can be made for disseminating resources and aid (Morton & Levy, 2011; Zhang et al., 2002). In light of the need for timely data collection, processing, analysis and communication, emergency response organisations can find themselves struggling to make both quick and effective decisions. As one possible solution to these challenges, Zhang et al. proposed a knowledge management framework which introduced the internet as a new channel for communication, data collection, and information dissemination (2002). Since this initial introduction of the internet as a communication tool for emergency management, other examples in the literature prove that internet-based technology, such as web-GIS, can significantly improve the performance and decision-making of response organizations (Morton & Levy, 2011).



Figure 1. The Disaster Management Cycle and the four phases. The cycle is split into two general periods, the pre-disaster period with the mitigation/risk reduction and preparedness phases to minimise risk and impacts before an event, and the post-disaster period, in the immediate aftermath of an impactful event, the response phase is initiated. After the immediate response phases, efforts shift into the recovery phase.

The introduction of the internet into emergency operations opened up new opportunities for improving emergency communication. The literature began to shift towards using the internet for improving communication and engagement with not only authoritative disaster management agencies, but also with general members of the public (Jaeger et al., 2007; Kemp, 2008; Palen et al., 2010; Palen & Liu, 2007). Emerging from this research was the use of crowdsourcing and volunteered geographic information in disaster response efforts. Since Goodchild first defined volunteered geographic information (VGI) in 2007 and identified its potential for early warning systems using “citizens as sensors,” and since then, numerous studies have been completed on VGI and crowdsourcing for disaster management (Horita, Degrossi, Assis, Zipf, & de Albuquerque, 2013; Poser & Dransch, 2010; Roche et al., 2011).

The development of a crowdsourcing or VGI platform for emergency response usually happens spontaneously, during or immediately after an adverse and impactful event (Burns & Shanley, 2012; S. Liu, 2014; Roche et al., 2011; Starbird, 2012). In addition, VGI platforms such as Scipionus are usually developed and implemented by members of the affected public or by non-governmental organizations (NGOs) such as Ushahidi (Roche et al., 2011). Scipionus was created by an individual from New Orleans and was a crucial tool for communication among victims of Hurricane Katrina when traditional communication infrastructure failed (Roche et al., 2011). Ushahidi became a major communication resource in the wake of the Haitian earthquake disaster in 2010: It is described as a resource and information sharing platform that allows users to send in information about a specific event unravelling on the ground via SMS, e-mail, or online form, for others to view (Roche et al., 2011). The purpose of platforms such as Ushahidi is to improve disaster response and resource allocation based on real-time reports sent in from disaster victims on the ground (Roche et al., 2011; Zook, Graham, Shelton, & Gorman, 2010). It is evident that the multi-directional flows of communication and information that crisis crowdsourcing² platforms offer are making response and recovery efforts more efficient (Roche et al., 2011). Another notable example of crisis crowdsourcing, the map mash-ups for the Santa Barbara wildfires of 2007 to 2009, further demonstrate how citizens built their own communication tools as a response to the inaccurate or missing government authorised updates (Goodchild & Glennon, 2010).

Most crisis crowdsourcing efforts are launched by volunteers, often not in an official or authoritative position related to the emergency response (Meier, 2012). In addition, most of these efforts demonstrate active crowdsourcing models, with volunteers actively contributing their information to the platforms. One other platform that has arisen in crisis events which is more passive rather than active, is social media. There is a clear shift in the literature from crisis crowdsourcing projects that require contributors to fill

² Given the preceding definitions of “disaster”, “emergency”, and “crisis”, the term “crisis crowdsourcing” will be used throughout this thesis document to reflect a specific type of crowdsourcing that is used for emergency communication. The crowdsourcing methods and models analysed in this paper focus on information and reports that are contributed directly by citizens to their government agencies (i.e. the information is based on the citizens’ perspectives and experiences at an individual level). Since “crisis” was defined as an event felt at the smallest scale (i.e. the individual/small population level), the term “crisis crowdsourcing” will be applied, even if the methods or models are used in larger scale emergencies or disasters.

out forms or send their information directly to a specific platform (active, intentional), to social media monitoring and harvesting (passive, non-intentional). Geolocated information from Facebook and Twitter users is now an additional resource to crisis crowdsourcing and mapping (Dransch, Poser, Fohringer, & Lucas, 2013; Foresti, Farinosi, & Vernier, 2015; Meier, 2012; Triglav-čekada & Radovan, 2013).

Social media has become a natural channel for communication during a disaster. In disastrous events, social media users “provide emotional support to each other, exchange situation updates, broadcast damage reports or propose and coordinate actions” (Dransch et al., 2013, p. 104). The 2004 Indian Ocean Tsunami and 2005 Hurricane Katrina events are commonly cited in the literature as being some of the earliest events in which blogs and social media became significant communication tools amongst victims of the disaster (Palen & Liu, 2007; Starbird & Palen, 2010). Several studies into the use of social media during crisis events proved that the emergency management realm can benefit from using social media during a crisis event by obtaining a deeper understanding of changes in sociotechnical behaviours in a crisis situation as well as using real-time analytical activity that is being performed by citizens and is published online (Palen, Vieweg, Liu, & Hughes, 2009; Vieweg, Palen, Liu, Hughes, & Sutton, 2008). Social media offers emergency managers with an opportunity to “use citizens as data reporters” (Starbird & Stamberger, 2010). Similarly, geo-located reports from social media can be used to populate a crowdsourcing web-map application to support crisis recovery and aid efforts (Gao, Barbier, & Goolsby, 2011).

2.2.3 Government Crowdsourcing

Government agencies have been slow to join the crowdsourcing trend, but in recent years more are turning to crowdsourcing in an effort to improve transparency and engagement with citizens. Government agencies in the USA, Canada, and Europe have experimented with incorporating various types of crowdsourcing and VGI into their own operations (Beaulieu, Bégin, & Genest, 2008; Johnson, 2014, 2016; Koch, Füller, & Brunswicker, 2011; Lodge & Wegrich, 2014). This is in response to the “Government 2.0” and “Open Government” movements that emerged in the past decade. The literature on government crowdsourcing efforts is continuing to grow and researchers are particularly interested

in creating frameworks for governments to follow when starting crowdsourcing or VGI projects (Bertot, Jaeger, & Hansen, 2012; Linders, 2012; Roberts, Grosser, & Swartley, 2012). For example, Brabham presented a complete report to public managers in which he analysed each type of crowdsourcing (e.g. Knowledge Discovery Management, Distributed Human Intelligence Tasking, Broadcast Search, and Peer-vetted Production) to aid in choosing appropriate approach based on the nature of their problem (Brabham, 2013b). Haklay et al. expanded on this analysis by introducing geographic crowdsourcing (collecting geographic attributes in addition to other data) to existing crowdsourcing methods and classifications (Haklay, Antoniou, Basiouka, Soden, & Mooney, 2014).

When crowdsourcing is used by the government it is often described as “public engagement” (Brabham, 2012; Lauriault & Mooney, 2014). Public engagement is largely related to information communications technology (ICTs) (also referred to as ICT-facilitated co-production), therefore much research related to government crowdsourcing involves examining ICTs like computers, mobile devices, the internet, and social media. The internet and ICTs have reduced the cost of collecting, distributing, and accessing government information, making it easier for governments to include citizens in the design, production, and delivery of their services (Bertot, Jaeger, & Hansen, 2012; Kannan & Chang, 2013).

2.2.4 Government Crisis Crowdsourcing

Despite the wealth of literature on crowdsourcing and VGI for emergency response and the latest literature on government adoption of crowdsourcing and VGI, there is very little research on government use of crowdsourcing for the other aspects of emergency management such as mitigation/risk reduction and preparedness, and recovery (Figure 1). In one particular paper, Johnson & Sieber (2013) described emergency response as the most “prominent” use of VGI, though not by governments. The authors suggest that the emergence of VGI during a crisis is a response to the failure of governments to act swiftly in distributing aid to the areas in most need. In a study around the communication of bushfire safety in Australia, Brady & Webb (2013) also suggested that various unofficial community bushfire websites existed due to a “perceived gap” in official online services from government sectors.

Government agencies may be slow in adopting crisis crowdsourcing because of a lack of awareness or understanding of the benefits the crisis crowdsourcing can offer them. Since the crisis crowdsourcing literature focuses on the use of it by NGO's and citizens and its associated benefits, it can be difficult for government agencies to determine whether adopting it into their own operations offers the same or different benefits. Despite this lack of assurance, some government agencies are using crowdsourcing and VGI for emergency management practices; sometimes it is in the form of passive crowdsourcing through social media, or active crowdsourcing through a developed application. Examples of these practices have been documented in the literature and are summarised in Table 1. As a result of these recent practices, a new trend has emerged: governments experimenting with social media and crowdsourcing to inspire policy change.

From the literature consulted in this study, it is clear that federal agencies from the United States of America (USA) are leading the way in global crisis crowdsourcing adoption. The applications launched by the US federal agencies listed in Table 1 each have very different, specific uses. For example, the USGS has launched more crisis crowdsourcing applications than any other agency, and use these for scientific research into very specific hazards (e.g. earthquakes, hurricanes). In fact, the USGS was the first government agency to systematically implement a crowdsourcing application in the realm of emergency management. Dating back to 1997, the USGS described the first "fully automated earthquake detection intensity system", known as "Did You Feel It?" (Wald et al., 1999). The "Did You Feel It?" (DYFI?) system is internet-based and allows untrained citizens to send in earthquake observations, which are used for early detection and data analysis (Wald et al., 2011). Alternatively, the crowdsourcing platforms developed by FEMA and Grundy County follow a different model and application: for citizens to contribute severe weather reports and/or photos of damage to inform emergency managers. The crowdsourcing practice employed by Miami-Dade County is also used to inform emergency managers, but is modelled and implemented differently from the FEMA and Grundy County platforms; the platform gathers information from 311 telephone calls and also through an online submission form, while the FEMA and Grundy County applications are mobile platforms.

Table 1. Summary of active crisis crowdsourcing applications implemented by government agencies.

| Agency | Country | Application Name | Date Implemented | Description |
|--------------------------------|----------------|----------------------------------|-------------------------|---|
| USGS (Federal) | USA | Did You Feel It? (DYFI?) | 1997 | The first “fully automated earthquake detection intensity system.” Citizens send in earthquake observations online, which are used for early detection and data analysis (Wald et al., 1999, 2011). |
| Miami-Dade County (County) | USA | Snapshot Damage Assessment & 311 | 2007 | The county receives online reports of damage and 311 telephone calls to enhance their situational awareness during an emergency event (Castellanos, Castillo, Gudi, & Lee, 2013; Schellong & Langenberg, 2007). |
| USGS (Federal) | USA | Tweet Earthquake Dispatch (TED) | 2011 | An earthquake detection procedure that relies on Twitter data alone. The procedure allows for rapid earthquake detection and a qualitative assessment of events (Earle, Bowden, & Guy, 2012). |
| USGS (Federal) | USA | Did You See it? | 2012 | A reporting application mirroring the DYFI? model to allow users to report instances of landslides experienced and witnessed (Baum et al., 2014). |
| FEMA (Federal) | USA | FEMA App | 2013 | The application provides weather alerts, emergency preparation tips, other disaster resources, and the ability for citizens to submit disaster photos onto a public web-map. The map is universally accessible, with no restrictions, thus allowing all emergency managers to view the information (Adamski, 2013). |
| Department of Energy (Federal) | USA | Lantern Live | 2014 | During an emergency or power outage, citizens can report the operational status of fuel stations, for other citizens to determine where fuel is available and identify where power outages are occurring (Department of Energy, 2014). |
| USGS (Federal) | USA | iCoast | 2014 | “Digital volunteers” compare before and after aerial photos of Hurricane Sandy and classify changes along the US coast caused by the hurricane. The application was designed to validate predictive models of coastal change (S. Liu, 2014). |
| Grundy County (County) | USA | Grundy EMA App | 2015 | The application educates citizens on local hazards and emergency practices, sends out alerts, and allows citizens to send in reports of damage after a severe weather event. The information gathered by the county is reported back to the National Weather Service (Litchfield, 2015). |

The examples listed in Table 1 demonstrate how the USA is leading in crisis crowdsourcing practices. The search for government-launched crisis crowdsourcing practices was a global one, yet results only showed up from the USA. The search included key terms entered into Google and Google Scholar such as “government crowdsourcing,” “government crisis crowdsourcing,” “crisis crowdsourcing,” “emergency management crowdsourcing.” The results were filtered through to determine whether the platforms met two criteria: 1) they were launched and managed by a government agency, 2) they are directly related to and applied in emergency management practices (this can be for scientific research and modeling, or for response and recovery efforts). The literature relating to government crowdsourcing and crisis crowdsourcing was scoured through, and any emerging example that met the two criteria were further investigated and noted. Following specialised emergency management and crowdsourcing profiles on Facebook and Twitter also aided in identifying recent examples such as the Grundy EMA App. The search results reveal a significant gap in both the research and the application of government crisis crowdsourcing practices outside of the USA; other countries appear to be faltering in adopting active crowdsourcing practices for emergency management.

Despite the above search results, further investigation into government adoption of social media for emergency management practices suggests that agencies inside and outside of the USA are experimenting with social media. Key word searches to identify the use of social media for emergency management included “social media emergency management,” “government social media”. Once again, results were filtered based on whether they met the two criteria of being used directly by government agencies, and being used for emergency management. There is a growing wealth of literature focusing on social media use by emergency management agencies in the USA and Australia, suggesting that agencies have begun to realise the value of social media and are now experimenting with it. There is a potential for social media to enhance 911 emergency system lines, to determine public sentiment and reaction to response agencies’ efforts, to enhance situational awareness, and to accelerate damage estimation processes based on information being posted by social media users (Bird, Ling, Haynes, & others, 2012; Flew et al., 2015; Fraustino, Liu, & Jin, 2012; Laskey, 2013; Latonero & Shklovski, 2011; Lindsay, 2011; Taylor, Wells, Howell, Raphael, & others, 2012; Virtual Social Media

Working Group & DHS First Responders Group, 2014). A vast number of government agencies from all levels in the USA are now using social media for pushing information out and for monitoring unfolding crisis situations (San Su et al., 2013). It is clear that social media is changing emergency management practices and the roles of emergency managers in the USA (Hughes & Palen, 2012; Latonero & Shklovski, 2011), and agencies in Australia are beginning to follow suit (Cameron, 2012; Cameron, Power, & Robinson, 2012; Flew et al., 2015).

In response to the changes social media is bringing to emergency management operations, the US Department of Homeland Security's Science and Technology Directorate established the Virtual Social Media Working Group (VSMWG) in early 2012. The purpose of the group is to provide guidance and determine best practices to emergency management agencies on the safe and sustainable use of social media in all phases of emergency management (Department of Homeland Security, 2012; Virtual Social Media Working Group & DHS First Responders Group, 2014).

The government of Canada appears to have only recently realized the value of social media in emergency management. While there is very limited research available on the use of social media for emergency management by Canadian government agencies, the existing literature indicates a shift in the Canadian government's efforts towards social media use in emergency management. Starting in 2011, mentions of social media and crowdsourcing for emergency management began to emerge online (Cloutier, 2011; Eaves, 2011; Leson, 2014). In several blog posts about two meetings held between social media and crisis crowdsourcing advocates from several Volunteer Technical Communities (e.g. Ushahidi, Crisis Mappers Net, Google Crisis Response, and Crisis Commons) and the Canadian Government (e.g. the Department of Foreign Affairs and International Trade (DFAIT)), it was revealed that the DFAIT is looking for information tools to enhance their response efforts abroad and to build resilience for Canadians abroad (Cloutier, 2011; Eaves, 2011; Leson, 2014). These meetings and continued discussions between the DFAIT and the Volunteered Technical Communities (Ushahidi and Humanitarian OpenStreetMap Team (HOT) in particular) led to workshops where government officials were able to participate in hands-on learning about the processes and the data that is used and gathered by these organizations (Beland, 2012; Leson,

2014). Most recently, in 2013 the “first-ever Canadian government sanctioned” simulation for CrisisMapping with Ushahidi, HOT, and Standby Taskforce. This event allowed officials from various levels of government in Canada to learn about the work these organizations undergo (Leson, 2014). All of these efforts have been focused primarily on Canada’s participation in global response efforts, with an emphasis on enabling and protecting Canadians abroad.

More recently, social media and crisis crowdsourcing literature in Canada has started to focus on practices within Canada by the Canadian government. It appears that in 2012 the Canadian Red Cross led the way in researching citizen use of social media and mobile technology during emergencies. The study, consisting of online and telephone surveys with 1,000 Canadians across the country, revealed that more than half of respondents would use social media to communicate with loved ones during an emergency, and that one-third of respondents would expect to receive assistance from emergency services after posting a call for help on social media (Canadian Red Cross, 2012). The study also discovered that the Toronto Police now undergo rigorous social media training for the proper monitoring of and engagement with citizens on social media; the City of Calgary has developed a mapping tool which pulls information from social media to build a picture of current ground conditions; and government officials have also started to use social media for rumour control (Canadian Red Cross, 2012). In the same year, results from the Third Annual National Roundtable on Disaster Risk Reduction indicate that social media has a role in supporting volunteerism during an emergency, in supporting cross-sectorial collaboration in disaster management, and promoting disaster resilience (Third Annual National Roundtable on Page Disaster Risk Reduction, 2012).

The 2013 Calgary Floods proved that social media has a central role in emergency information communication. Shortly after this the Government of Canada made funding available to a new project called Social Media in Emergency Management (SMEM). The goal of SMEM is to develop an understanding of the use of social media in Canadian emergency management operations and provide guidelines to help agencies increase their SMEM capability (Kaminska, Dawe, & Rutten, 2013; Kaminska & Rutten, 2014). This is very similar to the development of the VSMWG in the United States. Most recently, in 2015 the Canadian government participated in a resiliency experiment with the

American government to assess the performance of social media and other situational awareness tools for cross-border exchange of information and alerts and for coordinating aid during a simulated hurricane event (Cotter et al., 2015). It was found that social media and situational awareness tools can improve recovery operations, yet agencies in both Canada and the USA are not fully exploiting these tools; more consideration is needed on how social media and other situational awareness tools can inform in the policy realm (Cotter et al., 2015).

It is clear from this chapter's literature review that there is a gap in the understanding and documentation of crisis crowdsourcing efforts made in by government agencies in Canada. This provides a research opportunity in investigating and characterising the current state of crisis crowdsourcing in Canada. In addition, much of the focus in the crisis crowdsourcing literature has been on its use in the post-disaster phases in the disaster management cycle (i.e. response and recovery). This provides yet another opportunity for exploration into the application of crowdsourcing in the pre-disaster phases: mitigation/risk reduction and preparedness.

2.3 Primary Research Methods

Primary research involved conducting semi-structured interviews with officials from all levels of government in both Canada (n = 15) and the United States (n = 7). Semi-structured interviews were mainly conducted over the phone, with one being conducted in person. The purposes of the interviews were to develop a deeper understanding of the emergency or disaster management processes in the government agency, and to identify all of the tools and methods that are used for collecting information from the general public during an emergency event. The semi-structured interview model was selected as it allows for follow-up questions to be asked based on the participants' responses to the interview script questions (Dey, 1993; DiCicco-Bloom & Crabtree, 2006; Turner III, 2010). The interview script was designed to investigate how the government agency gathers information from the public for emergency management (Table 2). The participants were asked to perform an assessment of their current tools and processes, and to provide insight around the potential for a crowdsourcing application to be adopted if they have not already done so.

Table 2. Interview script themes.

| Theme | Purpose |
|---|--|
| Theme 1: Background on participant and applications/processes | To gain insight into the participant’s official role and the methods and processes that are used to collect information and requests from citizens during an emergency |
| Theme 2: Assessment of applications/processes | To discuss the overall performance and success or failure of the agency’s applications or processes |
| Theme 3: Benefits, Advantages/improvements, | List of advantages/improvements of government adoption of crowdsourcing and VGI for emergency management were constructed based on the literature. Participants were asked to identify which factors are or were relevant to them and how they were addressed. |

The participants were selected based on their positions within the government, their roles in emergency management, and their involvement with any crowdsourcing or VGI projects that have been undertaken by their agency. Participants ranged from community emergency management coordinators, to oceanographers, seismologists, warning preparedness meteorologists, and communications and marketing officials. Prospective participants were first contacted by e-mail with an attached information script for them to further understand the purpose of the study and their participation in it. Contact information was obtained from their agency’s public website. Interviews were audio-recorded with the participants’ consent, and were transcribed verbatim by the lead author. Interviews varied in length from 40 minutes to 2 hours, and were conducted at a time and place convenient for the participants and interviewer. All participants located outside of southern Ontario and Canada (n = 15) were interviewed over the telephone. Participants located in Southern Ontario (n = 7) were given the option of conducting the interview over the phone or in person. All but one participants in Southern Ontario opted for scheduling a telephone interview, while one interview was conducted in person. Data analysis of interview scripts involved using MAXQDA software for thematic coding and analysis of the interview scripts. The transcripts were coded based on interview script themes, the applications or processes that the participants described, and any other common themes that emerged from discussions with the participants. In accordance with the University of Waterloo’s Office of Research Ethics requirements, all of the participant quotations are identified only by their position, level of government, and country.

To understand the emergency management processes within government agencies from both Canada and the United States, it was necessary to request interviews with as many emergency and disaster management officials as possible from all levels of government, therefore 48 officials were contacted by e-mail in Canada and 52 in the United States. The total number of officials who were contacted and participated from each country and level of government is shown in Table 3. There was a 31% response rate from Canadian officials, and a 14% response rate from officials in the United States. The various positions from each level of government and years of experience for each respective position are listed in Table 4. Participants were successfully recruited from all levels of government in Canada, and all levels except for the state level in the United States. 26 officials from various state-level governments were contacted for the study, but none were able to participate. The level of experience amongst the participants in their respective roles ranges from one to 32 years.

Table 3. Number of participants from each level of government in Canada and the USA.

| | CANADA | | | USA | | |
|-------------------------|---------------|--------------|-------------------|------------|--------------|-------------------|
| | Contacted | Participated | Response Rate (%) | Contacted | Participated | Response Rate (%) |
| LOCAL | 17 | 5 | 29 | 10 | 2 | 20 |
| COUNTY | 26 | 6 | 27 | 8 | 1 | 13 |
| PROVINCIAL/STATE | 4 | 2 | 50 | 26 | 0 | 0 |
| FEDERAL | 1 | 1 | 100 | 7 | 4 | 57 |
| TOTAL | 48 | 14 | 31 | 51 | 7 | 14 |

Table 4. Official roles of participants from each level of government.

| Country | Government Level | Position | Years of Experience |
|--|-------------------------|--|----------------------------|
| Canada | City | Manager of Emergency Planning (1) | 1 |
| | | Emergency Preparedness Coordinator (1) | 6 |
| | | Customer Service Supervisor (1) | 9 |
| | | Community Emergency Management Coordinator (2) | 10-13 |
| | County | Communications and Marketing Coordinator/Emergency Information Officer (1) | 3 |
| | | Manager of 911 and Emergency Planning (1) | 10 |
| | | Community Emergency Management Coordinator (3) | 13-30 |
| | | Emergency Services Coordinator (1) | 14 |
| | Provincial | Director of Emergency Services (1) | 18 |
| | | Public Safety Director (1) | 6 |
| | Federal | Team Lead (1) | 12 |
| Warning Preparedness Meteorologist (1) | | 32 | |
| USA | City | Strategic Initiatives Coordinator (1) | 9 |
| | | Retired Fire Chief (1) | 10 |
| | County | Senior Systems Analyst/GIS Unit Lead Manager (1) | 13 |
| | Federal | Oceanographer (1) | 7 |
| | | Supervisory Research Geophysicist (1) | 22 |
| | | Postdoc Fellow (1) | N/A |
| | | Director of Operations (1) | 15 |

Potential participants were selected based on information available about their roles and their agency's involvement with crowdsourcing and VGI. Some agencies included in the study already had existing crowdsourcing applications developed and implemented, while other agencies were in the process of developing these or were simply using passive crowdsourcing methods through social media. Some instances occurred where the lead researcher contacted an official from an agency and was passed on to someone with more knowledge about the agency's crowdsourcing practices.

2.4 Findings and Analysis

Interviews with officials from both Canada and the United States revealed that there are several methods that participating government agencies use to collect information from the public for emergency management. Examples include call centres, email, social media, and specialised applications for online reporting. The most common method of gathering or monitoring information for emergency management purposes by participants in both countries is social media monitoring, as shown in Figure 2, where 76% of participants say they use social media in their agencies. Twelve out of the 14 participating agencies from Canada indicated that they monitor social media platforms, while four out of the seven participants from the USA monitor social media. The second most popular method of gathering information for participating Canadian emergency management agencies is phone calls. Six out of the 14 participating Canadian agencies described how they use telephone inquiries to inform emergency operations. Additionally, 211 and 311 call centres were also identified as methods for gathering citizen reports, thus with the telephone inquiries and 211 and 311 call centres combined, 11 Canadian agencies rely on the telephone. However, only two agencies from the USA use telephones and 311 call centres out of the seven interviewed. One participating Canadian agency uses a crowdsourcing model, while five of the seven participating agencies from the USA use specialised crowdsourcing applications.

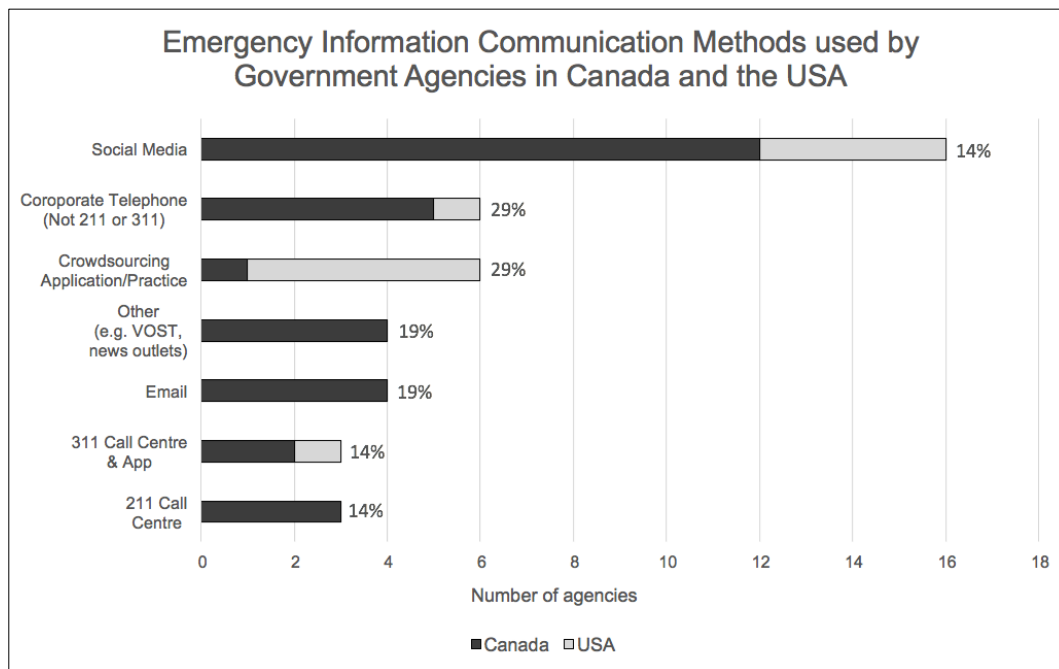


Figure 2. Methods used by government agencies to collect information from the public for emergency management.

2.4.1 Characterising crisis crowdsourcing by government agencies in Canada and the USA

The implementation of various emergency crowdsourcing-related methods differs between the Canadian and American governments, and at every level of government within each country. These methods are summarised in Table 5. Active crowdsourcing is primarily used by the participating federal government agencies in the USA. Alternatively, the participating agencies in Canada tend to prefer using passive crowdsourcing methods (e.g. harvesting data from social media). Participating municipal agencies in Canada appear to still rely on traditional methods of emergency information communication, such as corporate phone lines and call centres.

Table 5. Summary of emergency crowdsourcing efforts used by participating agencies in Canada and the USA. *No data is available for state level governments in the USA because none could be recruited.

| | | Canada | USA | Summary |
|--------------------------|----------------------|-----------------|---|--|
| Active Crowdsourcing | Federal | CANWARN | Did You Feel It? iCoast | The USA is leading the way in active crowdsourcing adoption for emergency management with two active crowdsourcing methods implemented at the federal level, and one at the county level. In Canada, one active method was adopted at the federal level, yet contributors to this method still require training. One city level agency is working towards active crowdsourcing through a new 311 mobile application. |
| | Provincial/ State | None | N/D* | |
| | County | None | Snapshot Damage Assessment | |
| | City | 311 App | None | |
| Passive Crowdsourcing | Federal | Social Media | Twitter Earthquake Dispatch Project Virtual Social Media Working Group | Passive crowdsourcing through social media is heavily used in both countries, at all levels of government. |
| | Provincial/ State | Social Media | N/D* | |
| | County | Social Media | Social Media | |
| | City | Social Media | Social Media | |
| Other | Federal | None | None | Agencies in Canada are still heavily reliant on non-crowdsourcing methods for collecting emergency information from the public. Call centres and corporate telephone lines are the preferred method amongst lower-tiered agencies for communicating with citizens. |
| | Provincial/ State | None | N/D* | |
| | County | 211 Call Centre | 311 Call Centre | |
| | City | 311 Call Centre | None | |

Results of the literature review and interviews suggest that active crowdsourcing models or methods are predominantly used by the participating federal-level agencies in both countries. In Canada, the only federal agency to participate in the study was determined to use an active crowdsourcing model for collecting severe weather reports from weather watchers (Participant L, 2015). In the USA, the active crowdsourcing applications are much more robust, and open to the general public instead of just a select group (Participants C, D, G, I, 2015). However, all of the active crowdsourcing applications/methods adopted by the participating federal agencies are focused on one specific type of hazard. For example, the method used by the Canadian federal agency is strictly for severe weather, and the US federal agency applications are specialised for earthquake and hurricane hazards. While the results suggest federal agencies are the most prominent users of active crowdsourcing, there were two lower-tiered agencies found amongst the participants that also use active crowdsourcing (Participant R, 2015; Participant U, 2015). Unlike the federal crowdsourcing practices that are designed for specific hazards, these applications are for any and all general types of hazards or problems within the jurisdiction.

Passive crowdsourcing through social media is heavily used by participating government agencies in both Canada and the USA, and for a variety of reasons. All levels of government in both countries who participated (with the exception of the state level in the USA due to no state-level participants) use social media for communicating emergency information. Some of these agencies use social media for passive crowdsourcing through monitoring and harvesting (Participants A, C, F, H, L, O, P, T, 2015), while others use it simply for communicating alerts and other emergency-related information (Participants B, F, J, N2, T, 2015). One participant from the provincial level in Canada outlined five reasons why governments use social media for emergency management:

1. To evaluate how well the official emergency information is being perceived and acted upon
2. To identify and help dispel rumours that might put public health and public safety in jeopardy
3. To identify threats to the agency's reputation that can impede the ability to respond to an incident, i.e. to address criticism from influential agencies

4. To isolate calls for assistance on social networks and make sure the agency has the proper protocol in forwarding them to 911 or another appropriate responding authority
5. To gather information on social networks that will provide further understanding of the situation, i.e. situational awareness
(Participant H, 2015)

It was found in the interviews that not all agencies use social media for all of these reasons. Furthermore, there appears to be a progressive trend in government use of social media for emergency management, from first adopting social media as another avenue for sending out emergency information (e.g. alerts, warnings, etc.) to using it for the various reasons listed above. Thus, participating agencies all appear to be at different stages in this progressive trend. For example, one county-level Emergency Information Officer stated that their agency only uses social media for sending out alerts and other information, and described it as “very much a push information tool, rather than as an information tool that we use to receive comments from the public” (Participant N2, 2015). Meanwhile, an official from another county-level agency described that their agency first used social media for information dissemination and soon realised the value of monitoring social media to check how their information was being received and to monitor incoming messages as well (Participant P, 2015). As a result, social media monitoring is now an official role in the agency’s EOC (Participant P, 2015). The next progressive step appears to be dispelling rumours based on the social media monitoring practices. A provincial-level official maintained that while social media is a “great source of information” for intelligence gathering, it is also helpful in validating information and identifying and correcting false information that is spreading around (Participant T, 2015).

Once agencies have realised the value of monitoring social media to gauge the way their messages are being interpreted and used by their citizens, it appears that they begin to monitor social media for more than rumour control and information dissemination. They begin to monitor reports from citizens that are on the ground during an emergency. A city-level Customer Service Supervisor described their transition from using social media for information dissemination to collecting reports from it:

“Customer service, or our involvement in that has only been for the last year, because primarily it was used here at the town for just information out, you know, pushing information out, and we just have been flirting with, you know, receiving information, receiving complaints, receiving this, so on and so on” (Participant O, 2015).

The above examples demonstrate the progressive steps that participating agencies seemed to follow when adopting social media. First they start with using it as a one-way information too sent out information and alerts to the public. Then they start monitoring it for information control and for dispelling rumours. Finally, agencies start using it as a two-way communication tool, to send out alerts and to receive reports from citizens.

Other methods of gathering emergency information from the public were identified by participants. Crowdsourcing is a relatively new phenomenon for government agencies to learn about and adopt, thus it is not surprising that traditional methods like phone calls and call centres (e.g. 211 and 311) and email are still used. It was discovered that agencies in Canada still appear to prefer communicating with citizens via telephone, especially agencies at the municipal level (Participants J, K, L, O, T, 2015). This is because the officials are properly trained with communicating over the phone, and it is easier to verify the information received over the phone rather than information posted on social media (Participant O, 2015; Participant K, 2015).

2.4.2 Crowdsourcing in the Disaster Management Cycle

Crisis crowdsourcing normally arises during or directly after a disastrous event. Within the disaster and emergency management realm, there are four phases in what is referred to as the disaster management cycle: mitigation, preparation, response, and recovery. The focus on crisis crowdsourcing has primarily been in the response and recovery phases (see Figure 1 for a diagram of the complete disaster management cycle), however the participants revealed that the crowdsourced information still feeds into the mitigation/risk reduction and preparedness phases. In the following analysis, examples that demonstrate the use of crisis crowdsourcing in the post-disaster phases (i.e. response and recovery shown in Figure 1) will be presented first. These examples are the most evident and they provide a foundation in understanding the mechanics of crisis crowdsourcing. Afterwards, examples that illustrate how the information gathered from

crisis crowdsourcing feed back into the pre-disaster phases (i.e. mitigation/risk reduction and preparedness in Figure 1) are presented and discussed. In most cases in this study, the crowdsourcing information used in the pre-disaster phases are a result of the most recent disaster experience, thus the information flow generally starts with the initial crowdsourcing during the response and recovery which is later used to inform and improve mitigation/risk reduction and preparedness for future events.

Response and Recovery

The response and recovery phases in the disaster management cycle occur after a disaster strikes, as demonstrated in Figure 1, thus they are referred to here as the post-disaster phases. In the response phases, efforts are focused on conducting search and rescue operations and providing basic humanitarian needs for those impacted by the disaster (Poser & Dransch, 2010). After the initial response, the recovery phase begins in which repairs to damaged infrastructure and property are made, ensuring that those impacted by the disaster are provided with the appropriate means to restore their lives back to what they were like before the disaster (Poser & Dransch, 2010). Much of the focus on crisis crowdsourcing has been in these post-disaster phases, particularly in the response phase. The interview results provide further support for this trend.

Social Media and Passive Crowdsourcing

It is clear from the literature that social media offers valuable insight into the impact of a crisis on those involved. The interview results provide further evidence of this. Participating government agencies turn to social media for a variety of reasons (see also section 2.4.1), to dispel rumours, for reputation management, for responding to calls for aid, for enhancing situational awareness, for monitoring citizen use of and response to official information (i.e. sentiment analysis), and for remote monitoring. All of these uses apply in the post-disaster phases.

Often times monitoring social media is also used to keep track of any false information or false reports that are beginning to spread during an unfolding disaster and must be corrected (Participant H, 2015; Participant M, 2015). An Executive Director of Public Safety Initiatives at the provincial level described how social media can be used by provincial governments in assuring that rumours are being dispelled:

“It’s a great source of information, so you’re looking to it from a sort of mining it for information, so an intelligence type use, but also to track the information for correctness of information. And when required we would correct wrong information” (Participant T, 2015).

The negative impacts of rumour spreading on social media can be problematic, making rumour control a critical factor in social media for emergency management, as described by a provincial level official in Canada:

“There was an extensive distribution of false information, rumours, fake pictures on Twitter, Instagram and Facebook during Hurricane Sandy that helped, perhaps, create some concerns or unfounded fears among the people in the areas that were impacted by the storm” (Participant H, 2015).

By controlling false rumours, the response and recovery can be much improved on by avoiding the unnecessary spread of fear and panic, which can distract responders from the real impacts that are unfolding and create additional problems.

Social media can also be used by agencies for reputation management. Agencies can practice monitoring social media to identify threats to their reputation (Participant H, 2015). For example, influential people or organizations may start criticizing the government’s response efforts during a situation, putting pressure on the emergency managers and other officials that are involved, and distracting from the main operational objectives (Participant H, 2015). These kinds of threats, once identified, can usually be addressed by one or more public relations statements.

Results from the interviews also revealed that one of the primary uses of social media, and any crowdsourcing application for that matter, is to enhance situational awareness during an emergency. Situational awareness refers to the state of understanding unfolding events in a given situation that is impacting many actors and “moving parts” (Vieweg, Hughes, Starbird, & Palen, 2010). Situational awareness is used to build a “common operating picture” of the unfolding situation and all of the actors involved, from response and recovery agencies, to citizens spreading the word about current

conditions. By enhancing and maintaining situational awareness, emergency management officials can create and implement more effective response plans and adequately manage requests for information (Cameron, Power, Robinson, et al., 2012).

Participants indicated that social media is an essential tool in building situational awareness (Participants A, C, E, F, H, K, M, N2, O, P, Q, T, U, 2015). One county-level official from Canada described how social media is used to “augment our situational awareness, and it’s also used to gauge what the community needs are” (Participant P, 2015). Sometimes the community needs do not line up with the actual response efforts that are being undertaken by the agency; social media provides an opportunity for officials to identify the community needs and adjust their response efforts to suit those needs (Participant P, 2015). The same participant also used social media to monitor the “response to our response”, and uses sentiment analysis to determine how their information is being propagated, which then helps assess the effectiveness of their agency’s communications reach (Participant P, 2015).

The situational awareness built from social media can be used to inform the Emergency Operations Centre (EOC), to update alerts, or to result in actionable decisions, such as sending out response crews. For example, a county-level Community Emergency Management Coordinator (CEMC) from Canada monitored social media during a tornado-producing severe weather event. The participant followed reports of storm activity on Twitter and matched it up with alerts from Environment Canada, and used this to issue up to date information over social media and email (Participant F, 2015). At the provincial level, in Canada, situational awareness can improve information sharing between agencies, which can then inform decision-making:

“[Social media] helps us build our situational awareness, and then what we do is we build a situation, we call it a common operating picture report, and then we disseminate that across government and to the affected communities. And so the advantage of that is that report takes the information we’re gathering from all sources, collates it, verifies the information and then we push it out to those [affected communities]. So it’s, everybody has a common understanding of what’s going on and the information they have in their hands is verified reliable information that they can act on” (Participant T, 2015).

Building situational awareness is critical in the response and recovery phases. The focus of participants on using social media for situational awareness demonstrates how it can improve response efforts and decision making in emergency operations. As an added bonus, the widely accessible nature of social media and its large user base provides yet another improvement to building situational awareness as it enables agencies to partake in remote monitoring. Now, agencies from across the country (even internationally) can offer help in an unfolding, large-scale disaster happening somewhere else. One participating county-level agency in Canada did just this when they were asked to monitor social media for a large scale flood disaster in another province (Participant A, 2015). This county-level agency is recognised in the emergency management community for their active adoption of social media (Participant A, 2015; Participant B, 2015).

Active Geographic Crowdsourcing

Building on the situational awareness theme, an active geographic crowdsourcing application allows emergency management officials to visualize current ground conditions on a map, and identify the neighbourhoods in most need of aid. This is exactly what is used by a county-level agency in the USA (Participant U, 2015). The agency uses active crowdsourcing to obtain a fuller picture of an unfolding situation and has a fully implemented web-application for citizens to submit reports of storm damage and flooding. A screenshot of the application is shown in Figure 3. During a disaster, citizens can submit reports of damage online through this form. The citizens are asked to select a damage level (e.g. moderate, major, destroyed) and a flood level (e.g. street level, inside home) for the county to get an idea of the kind of damage that was sustained in a given neighbourhood (Participant U, 2015). The information from this form is published onto a map which is accessible to the public. This information is not publicised by the agency, but the application to which it is published is openly available to any member of the public seeking it out (Participant U, 2015). This web-mapping application is used by the EOC to identify areas that have suffered damage, as described by the county's Senior Systems Analyst:

“It's basically used for people at Emergency Operations Centre to see where the damage are or for officials to see that. What I do is, in addition to showing the points at Emergency Operations Centre, I use the heat map to identify

concentration and density to, basically it's used to get an idea where we need to send our ... damage assessment people" (Participant U, 2015).

Every data point entered into the application by the citizens is automatically plotted onto the county's web-mapping application. There is no verification process in place before the information is made available to the public and the EOC. During an emergency, the county's EOC does not have time to verify, so it is published and disseminated "as is" (Participant U, 2015). The county does recognise that the information is coming from the public, and so they use the information to obtain a deeper understanding of the situation on the ground (i.e. to enhance situational awareness), and to disseminate aid to neighbourhoods in need (Participant U, 2015). The application is not used for responding to individual reports.

Neighborhood Damage Assessment Entry Form

To submit a Damage Report follow these steps:

1. Report the address
Write the address starting with the house number and following with the direction prefix, street name, street type, post direction suffix, city and zip code .
Notice that the direction prefix and direction suffix as well as the street type must be selected from the corresponding drop down list.

| | | | | |
|----------------------|----------------------|----------------------|----------------------|----------------------|
| House number: | Direction: | Street Name: | Street Type: | Dir. Suffix: |
| <input type="text"/> | <input type="text"/> | <input type="text"/> | ALY | <input type="text"/> |
| City: | Zip: | | <input type="text"/> | |

2. Select the Damage/Flood Level
From the Damage Level Pictures 1 through 4 shown below, choose the Damage Level and/or Flood Level Number that more closely resembles the damage in the address you are reporting. Then find the number in the Damage and/or Flood level drop down list.
The Flood Level is indicated by the numbers 5 and 6 shown only in picture 1, but it can be also applied to pictures 2, 3, and 4. Flood level 5 demonstrates street flooded or water level onto the property but outside the home, while flood level 6 demonstrates water level inside the home.
The pictures 1 through 4 can be enlarged by clicking with the mouse on them.

| | | | |
|-------------------------------|----------------------------|--------------------------------|---------------|
| NO/MINOR DAMAGE HABITABLE | MAJOR DAMAGE HABITABLE | MAJOR DAMAGE UNINHABITABLE | DESTROYED |
|-------------------------------|----------------------------|--------------------------------|---------------|

| | |
|----------------------|----------------------|
| Damage level: | Flood level: |
| <input type="text"/> | <input type="text"/> |

3. Submit your Neighborhood Damage Report
Please submit your Neighborhood Damage Report by clicking the SUBMIT button. Thank you for your cooperation!

Figure 3. The online damage reporting form used by a county-level government in Florida.

Respondents indicated that both passively and actively crowdsourced information can also be included in situational reports, and command reports (Participants A, B, H, L, 2015). During the response and recovery phases, these reports are distributed amongst other impacted communities to maintain open communication and coordination between jurisdictions (Participant T, 2015). They are also used to apply for disaster relief funds from higher-tiered government agencies (i.e. the provincial/state or federal government) (Participant B, 2015; Participant T, 2015). This takes place in the recovery phase, when agencies and citizens are attempting to rebuild and are submitting insurance claims.

Mitigation/Risk Reduction and Preparedness

The mitigation/risk reduction and preparedness phases in the disaster management cycle (Figure 1) focus on reducing risk and vulnerability to a hazard to lessen the impacts to populations and infrastructure if a disaster were to occur. Much of the focus within the disaster management realm has shifted to these pre-disaster phases rather than the post-disaster phases of response and recovery (Chikoto, Sadiq, & Fordyce, 2013; Christoplos, Mitchell, & Liljelund, 2001; Paton, 2003; Paton & Johnston, 2001). Mitigation/risk reduction involves continuous risk identification and analysis, and risk reduction through planning, and education and awareness (Poser & Dransch, 2010). Preparedness follows mitigation/risk reduction with direct planning of response protocols if a disaster were to strike; monitoring and forecasting of an approaching hazard is undertaken, and warning systems are implemented (Poser & Dransch, 2010). While much of the focus in the crisis crowdsourcing realm has been on its use in the post-disaster phases, interviews with officials from both Canada and the USA revealed that it is also valuable in the pre-disaster phases.

Social Media and Passive Crowdsourcing

During the mitigation/risk reduction and preparedness phases, social media is used primarily as a government- to- citizen information flow tool. Social media has proven to be useful in educating the public around proper emergency preparedness practices and for sending out alerts and warnings for an approaching hazard (i.e. severe weather, flooding, wildfire, etc.) (Participants A, B, F, H, J, K, N2, O, P, T, R, T, Q, U, 2015). It was

even described by one county-level official as being their agency's "dominant method" of communicating emergency information and alerts to the public (Participant P, 2015). A separate example of how social media can be used to prepare for an oncoming hazard (in this case, heatwaves) was provided by another city-level Community Emergency Management Coordinator (CEMC):

"[We use social media] more as a tool for preparedness and education, so reaching out to the municipality, and if we know that we've got potential for a heat wave, so prior to the heatwave, in conjunction with the health unit, sending out reminders about how to protect yourself and be ready" (Participant K, 2015).

Interestingly, during the interviews many participants focused specifically on how social media has improved their information dissemination for increasing preparedness and readiness. This focus reflects the shifting focus in the emergency management realm from response and recovery to mitigation/risk reduction and preparedness. It was determined that social media is highly effective for government information dissemination because it connects to many people at once, is accessed daily by public citizens, and is fast (Participant H, 2015; Participant Q, 2015).

As an extension of information dissemination, social media can be used to understand the public's perception of and response to official emergency information posted by the government. This is the first of the five reasons listed in the previous section for a Canadian government official choosing to use social media for emergency management (See section 2.4.1). Government agencies want to ensure that their messages are being received and understood correctly, otherwise they need to provide further instructions or clarification (Participant H, 2015; Participant P, 2015). Agencies can also monitor social media for feedback on their awareness and preparedness initiatives, as one city-level official did during a special education session they held during Emergency Preparedness Week in May of 2015 (Participant K, 2015). The feedback that the officials received over social media confirmed that there is value in hosting these educational events (Participant K, 2015).

In the USA, the federal government developed a passive crowdsourcing approach to earthquake monitoring by harvesting Twitter data. This application gathers qualitative descriptions of earthquakes experienced by Twitter users (Participant C, 2015). The application was implemented in 2009 following the 2008 earthquake disaster in

Wenchuan, China that killed almost 70,000 people. The earthquake was detected on Twitter before seismologists were able to publish information based on earthquake data from seismometers (Participant C, 2015). The Director of Operations from the federal agency described how this was possible:

“How they detected this earthquake on Twitter before the seismologists published the information based on the earthquake data and this makes sense because, you know if you have seismometers a long ways away, the shaking waves won’t get there, but if you have people closer they’ll feel it faster and then feed that information, which travels at the speed of light and then you can get those tweets, so it’s a matter of increasing the coverage of your sensors” (Participant C, 2015).

In response to this phenomena, the agency formulated several questions that they hoped to answer with the Twitter harvesting application: “What can you do with this information? Can you make a system that gives you useful information, actionable information?” The Twitter harvesting system was developed to answer these questions. It detects an average of two to three earthquakes a day in regions with sparse seismic networks (Participant C, 2015). As the Director of Operations said, “it can give us a quick “heads up” that something’s going on, and then a qualitative measure of the interest in that, and potentially the impacts of that earthquake” (Participant C, 2015). As a result, the application has evolved into a short-term earthquake alert system. For example, Figure 4 shows a screenshot taken from the agency’s specialised Twitter feed of a recent earthquake that was detected over Twitter. The tweet provides a quick a warning about an earthquake situation unfolding so that the appropriate response agencies can prepare. Thus, this application enables immediate and short-term preparedness efforts.

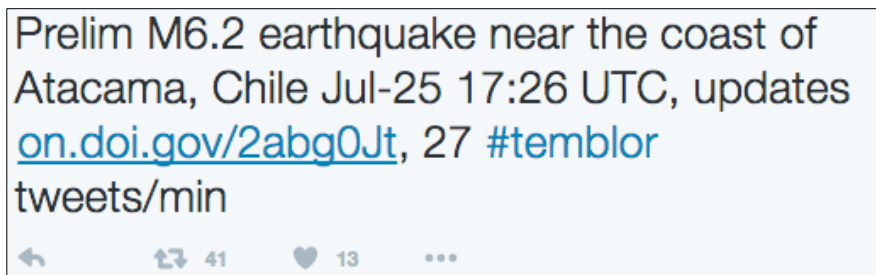


Figure 4. A screenshot of a recent earthquake alert detected by the USA federal agency’s specialized Twitter harvesting application. The alert provides an initial “heads up” to the public and to responders to prepare for a potential disaster.

Active Crowdsourcing

On the active crowdsourcing side, interview results indicate that while the crowdsourcing applications are typically used by citizens directly after an emergency or a disaster, the information gathered from the applications can be used to inform the pre-disaster phases. This is true for the federal-level crowdsourcing applications used in the USA and in Canada.

In Canada, the federal government practices a unique form of crowdsourcing which dates back to the late 1970's. In 1978, the agency started a volunteer Weather Watch Program and created an unlisted 1-800 phone number for registered volunteers (i.e. weather watchers or storm spotters) to report instances of severe weather across Canada (Participant L, 2015). Since then, the program has evolved to allow volunteers to submit reports over telephone, email, and social media (Figure 5). There is no specially developed application for volunteers to download or report to, but the process of collecting reports from the volunteers over the various mediums is well-defined and managed.

Weather enthusiasts and storm spotters are offered the chance every spring to receive official training from the federal agency to accurately identify the types of severe weather that they are witnessing and reporting. This ensures that reports received by the agency are credible and accurate (Participant L, 2015). The training instructs the volunteers on the specific types of information that the agency is looking for in the reports, such as specific locations and detailed descriptions on storm type, size of hail, damage, etc. Upon collecting the reports through both telephone and email, the agency plots these reports on a map for verification and tracking (Participant L, 2015). This map is only accessible internally to the meteorologists. In efforts to make the map publicly available, the agency is looking to build a stable database as well as looking to find a way to "divorce the personally identifiable information from the point data" (Participant L, 2015). The agency has also run into the issue of vetting the reports for accuracy and is currently researching processes for this (Participant L, 2015).



Figure 5. Examples of severe weather reports posted on Twitter for the Canadian federal agency in a recent severe weather event.

The primary application of this active crowdsourcing practice, surprisingly, is in the mitigation/risk reduction and preparedness phases, with a more direct use in preparedness. The volunteer weather reports can be applied both in real-time and after an event to inform short-term and long-term preparedness respectively. In real-time, the agency uses the reports from one geographic location to alert populations in another location as to what kind of severe weather is headed their way (Participant L, 2015). Afterwards, the reports can still be “invaluable” for the agency’s verification program. The agency issues thousands of watches and warnings each year, and in some cases they are unable to confirm the actual occurrence of a storm for these watches and warnings. The “concrete reports” from the trained weather watchers can help verify the agency’s performance in sending out the appropriate alerts (Participant L, 2015). Thus, this crowdsourced information feeds into the short term preparedness and mitigation/risk reduction of an unfolding event, as the agency uses the reports to verify and update their watches and warnings. In the long-term, the agency can use this information to continuously improve their monitoring and forecasting system, to understand how their alerts are being perceived and responded to.

The US federal government uses two active crowdsourcing applications for preparedness and mitigation/risk reduction efforts. The first application, called “Did You Feel It?” (DYFI?), is specifically designed for earthquakes and evolved from a traditional paper survey method to an online web application. The original method involved sending out paper surveys to postmasters at different zip-codes who would then fill out the survey and send it back after experiencing an earthquake in their area (Participant G, 2015; Participant I, 2015). These surveys were used to assign intensities to earthquake events using descriptive information provided by the postmasters. The surveys were typically only conducted for significant earthquake events and excluded the minor, felt earthquakes that happen on a regular basis. This resulted in major gaps in the data (Participant G, 2015).

The system was brought online in 1999 (Participant G, 2015; Participant I, 2015). Bringing it online allowed the agency to create an algorithm that could automatically assign numerical intensity values based on the digital survey results which could be machine read and machine processed. In turn, the project was “scaled up tremendously

over what you could do with humans and the postal service” (Participant G, 2015). The “DYFI?” application is now accessed worldwide for any felt earthquake. The online questionnaire is part of an information flow within and outside of the federal agency. Primarily, the application is used to depict the shaking distribution after an earthquake of any magnitude, from small scale, low magnitude, to large scale, significant events with tens of thousands of reports (Participant G, 2015). An example of a resulting “shakemap” distribution from the crowdsourced information is shown in Figure 6. The intensity of the event is derived from a number of questions that citizens answer when filling out the online form, shown in Figure 7. In some cases, the online application has been able to provide seismic information from areas that are lacking significant seismic instruments; it has been able to fill gaps in seismic data where there are not enough seismic instruments placed out (Participant G, 2015).

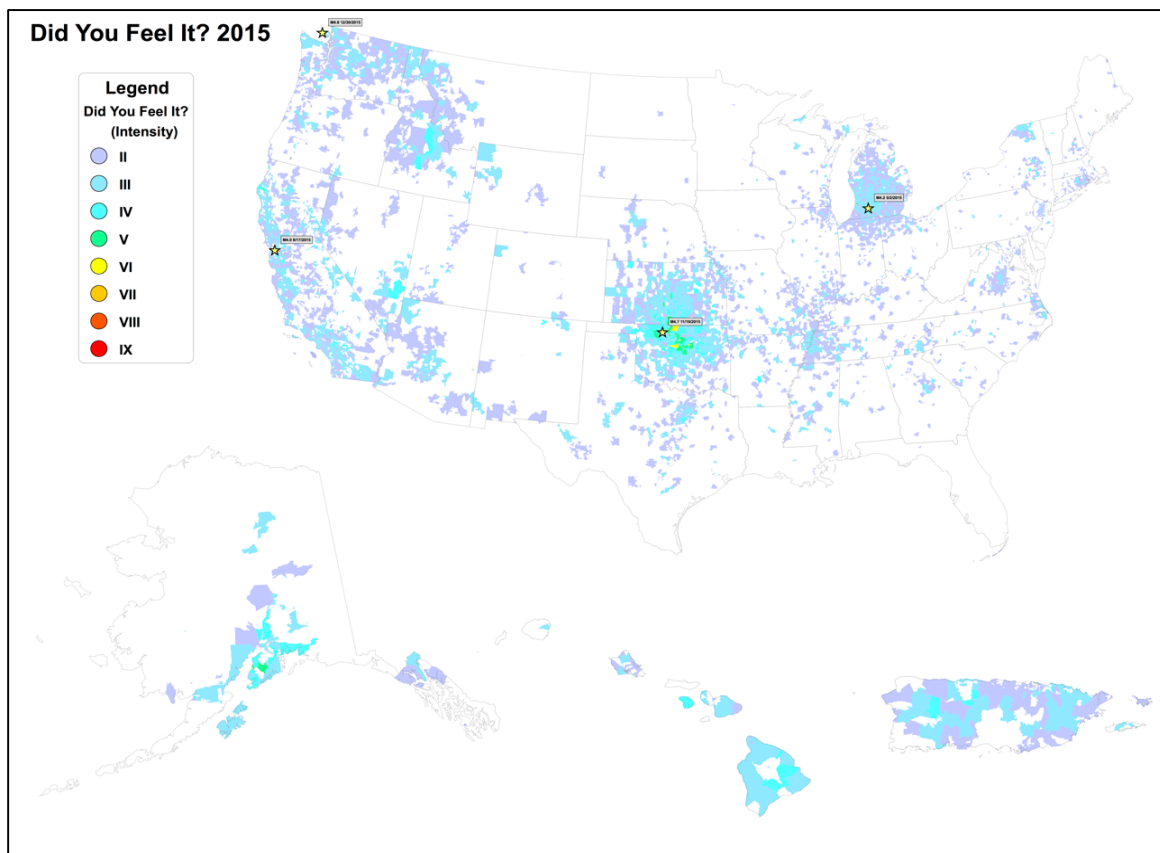


Figure 6. A "shakemap" displaying the distribution of reported earthquakes and the derived intensity in 2015 (Source: USGS).

Felt Report

OMB No. 1028-0048
Expires 05/31/2018

Your location when the earthquake occurred

Choose Location

Time of Earthquake Local time *1/31/2008 9:00 AM*, or Relative time *5 minutes ago*

Did you feel it?

- Yes
 No



The remainder of this form is optional.

Help make a shaking intensity map by telling us about the shaking at your location.

What was your situation during the earthquake?

- Not specified
 Inside a building
 Outside a building
 In a stopped vehicle
 In a moving vehicle
 Other

Please describe

Were you asleep?

- Not specified
 No
 Slept through it
 Woke up

Did others nearby feel it?

- Not specified
 No others felt it
 Some felt it, most did not
 Most felt it

Submit

Cancel

Figure 7. Upon feeling an earthquake, citizens can anonymously submit reports to the US federal government. Having the citizens fill out a very structured reporting form allows the agency to derive quantitative data from qualitative information.

The rich data that is collected from this crowdsourcing application is primarily used to build a scientifically sound database for informing earthquake management. As the lead geophysicist on the project described, “our job is really to do the science for which decisions are made whether they’re long term planning or response” (Participant G, 2015). As the global database on felt earthquakes continues to grow, earthquake modeling and forecasting can be improved on, which further enables the overall mitigation/risk reduction efforts within earthquake hazard and risk management.

The second active crowdsourcing application implemented by the US federal agency included in this study, called “iCoast,” aids in improving hurricane mitigation/risk reduction and preparedness. The initial idea of the application came from the knowledge that the federal agency possesses a large aerial imagery collection of coastlines before and after significant hurricane events. The imagery is expensive to collect, yet it is not used very much (Participant I, 2015). This application was proposed as a potential use for this expensive imagery collection, allowing citizens to perform image analysis with the existing imagery (Participant I, 2015).

The application was implemented in November of 2013 on the one-year anniversary of Hurricane Sandy (Participant D, 2015), and it was designed to perform two scientific tests. The first was to test the ability of untrained users in image analysis, and the second was to test the image analysis with proven statistical and numerical models. The first test involves comparing the results of a control group (trained officials) with the results from the “crowd” (citizens) to determine whether the crowd reached similar inferences as the control group (Participant D, 2015). The second test involves comparing the crowd inferences to traditional oceanographic and topographic measurements and statistical predictive models. The goal of the testing was to determine whether the “crowd” could infer coastal change processes as accurately as the more expensive, traditional methods of taking field measurements and running intensive models (Participant D, 2015).

Citizens access the application through their computer’s browser and contribute by comparing aerial imagery of the coastline before and after Hurricane Sandy. Citizens are required to log in before they can access the imagery. The citizen is then presented with aerial images of the eastern coast from before and after Hurricane Sandy, as shown in Figure 8. The citizens follow a step-by-step process to identify specific damage types caused by the hurricane; it is very similar to a “spot the difference” game traditionally found in newspapers and magazines (Participant I, 2015).

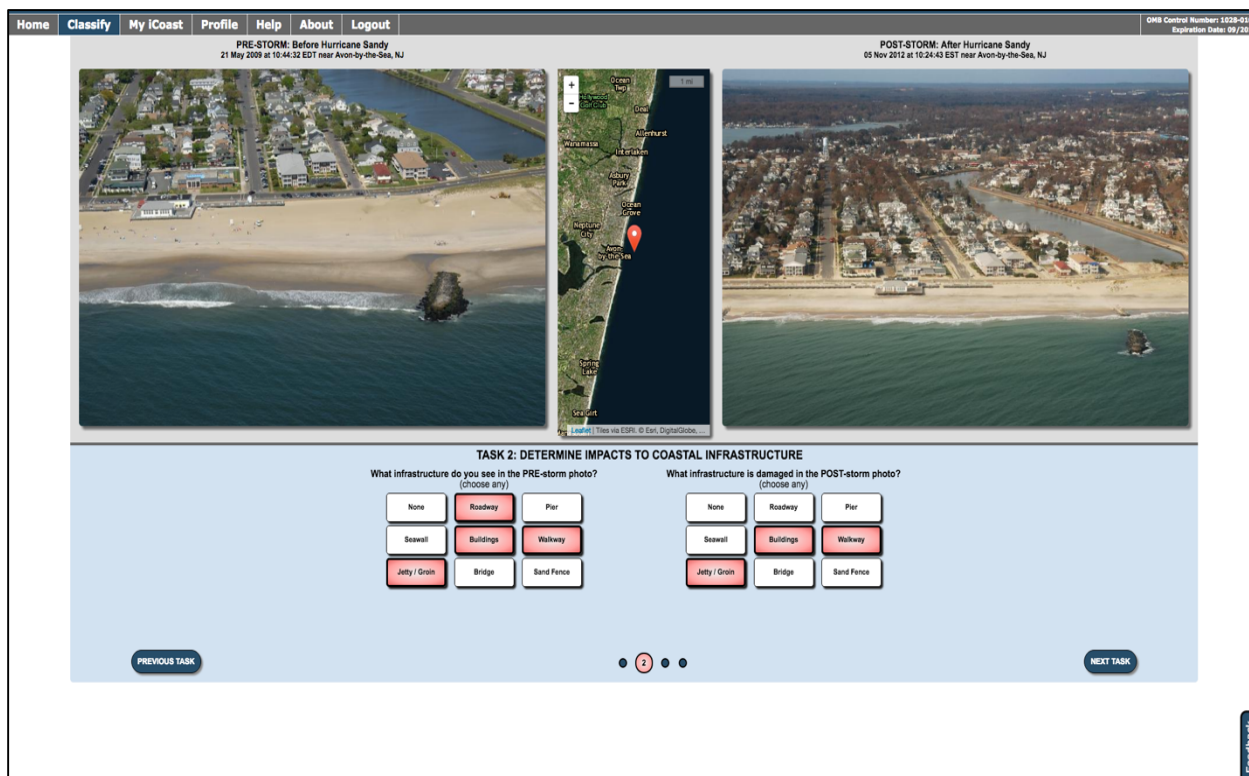


Figure 8. Citizens are presented with a before and after aerial image along a section of the coastline. The citizens are then asked to identify specific changes in the photos that may have resulted from Hurricane Sandy.

Aside from the stated goals of the application, it was found that the iCoast provided an added benefit of raising hurricane hazard education and awareness. The nature of the application requires citizens to provide or produce information for the agency (Participant D, 2015). In order to get this information, the agency needs to explain why they are asking the citizens to do this activity, as outlined by the agency’s participating official:

“It’s sort of a two-way street where we actually had to put a lot of effort and clarity in what we’re doing and actually prove our research I think, because we had to explain clearly what we were doing” (Participant D, 2015).

Taking the citizen through the entire process provided an opportunity for citizens to learn about the coastal hazards associated with hurricanes. Citizens living along the coast became more aware of the issues they may face on their coastal properties. The agency received feedback which outlined this:

“We got some feedback from people who are participating and how they're starting to realize and learn what does coastal erosion mean? what are the issues that I need to be aware of living on the coast? and things like that. So to some level it was educating people in a way where they're helping us but they're also learning how we are communicating our science” (Participant I, 2015).

There are two distinct uses for information produced from this project, both of which fit into the mitigation/risk reduction and preparedness phases: 1) to improve modelling of associated hurricane hazards such as coastal erosion, and 2) to provide an educational tool for contributors to learn about coastal hazards associated with hurricanes. Improved modelling can be used to enhance efforts to reduce coastal erosion and flooding caused by hurricanes while the contributors who live on the coast can learn how their coastal properties are impacted by hurricanes. This application is enabling the US federal government to raise public interest towards hazard mitigation, and fuel voluntary mitigation/risk reduction practices at the individual level (Godschalk, Brody, & Burby, 2003; Semenza, Ploubidis, & George, 2011).

The above findings demonstrate that information gathered from passive and active crowdsourcing through various platforms can inform long-term and short-term mitigation/risk reduction and preparedness efforts. Study participants also suggested that the photographic and geographic information that crowdsourced information offers can be used to inform “after-action” reports and situational reports (Participants A, B, H, L, 2015). These reports are then used to learn from an incident, to identify what was done well and what could be done better in the future, to prepare for future ones (Participant A, 2015; Participant L, 2015), thus improving mitigation/risk reduction and preparedness. They are also used to perform risk analysis (Participant J, 2015), which further enhances mitigation/risk reduction efforts.

Aside from the iCoast application, the above examples, while having indirect uses and benefits in the mitigation/risk reduction and preparedness phases, are directly used in the response and recovery phases. The information that is produced from these crowdsourcing applications is then used to learn from the recent event to improve mitigation/risk reduction and preparedness efforts for future events. There is a noticeable gap in government engagement with citizens during these two phases. The iCoast application launched by the USA federal government is one example of very recent efforts in bridging this gap. There is more opportunity for new crowdsourcing efforts to improve engagement in the mitigation/risk reduction and preparedness phases.

The Complete Disaster Management Cycle

The results show that crisis crowdsourcing plays a role in all phases of the disaster management cycle. Moreover, it was surprising to observe the high-level of focus on using crowdsourcing information to further enhance mitigation/risk reduction and preparedness efforts. The findings are summarized in Figure 9, which is a diagram of the disaster management cycle. The diagram illustrates how disaster management is a continuous cycle that flows from pre-disaster to post-disaster, and the experiences from the post-disaster phases are used for continuous improvement of mitigation/risk reduction and preparedness efforts. While crisis crowdsourcing has clear benefits and uses in the post-disaster phases, it is also indirectly used in the pre-disaster phases.

The interview results reveal a pattern in the adoption and use of crisis crowdsourcing for each level of government. Participating agencies from the federal level appear to use crisis crowdsourcing for mitigation/risk reduction and preparedness, while local and county-level agencies in this study use crowdsourcing for response and recovery. This may be due to the fact that lower-tiered agencies experience the direct impacts of a given crisis event, while higher-tiered governments are concerned with providing appropriate support and resources to mitigate those impacts (Participant T, 2015). The participating federal agencies are primarily focused on using the crowdsourced information to improve modeling and forecasting of future events for a specific hazard, such as earthquakes, hurricanes, and severe weather (Participant G, 2015; Participant L, 2015). The lower-tiered agencies are more concerned with the direct response and recovery of

an unfolding event (Participants A, F, L, 2015), thus they use the crowdsourced information for improving situational awareness and formulating effective response plans. After the initial shocks of the event, the information then becomes useful for applying for aid and support in the recovery phase.

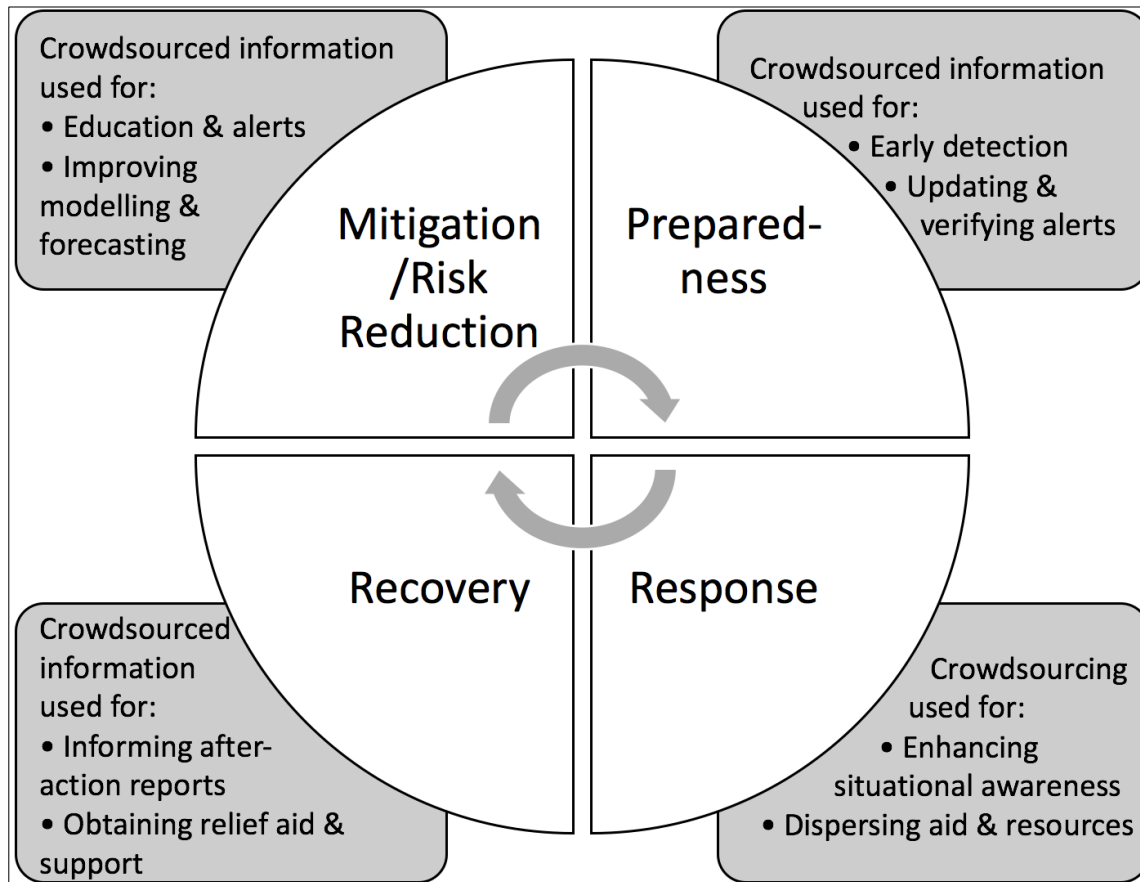


Figure 9. Crisis crowdsourcing fits into all four phases of the disaster management cycle. In the pre-disaster phases, the crowdsourced information can be used to develop a long term picture of trends to enhance planning and prediction of events and can also be used to verify short term alerts and warnings. In the post-disaster phases, crowdsourcing enhances situational awareness and information situational reports that can be used to apply for disaster relief and aid from upper-tiered government agencies.

There is a clear opportunity for crowdsourcing practices to be directly applied in the pre-disaster phases by allowing citizens to raise their own awareness of specific hazards, as is done with the USA federally managed hurricane crowdsourcing application included in this study. Crowdsourcing in the pre-disaster phases can also enable citizens to contribute their ideas and personal practices to the mitigation/risk reduction and preparedness phases.

2.5 Building a case for government crisis crowdsourcing

Effective communication is critical in emergency management operations. There should be a constant flow of information during all phases of the disaster management cycle, as demonstrated in the above discussion. Crowdsourcing and social media offer new ways of enhancing these communication patterns. The participants identified several ways in which crisis crowdsourcing can improve or benefit communication and overall government emergency management. These improvements and benefits are summarized in Table 6.

Each participating agency was found to be at a different stage of social media or crowdsourcing implementation. Consequently, the participants described both benefits and improvements that they have experienced through social media and crowdsourcing, as well as those that have not yet been experienced, but are anticipated.

Table 6. Summary of benefits participants identified from using a crisis crowdsourcing model (Participants A, B, C, D, E, F, G, H, I, K, L, M, O, P, Q, R, S, T, 2015).

| Improvements and benefits | How... |
|----------------------------------|--|
| Transparency & Accountability | Increase in trust Education Citizen decision making Progress visual Updates (live vs. periodic) Resource allocation |
| Government-Citizen Communication | Timeliness Alerts and information dissemination Public engagement Gathering feedback Sentiment analysis |
| Internal Communication | Direct and fast Alternate routes Progress visual Resource allocation |
| Enriching the dataset | Risk analysis Order of magnitude Situational reports Aid field crews Photos Geographic information |

Transparency and Accountability

Participants described five ways in which crowdsourcing or social media have, or could, improve government transparency and accountability with respect to emergency management. Crowdsourcing can increase trust of citizens in a government agency by publicizing the information gathered by the agency and showing the citizens what the information is used for (Participants C, D, G, I, 2015). Crowdsourcing applications can also be educational as they can raise awareness about hazards in their areas, much like the hurricane application in the USA (Participant I, 2015).

Government-Citizen Communication

Governments are always looking for ways to improve communication with their citizens. In efforts to improve their communication, governments have turned to the various methods described above: call centres and telephone lines (e.g. 211, and 311), email, social media outreach, and crowdsourcing. The participants agreed that each of the respective methods their agencies use have improved communication with citizens in different ways. Social media is particularly beneficial for reaching out to citizens and putting out information, as described by a county level emergency manager in Canada:

“I can go back to our Facebook page two years ago during our winter storm emergency, where we had somebody post on there, ‘this was the best dissemination of information by a government agency ever,’ is what the post said. And we’re pretty proud of that because we did work very hard to use social media to communicate with the affected public” (Participant A, 2015).

Active crowdsourcing allows citizens to share their stories and experiences with the government, knowing that their information is being used for everyone’s benefit (Participant G, 2015). Both social media and active crowdsourcing improves the timeliness of communication during an emergency by allowing governments to send out alerts faster and to more people, and also to monitor for real-time information (Participants A, L, P, Q, R, U, 2015). The process of sending out alerts and information about an upcoming or unraveling event can then become a feedback loop, as agencies can look to crowdsourcing or social media to get a better sense of the scope of an event and the citizens’ firsthand experiences. The agencies can then use this information from their citizens, along with some sentiment analysis, to improve the alerts and response (Participant L, 2015; Participant P, 2015).

Internal Communication

Participants were asked to describe ways in which crowdsourcing and social media can also improve internal communication, i.e. communication between response crews and departments within the agency. In many cases, emergency management agencies already have systems in place to maximize communication between departments and with response crews (Participants A, J, K, O, P, S, U, 2015). These systems involve a central database in which reports received through phone call and email, and in some cases social media (Participant N2, 2015; Participant U, 2015), are inputted by officials on the desk. The requests are then forwarded to appropriate departments and tickets are generated. Two agencies (one city-level agency from Canada, and a county-level agency from the USA) even make the information publicly available on a map, with personally identifying information removed, and set to an appropriate scale where specific houses cannot be identified (Participant S, 2015; Participant U, 2015).

Not all of these communications systems fully integrate social media or any other crowdsourcing effort, and many do not automatically update “on-the-fly” for response crews who are out in the field to receive live updates. Participants suggested that adding crowdsourcing and live updates to their existing systems could improve response times, resource allocation, and overall situational awareness (Participants A, J, Q, R, 2015). One county-level agency from Canada does take live updates with photos and plot points from responders who are out in the field, and then uses the system to instantaneously create alternate routes based on live information. The photos provided by the responders allow the emergency managers in the EOC to see all sensitive facilities that are near the damaged area (Participant P, 2015).

Enriching the Dataset

Enriching the emergency/disaster management dataset is closely tied to improving internal communication. Crowdsourcing and social media can enrich the data that agencies are collecting for situational awareness and response by adding real-time photos and geographic information. One county-level emergency manager from Canada described how photos and geographic information from social media help at their agency’s EOC:

“Geographic attributes and photos of damage are priceless in the emergency operations centre. When I gather my emergency control group and we're in a room trying to determine our priorities and determine the validity of the information that's coming in, knowing the geography, seeing photos of damage really allows us to determine the severity and allows us to mobilize resources faster than we would otherwise” (Participant A, 2015).

The ability to use photos to assess the severity and magnitude of an event allows responders to determine what resources are needed, the amount, and where (Participants A, E, H, K, L, Q, S, T, 2015). This is especially important for government agencies because they have limited resources, so it is crucial to utilize those resources appropriately (Participant H, 2015). The added photos and geographic information can also be used to draw a fuller picture in the agencies' command reports, after-action reports, and situational reports (Participants A, B, H, L, 2015).

2.6 Conclusions

The literature shows that governments are realising the value of crowdsourcing and ICTs for emergency management. There is a strong focus on the adoption of crowdsourcing, both active and passive, for emergency management in the United States. Currently no adequate studies into the state of crowdsourcing for emergency management in Canada have been conducted. This research addresses the gap by characterizing the current state of crisis crowdsourcing amongst Canadian emergency management agencies and compares these efforts to those of the USA. In addition, this research determines that crisis crowdsourcing can be, and is, applied in all phases of the disaster management cycle, not just in response and recovery.

Social media is currently the leading platform for crisis communication amongst the participating government agencies in both countries. Many of the participating agencies in the USA are also employing active crowdsourcing models, while in Canada only one agency that was contacted is using an active crowdsourcing model. Participating lower-tiered government agencies in both Canada and the USA use active and passive crowdsourcing directly for response and recovery purposes. The information gathered is used to augment situational awareness, which then allows for more informed and effective decision making in emergency operations. Afterwards, the information is used in the recovery phase to inform incident reports which can then be used to apply for

aid. The active crowdsourcing models employed by agencies at the federal level in both countries are typically used for mitigation/risk reduction and preparedness efforts. They are designed for specific hazard types, and the agencies use the information collected from the applications to improve modeling and planning for future events.

Results from this research clearly indicate that crisis crowdsourcing and its resulting information can feed into all phases of the disaster management cycle. However, there is a clear lack in the direct application of it in the mitigation/risk reduction and preparedness phases. The crowdsourced information that is directly gathered from an unfolding event in the response and recovery phases can be indirectly used to inform and improve mitigation/risk reduction and preparedness for future events. Emergency management officials and scholars in this field are presented with a clear opportunity in discovering new ways to use crowdsourcing directly for mitigation/risk reduction and preparedness. The US federal government has taken the first step in this direction with the hurricane crowdsourcing application. It is time for other agencies to begin exploring this avenue.

The examples in this study clearly illustrate the various ways in which social media and crowdsourcing are improving emergency management operations. These results provide further proof and reason for governments to start exploring their options with social media and crowdsourcing for emergency management, if they have not already.

Transition

Chapter 2 provided an overview and characterisation of the current crisis crowdsourcing practices used by participating government agencies in Canada and the USA. Of the total 21 interviews, all of them were used for Chapter 2, and 14 out of the 21 interviews were used for Chapter 3. Chapter 3 provides a narrowed focus on the crisis crowdsourcing practices in Canada, thus only the interviews with Canadian agencies were used.

The purpose of Chapter 2 was to fulfill the first three objectives of this research project:

1. Characterise the adoption of crisis crowdsourcing by the various levels of government in Canada and the USA;
2. Identify the ways in which crisis crowdsourcing can improve emergency management within government, and;
3. Determine the various ways in which crisis crowdsourcing feed into all four phases of the disaster management cycle.

The aim of the remaining core chapter, Chapter 3, is to address the remaining two research objectives:

4. Identify the unique barriers and constraints that may be inhibiting the adoption of crisis crowdsourcing in Canadian government agencies, and;
5. Create a readiness assessment framework for Canadian agencies to pinpoint their unique barriers or constraints in adopting crisis crowdsourcing and provide recommendations to overcome the barriers and constraints.

As such, Chapter 3 will only draw from the interviews conducted with Canadian officials. Together these two core chapters fulfill the research goal of characterising crisis crowdsourcing by participating government agencies in Canada and the USA and providing recommendations to ease the adoption of this new technology by government emergency management agencies.

Chapter 3

Building a basis for the adoption of crisis crowdsourcing: Barriers and Constraints posed in the Canadian emergency management realm

3.1 Introduction

Crisis crowdsourcing is now considered an integral tool in the response and management of a large-scale crisis as it provides a way for responders and victims to share up-to-date information about an unfolding event. The early and most successful launches of crisis crowdsourcing platforms have typically been from non-governmental agencies, and even private citizens. There is a clear lag in the adoption of crisis crowdsourcing by government agencies, which may be due to specific costs outweighing the benefits of crisis crowdsourcing practices. However, select government agencies have made recent efforts in this domain, particularly federal agencies in the United States of America (USA) with some state and county level agencies following suit. These examples prove that the adoption of crisis crowdsourcing can benefit government agencies and citizens by showing the citizens that their government cares about their experiences, which in turn increase the citizens' trust in their government. With these benefits in mind, government agencies in Canada have yet to make a strong, documented effort in practicing crisis crowdsourcing. This is likely due to the numerous barriers and constraints that emerge with the adoption of new technology.

Barriers and constraints exist that are specific to government agencies for adopting crowdsourcing. Examples include credibility and liability, resource costs, and policies. All have been identified and discussed in the literature with regards to efforts in the USA and Australia. Unique challenges also arise during crisis events, such as the digital divide³, accessibility during service outages, and accuracy. This adds to the already existing difficulties of government crowdsourcing adoption. As a result, social media has emerged as another integral tool for crisis communications; governments tend to prefer these social media platforms because they are already in place with a strong user

³ The “digital divide” refers to those populations who do not have access to the internet and its services (Goodchild & Glennon, 2010).

base. However, even with social media, government agencies are faced with barriers such as policies, unfamiliarity, privacy and security issues, and rumour spreading.

The objective of this paper is to understand and document the barriers and constraints to crisis crowdsourcing in the Canadian emergency management context. Interviews with 15 emergency management officials from 14 Canadian government agencies at all levels (federal, provincial, county, and municipal) were conducted to identify and understand these barriers and constraints. The results indicate that the participating Canadian agencies are deeply concerned with the credibility of crowdsourced information, and are seeking ways ensure that the information is credible. In response, several tools are identified to aid in determining the credibility of crowdsourced information. Additionally, hazard risk, organizational factors, and demographic factors all influence the decision for a given agency to adopt crisis crowdsourcing. An assessment framework is introduced to evaluate a given agency's readiness for crisis crowdsourcing adoption based on an analysis of these factors. The assessment framework provides an opportunity for agencies to assess their own readiness for crisis crowdsourcing adoption, and to quickly determine which barriers or constraints are hampering their progress. In this way, agencies can formulate solutions to address these unique barriers and constraints. Two general recommendations are provided to agencies facing crisis crowdsourcing barriers and constraints: adopt the bottom-up approach to initiate change and adopt new technology, and build partnerships with neighbouring government agencies and non-government agencies like the Canadian Virtual Operations Support Team (CanVOST) if a given agency's resources are limited.

This research aims to clarify the current barriers and constraints that are associated with government crisis crowdsourcing in the Canadian emergency management realm. Governments can begin to critically assess their own practices and operations, identify unique barriers and constraints that they face, and formulate the appropriate solutions to address them. Further research can build on the readiness assessment framework introduced here, and could devise more specific, case-based solutions for individual government agencies.

3.2 Literature Review

3.2.1 Government Crisis Crowdsourcing

In the past decade, crisis crowdsourcing has emerged as a central tool in the response and recovery phases of large scale disasters. Crowdsourcing is a result of the evolution of the internet into web 2.0, a new generation of the internet built on collaboration and participation by users of the internet, now referred to as “producers” (Bruns, 2008; Feick & Roche, 2013).

When disaster strikes, there is a critical need for timely and accurate information to enable quick and effective response efforts. Since the mid-2000’s, many humanitarian crowdsourcing platforms have emerged and have become critical communication tools during a disaster. “Scipionus” was the first documented instance of crisis crowdsourcing, developed by a private citizen during the 2005 Hurricane Katrina disaster (Roche et al., 2011). After that, other citizen-made map mashups emerged, like those used in the 2007-2009 Santa Barbara Wildfires (Goodchild & Glennon, 2010). Largescale platforms, such as Ushahidi, Humanitarian OpenStreetMap, and more, now exist and are run by non-governmental organizations (NGOs) to aid in the response and communication for large-scale disasters.

One thing that all of the above examples have in common is that they were all started and managed by either private citizens or non-government organizations (NGOs). Not surprising, authors comment that government agencies have been slow in launching their own crisis crowdsourcing applications (Meier, 2012; Roche et al., 2011). It is even suggested in the literature that the emergence of these NGO/citizen-based platforms is in response to the government’s failure to respond effectively (Goodchild & Glennon, 2010; Johnson & Sieber, 2013). Government agencies may be slow in adopting their own crisis crowdsourcing projects because they are unsure whether the costs outweigh the benefits of launching a resource-intensive project. However, examples of existing government crisis crowdsourcing practices demonstrate how governments can benefit from them. Leading the way with at least three disaster-related crowdsourcing projects (Did You Feel It? (Wald et al., 1999, 2011), Tweet Earthquake Dispatch (Earle et al., 2012), and iCoast (S. Liu, 2014)), the United States Geological Survey (USGS) is offering novel ways of connecting with citizens over their personal experiences and knowledge of

hazards. The Federal Emergency Management Agency also launched their own disaster reporting application in 2013, which gives citizens a way to “become part of the emergency management team” (Adamski, 2013). It is clear that the USA is a global leader in government crisis crowdsourcing.

The small number of documented active government crisis crowdsourcing efforts indicates that governments have not fully embraced the new technology, especially those outside of the USA. However, an alternative method of emergency communication between government and citizens emerged around the same time as crisis crowdsourcing: social media. The USA is, once again, leading the way in terms of using social media for emergency communication. A 2013 study revealed that all American emergency management agencies surveyed were using social media, with 68% of county-level agencies and 85% of local agencies using it for both pushing information out and monitoring unfolding situations (San Su et al., 2013). In fact, it was found in other studies that social media is changing emergency management practices in the USA, by allowing emergency managers to analyse public reactions to response efforts, enhance situational awareness, and use the information posted online to quickly estimate the damage extent (Hughes & Palen, 2012; Latonero & Shklovski, 2011; Newton, 2014). In response to this, the US Department of Homeland Security’s Science and Technology Directorate developed the Virtual Social Media Working Group (VSMWG) in early 2012 to provide emergency agencies with guidance in the appropriate use of social media (Department of Homeland Security, 2012; Virtual Social Media Working Group & DHS First Responders Group, 2014).

The literature shows that the USA is a leader in government crisis crowdsourcing adoption and social media use for emergency management. Government agencies in Australia and Canada are following the footsteps of the USA and are creating their own social media networks for emergency management (Flew et al., 2015; Kaminska et al., 2013; Kaminska & Rutten, 2014). A recent example shows the use of social media for emergency management by a local Canadian government’s agency. During the 2016 Fort McMurray wildfire disaster, the Regional Municipality of Wood Buffalo stayed in contact with Fort McMurray residents over Twitter, answering their urgent questions and coordinating response efforts to ensure that residents in need were being helped (Mertz,

2016; Normand, 2016). Yet, even with this recent example, there is a clear gap in the widespread existence and knowledge of crisis crowdsourcing applications and social media for emergency management outside of the USA, particularly in Canada, as no in-depth studies have been completed. Several barriers and constraints associated with government crowdsourcing and crisis crowdsourcing projects have been discussed extensively in the literature (see for example: (Dodge & Kitchin, 2013; Haklay et al., 2014; Johnson & Sieber, 2011, 2013). It is possible that many of these barriers and constraints are impeding the development of government crisis crowdsourcing applications in Canada. Barriers and constraints to the use of social media for emergency management have also been discussed, though not at as great a length as those for crisis crowdsourcing, but it is possible that the government agencies in Canada are also trying to navigate their way through those as well. The barriers and constraints identified in the literature are described below.

3.2.2 Barriers and constraints of Government Crisis Crowdsourcing

The introduction of new technology into a government agency often comes with various barriers and constraints. Crowdsourcing is no exception, especially in a government context. These barriers and constraints will be outlined in this section based on a review of the literature.

Government Specific Barriers and constraints

Government agencies appear to be hesitant in adopting crowdsourcing, and particularly VGI, projects due to concerns with accepting unofficial, unverified data and integrating it into their database; in other words, a lack of trust in non-expert produced data (Brabham, 2013b; Burns & Shanley, 2012; Dodge & Kitchin, 2013; Haklay et al., 2014; Johnson & Sieber, 2011, 2013). Governments prefer to maintain a single-direction communication flow on the internet to distribute information, but are not actively looking to engage with citizens or facilitate online participation (Johnson & Sieber, 2011). This is because governments are concerned with the accuracy of the data, potential biases, and conflicts of interest (Burns & Shanley, 2012; Johnson & Sieber, 2011).

Other concerns relate to legal aspects, and risks over the credibility and trustworthiness of the information being released by the government (Burns & Shanley, 2012; Dodge & Kitchin, 2013; Johnson & Sieber, 2013). The legal aspects of accepting non-expert data through crowdsourcing and VGI raises questions around who takes responsibility for incorrect data (Johnson & Sieber, 2013). Governments are responsible for sharing and possessing accurate data, yet the quality of VGI has been questioned since its inception, creating a challenge for governments to accept it with confidence (Dodge & Kitchin, 2013; Flanagan & Metzger, 2008; Haklay et al., 2014; Haklay, Basiouka, Antoniou, & Ather, 2010; Johnson, 2014, 2016).

The introduction of new technology always introduces additional costs and crowdsourcing and VGI applications are no different. Smaller (i.e. lower-tiered) governments may have a more difficult time with adopting a crowdsourcing application than larger (i.e. higher-tiered) governments, as they have to allocate the appropriate resources to support such a project, for instance, financial support to build the online platform and staff to manage it (Brabham, 2013b). The introduction of VGI brings even more costs as the technology (e.g. GIS) is much more complex and expensive. Governments that already have an existing GIS division or larger budget generally have a greater capacity to absorb the costs of gathering and using VGI (Haklay et al., 2014).

Government agencies looking to start a crowdsourcing or VGI project may also face internal barriers. There might be resistance within the agency towards consulting with the public and collecting ideas from them as they may feel that their jobs are threatened (Brabham, 2013b). For example, urban planners, engineers, architects, and GIS analysts and technicians may be opposed to collecting VGI or any other form of crowdsourced information; in their view, “the efforts of volunteer citizens may make their jobs obsolete” (Brabham, 2013b, p. 29). Staff members may also oppose the adoption of a crowdsourcing or VGI project as it would make the agency accountable to the public; citizens will expect their government to respond to the ideas and feedback that they provide (Johnson & Sieber, 2011).

Government policies may also impede on a given agency's attempts in adopting crowdsourcing and VGI. The policies may be out of date, or even non-existent, which restrict the adoption and implementation of this new technology. A case study of the USA Federal Government's crowdsourcing project to geocode Credit Authority Data identified a number of barriers that had to be overcome. For example, the first issue was whether the government may use crowdsourcing (Roberts et al., 2012). Fortunately, in January 2011 the White House Office Management and Budget published a Technology Neutrality memo, which states that agencies should consider all cost-effective alternatives when designing a project. Crowdsourcing was determined to be the most cost-effective way of correcting the large volume of data for this project. Additional policies and concerns they had to address were the compliance of the Non-Disclosure Act and releasing publicly identifiable information, which raised privacy concerns (Roberts et al., 2012). Governments in other countries may not have the appropriate policies in place to allow for the adoption of crowdsourcing like the U.S. Federal Government just recently implemented. As a result, new policies will have to be developed and implemented, which could slow down the progress of adopting the technology (Bertot, Jaeger, & Hansen, 2012; Bott & Young, 2012).

Crisis Specific Barriers and constraints

The "digital divide" presents another barrier to adopting crowdsourcing, because those who have no access to the technology (e.g. the internet, a computer or mobile device) will not have the chance to participate. The digital divide refers to the difference between populations who are "fortunate" to have Internet access and those who do not (Goodchild, 2007). Experiencing the digital divide can either arise from personal choice or from barriers that are restricting access to digital devices and the Internet, such as financial, social, accessibility, and/or cultural barriers, digital literacy, etc. (Goodchild & Glennon, 2010; Thatcher, 2013). Those who experience the digital divide are often the "most vulnerable members of the population" since it is most likely their lower income levels and lack of education which prevent them from gaining access to this technology (Bott & Young, 2012). The digital divide can impact the results of any crowdsourcing project by creating bias as it will only represent the more "privileged" populations (Bertot, Jaeger, & Grimes, 2012; Brabham, 2009). In a crisis crowdsourcing application areas where the digital divide is present could be excluded from the crowdsourced data,

thus showing no reports in those areas. Meanwhile, on the ground critical damage has impacted those areas.

Accessibility to the application during a crisis event present yet another challenge to adopting the technology. Crisis events commonly result in power outages and other damage to critical infrastructure (i.e. cell towers, telephone and internet lines, etc.) (Goncalves, Silva, Morreale, & Bonafide, 2014). If the users do not have access to the internet or a cellular data network, then they will not be able to upload their information. Another concern is that of data expiration. Since the information is almost real-time, once the reports have been addressed and resolved, they are no longer valid and must be removed from the map (Goncalves et al., 2014).

Privacy, security, and credibility of the users of a crisis crowdsourcing application are additional constraints. In order to ensure that the information being posted is true and credible, some applications require user accounts to make them accountable to the information they provide (Goncalves et al., 2014). However, users will most likely be concerned with their privacy; they need to know that their identities are secure and protected. Thus, Goncalves et al. state that there must be “a balance between accountability and anonymity” (2014). Additionally, sharing sensitive information between response agencies becomes a concern when crowdsourced information from a crisis event is aggregated in such a way that risks violating the privacy of the victims in an event (Burns & Shanley, 2012; Elwood & Leszczynski, 2011).

Concerns also exist with regards to the accuracy and the efficient management and analysis of crisis crowdsourced information. Emergency management officials often say they are most concerned with the accuracy and reliability of the crowdsourced data, however it has been proven that crowdsourced data can be just as accurate as authoritative data (Burns & Shanley, 2012; Haklay, 2010; Roberts et al., 2012). In times of crisis, efficiency is critical as decisions must be made quickly and effectively (Burns & Shanley, 2012; Computing Community Consortium, 2012). The crowdsourced information must be presented to emergency management officials in a usable format so that actionable decisions can be made (Burns & Shanley, 2012).

Social Media for Emergency Management Barriers and Constraints

Emergency management officials are discovering the value of social media for emergency management. As a result, many agencies in the USA are integrating social media practices into their emergency management operations. The lack of literature on social media practices for emergency management outside of the USA, however, suggest that agencies outside of the USA are making slower progress. Recent studies suggest that agencies in Australia are experimenting with the use of social media for emergency management (See for example: Bird et al., 2012; Brady & Webb, 2013; Newton, 2014; Taylor et al., 2012). In Canada, it appears that agencies are also beginning to realise the value of social media for emergency management (e.g. (Cotter et al., 2015; Kaminska, 2014; Kaminska & Rutten, 2014; Waldman & Kaminska, 2015). The slow progress in adopting social media by agencies outside of the USA may be due to the various barriers and constraints associated with using social media in the public sector and for emergency management.

Social media use in the government faces significant policy barriers, for both emergency management and other uses. Existing policies around communications and information management are outdated and limited; do not address the processes, training, or education required for effective social media use (Cotter et al., 2015; Mergel, 2012). Existing policies may block social media access to government officials (Cotter et al., 2015). Additionally, government agencies may not have established the proper data standards and support for managing social media data and integrating it into their operations (Cotter et al., 2015). The standard top-down approach to policy change in governments is yet another barrier. It is typically a slow process that cannot keep up with the speed of social media development, access and communication; social media users expect almost 24/access and response times but government agencies are usually unable to meet these expectations (Mergel, 2012).

Unfamiliarity and resistance to new technology is another challenge that can exist in agencies. Government officials who are not familiar with social media may refuse to experiment with it (Mergel, 2012). Some authors suggest that this closed-minded attitude is harming any potential for technological innovation within the agency (Mergel, 2012); it is limiting the way governments can and should interact with their citizens.

The quick spread of rumours and false information over social media is a concern for emergency management agencies. One example of the “misinformation disaster” after the 2013 Boston Marathon bombing indicates how quickly false information spreads, and how damaging it can be (Madrigal, 2013; Newton, 2014). In the immediate aftermath of the 2013 Boston Marathon bombing the incorrect identities of the two bombing suspects circulated on social media and became “two of America’s most notorious alleged criminals” (Madrigal, 2013). The identities of the two incorrectly identified suspects began circulating before the Federal Bureau of Investigation released the true identities, and was a result of social media users comparing surveillance photos of the suspects and speculating who they were (Madrigal, 2013). Researchers suggest that the quick spread of false information in the 2013 Boston Marathon bombing case and in other cases is because social media users perceive other user-generated content as trustworthy, without verifying it first before sharing (i.e. “re-tweeting” or “re-posting”) (Crowe, 2011).

Government agencies are also concerned about the privacy and security of their own technological infrastructure and the staff members who use it. Hacking of social media accounts is a real risk, as is security breaches in government databases (Newton, 2014). The 2015 hacking and breach of the US Office of Personnel database is a very recent incident that provides grounds for these concerns; personnel records and security clearance files were compromised, exposing sensitive information about approximately 22.1 million Americans (i.e. federal employees, contractors, families and friends) (Nakashima, 2015).

The literature is lacking in documentation and understanding of crisis crowdsourcing and social media emergency practices in Canada. The barriers and constraints described above are specific to government agencies in the USA as there is a wealth of research on these topics there. However, in order for government agencies in Canada to make progress in this new realm, it is important that the Canada-specific barriers and constraints are first identified. The objective of this paper is to fill this gap through developing an understanding of the barriers and constraints Canadian emergency

management agencies face in adopting new technology, whether it be active crowdsourcing or social media engagement.

3.3 Primary Methods

Primary research involved conducting semi-structured interviews with emergency management officials from all levels of government in Canada. In total, 15 participants were recruited from 14 agencies in Canada (two officials from one agency were interviewed together). The semi-structured interviews were primarily conducted over the phone, with one conducted in person. The purpose of the interviews was to develop a deep understanding of the current barriers and constraints associated with adopting crisis crowdsourcing by government agencies in the Canadian emergency management realm. The semi-structured interview model was selected as it allows for follow-up questions to be asked based on the participants' responses to the interview script questions (Dey, 1993; DiCicco-Bloom & Crabtree, 2006; Turner III, 2010).

The interview script was organised by theme, as defined by the lead researcher after a review of the existing literature, and was designed to develop a deeper understanding of the constraints that Canadian government agencies face with the adoption of crisis crowdsourcing. The themes are summarised in Table 7. Participants were provided with a list of common crisis crowdsourcing barriers and constraints that were identified through an international literature review. They were asked to identify from the list which barriers or constraints are present in their agency and provide additional ones that were not included. Participants were then presented with a template for the design and development of a potential crisis crowdsourcing application. They were asked to evaluate the importance and usefulness of each feature described in the template by ranking the importance of each feature from "not important" to "very important." The purpose was to understand how a crisis crowdsourcing application would be used in the Canadian emergency management realm.

Table 7. Interview script themes.

| Theme | Purpose |
|---|---|
| Theme 1: Background on participant and applications/processes | To gain insight into the participant’s official role and the methods and processes that are used to collect information and requests from citizens during an emergency |
| Theme 2: Constraints, disadvantages/barriers/constraints | List of disadvantages/barriers/constraints of government adoption of crowdsourcing and VGI for emergency management were constructed based on the literature. Participants were asked to identify which factors are or were relevant to them and how they were addressed. |
| Theme 3: Criteria for building a government-managed emergency crowdsourcing application | A template for the design of a government crowdsourcing application was designed and provided to the participants. Participants were asked to determine whether an application with all the tools listed would be helpful to their agency. |

The participants were selected based on their positions within the government, their roles in emergency management, and their involvement with any crowdsourcing projects that have been undertaken by their agency. Official roles of the participants ranged from Communications and Marketing Officers and Community Emergency Management Coordinators (CEMC), to Emergency Services Directors and Meteorologists. Prospective participants were first contacted by e-mail with an attached information script for them to further understand the purpose of the study and their participation in it. The contact information was obtained from their agency’s public website. Interviews were audio-recorded with the participants’ consent, and were transcribed verbatim by the lead author. Interviews varied in length from 40 minutes to 2 hours, and were conducted at a time and place convenient for the participants and interviewer. All participants located outside of southern Ontario and Canada (n = 8) were interviewed over the telephone. Participants located in Southern Ontario (n = 7) were given the option of conducting the interview over the phone or in person. All but one participants in Southern Ontario opted for scheduling a telephone interview, while one was conducted in person. Initial recruitment for study participants focused on recruiting emergency management officials from Ontario. Later recruitment stages called for participants outside of Ontario to obtain a broader understanding of crisis crowdsourcing practices in the rest of Canada. Agencies known to experience frequently occurring hazards such as flooding, wildfires, etc. were targeted for the later recruitment stages outside of Ontario. Data

analysis of interview scripts involved using a qualitative data analysis software for thematic coding of the interview scripts. The transcripts were coded based on interview script themes, the applications or processes that the participants described, and any other common themes that emerged from discussions with the participants. In accordance with the University of Waterloo's Office of Research Ethics requirements, all of the participant quotations are identified only by their position, level of government, and country.

Interviews were requested with as many government agencies as possible, across all levels of government in Canada. In total, 15 government officials were recruited: five from the city level, seven from the county level, two from the provincial level, and one from the federal level. The level of experience amongst the participants ranged from one to 32 years. The participants were selected based on information available about their role and agency and their agency's public website. Some instances occurred where the lead author contacted an official from an agency and was passed on to someone with more knowledge about the agency's emergency information management practices. Additionally, other instances occurred where participants recommended that the lead author contact a specific official from another agency who was much more experienced in the social media for emergency management realm.

3.4 Findings and Analysis

The participating government agencies in Canada primarily engage with telephone and social media for emergency information management. Interviews with Canadian emergency management officials suggest that there is a preference for agencies to receive information from citizens over telephone (Figure 10). With 211 and 311 call centres and corporate telephone lines combined, ten participating agencies use telephone to receive emergency and non-emergency related information from the public. Alternatively, Figure 10 shows that social media is used by 12 out of the 14 participating agencies from Canada, from all levels of government. However, it was found that although social media is primarily used for information dissemination, some of the agencies are now using social media for passive crowdsourcing of emergency information from citizens and other agencies (i.e. news outlets, radio stations). Only one agency, at the federal level, engages in active crowdsourcing practices. These results

indicate that the participating government agencies in Canada are not yet prepared to fully adopt a crisis crowdsourcing platform, nor are many of them ready to fully engage with citizens on social media or collect crisis-related information from those platforms, as one Community Emergency Management Coordinator summarised:

“The concern that is right now, is that in order to effectively monitor and go back up to ensuring the credibility of the information that we’re receiving, you need sufficient manpower. And again it comes back to taxpayers, and having the sufficient manpower to monitor and do all of that ... And that is, right there, a big concern, as to one of the reasons, looking at it from our perspective, it is a concern ... So at this point in time we’re not prepared to endorse it” (Participant B, 2015).

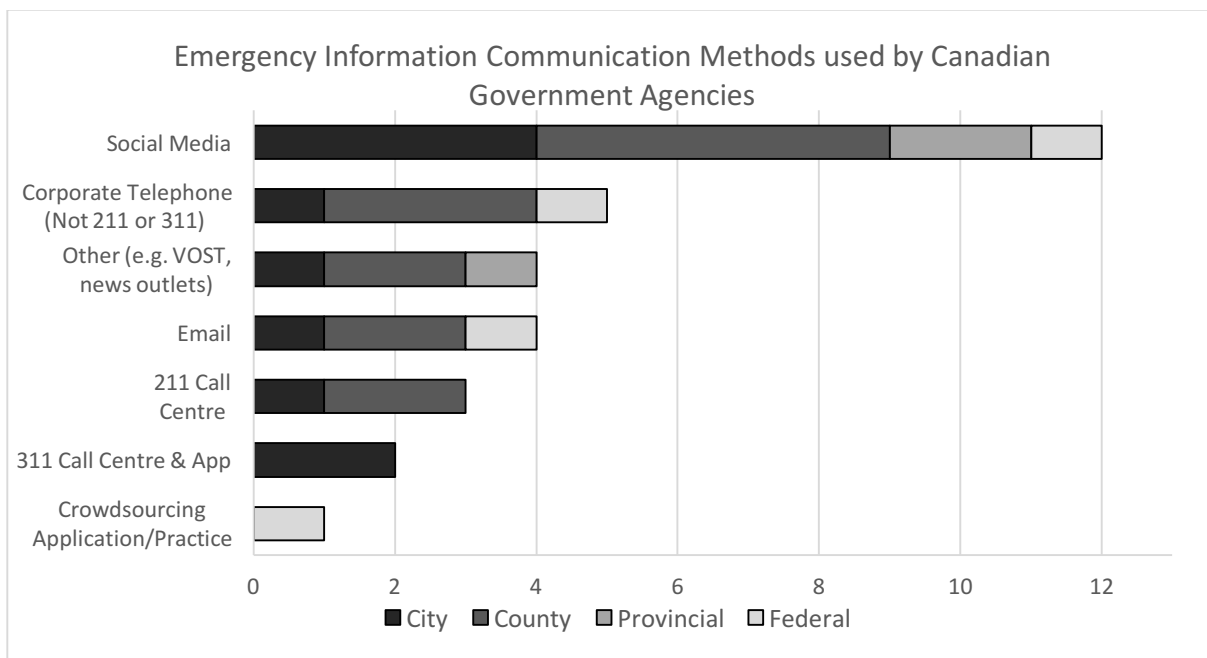


Figure 10. The number of participating Canadian agencies that use each method of emergency information communication, broken down by level of government.

The lack of readiness of these emergency management agencies to fully adopt crisis crowdsourcing, be it active or passive (i.e. social media monitoring and harvesting), raises questions as to why they are not ready. There are many barriers and constraints associated with the government adoption of crisis crowdsourcing and social media for emergency management, as identified in the literature review. The next section provides insight into the current barriers and constraints that the participating Canadian agencies face with regards to crisis crowdsourcing and social media for emergency management.

3.4.1 Barriers and Constraints

There are many barriers and constraints associated with both active and passive crisis crowdsourcing practices in Canada. The participants were provided with a list of anticipated barriers and constraints that were identified through a review of the literature and asked to identify whether their agency faces those barriers and constraints, and discuss why or why not.

Initial findings show that the top barriers and constraints faced by the participating Canadian emergency management agencies from various levels of government are the digital divide, financial limitations, issues with credibility and liability of crowdsourced information, organizational constraints, and policies (Figure 11). While human resources limitations and privacy and security concerns were not as readily identified by the participants as top barriers or constraints, it should be noted that the participants brought up several factors that are closely related to these two constraints.

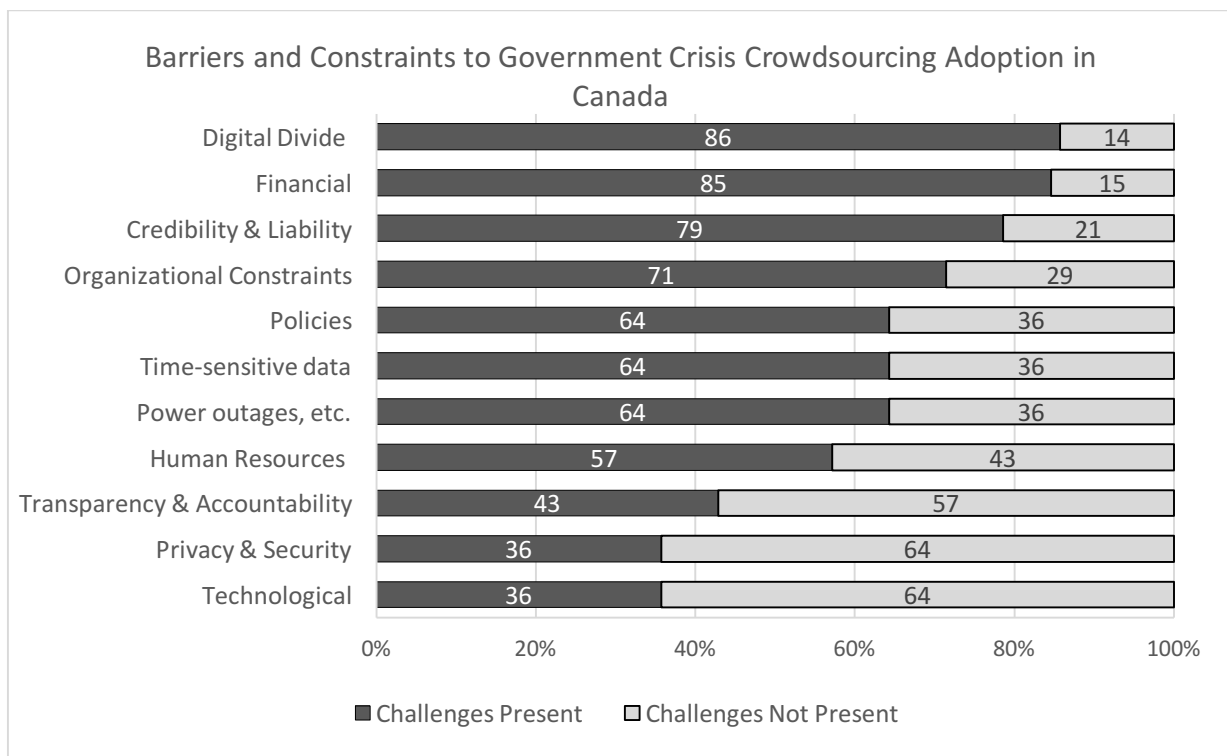


Figure 11. Percentage of participating Canadian agencies facing barriers and constraints with adopting crisis crowdsourcing and ICT practices.

Digital Divide

The “digital divide” refers to those populations who do not have access to the internet and its services, primarily in least developed countries (LDCs) but also present amongst marginalized populations in developed nations (Goodchild & Glennon, 2010; Thatcher, 2013). However, the digital divide is also a choice for some populations, those who choose not to embrace technology or to remain “technologically illiterate.” The digital divide is a clear challenge for government agencies and NGOs engaging in technology and the internet for emergency management. It has especially been identified as a challenge for government online engagement and adopting crowdsourcing projects (Brabham, 2009; Jaeger & Bertot, 2010).

Interviews with emergency management officials from all levels of government in Canada revealed that the digital divide is a pressing issue for many of these agencies, especially those who govern aging and rural (e.g. agricultural or small town) communities. The digital divide was identified by 86% of participants as an existing challenge in emergency management information, not just specific to crowdsourcing but also for information dissemination. However, poverty and socioeconomic status was not mentioned as a primary concern, rather, the most prominent concerns were of demographics and urban bias.

The demographics of a given region can either enhance or reduce the digital divide. Five participants indicated that the age of a population impacts the level of digital engagement they can partake in with a given population. Older populations tend not to embrace technology as openly as younger populations (Participants E, F, O, S, T, 2015), and prefer to talk with “real people” and directly help each other in their community rather than expect help from authorities (Participant E, 2015). Even so, with younger populations there may not be an interest in engaging with the government, as suggested by a county-level Emergency Services Coordinator:

“... our population in [the] County is older, and social media is not as well-used, not as prevalent. I would say our population is probably 34-40% over 40 years old, and then we have a large youth, children, teenagers, but the social media [use by] people between 20 and 40 to 45 is probably very limited, and I’m guessing percentages here, maybe 20 to 25%, and that’s really the ones that would be utilizing social media” (Participant E, 2015).

It should be noted, however, that even though aging populations tend not to embrace technology as much as younger populations, and prefer traditional methods of telephone and television and radio, there are people within the aging population group that are adopting technology. One city-level Community Emergency Management Coordinator acknowledged that there is an aging population in their region, yet there are signs that people within that population are adopting technology to stay connected with the younger population (Participant K, 2015).

Closely related to a population's age is the region in which that population resides. The literature indicates that an urban bias exists in crowdsourced and volunteered geographic information, meaning that rural populations are less likely to engage in online networks and tools than urban populations (Hecht & Stephens, 2014). In support of this, participants indicated that there is not as much digital participation or engagement from rural areas as in urban areas (Participants A, E, H, 2015). This could be due to limited connectivity (Participant A, 2015; Participant E, 2015), and also to demographics and culture (Participation E, 2015). In general, the rural areas also contain the highest levels of aging populations who, one participant suggested, are more interested in direct communication with community members rather than online communication (Participant E, 2015).

Credibility and Liability

Credibility and liability of crowdsourced information was a concern for 11 out of the 14 (79%) participating Canadian agencies. Government agencies find themselves challenged with making decisions based on information they find online from sources that have not been verified; it is difficult to justify these decisions (Participant B, 2015; Participant P, 2015). Agencies also find issues in the spreading of false information and rumours, sometimes deliberately and other times unintentionally (Participants F, H, N2, T, 2015). For example, there have been instances where officials monitoring social media discovered digitally altered images that were circulating over social media, which created unfounded fears and concerns (Participant H, 2015; Participant L, 2015). Conversely, there are instances where community groups post information as fact before officials have confirmed it (Participant N2, 2015). Additionally, the inherent nature of social media, that of reposting and "retweeting" information without any intimate knowledge

of the event exacerbates the rumour-spreading (Participant T, 2015). As such, the participants indicated that they could not make any actionable decisions based on information they receive through social media or any other crowdsourcing platform.

Organizational Constraints & Policies

It was initially considered that organizational constraints and policies were two separate constraints to crowdsourcing and social media adoption for government emergency management. However, the results from the interviews show that these issues are very closely related. In some participating agencies, the organizational constraints can impede policy change, while in others the accepting culture of the agency can inform or initiate policy change.

Two types of government social media policies emerged in the interviews: policies regarding access to social media by staff on corporate computers, and policies regarding the use of social media for citizen engagement. Three participants stated that their agencies have policies in place to block access to social media on corporate computers (Participants F, L, O, 2015), however it can be assumed that the majority of participating agencies likely have these policies in place. It seemed that participants were confused between the types of policies they were being asked about, which can explain the differences in the answers they provided. Four participants stated that there are currently no social media policies in place for citizen engagement (Participants B, P, H, O, 2015), while three participants said that there were no policies in place before they initiated the development of social media policies for citizen engagement (Participants A, R, T, 2015). One participant said that their agency currently has a social media policy in place for citizen engagement, but did not state whether they had to initiate any sort of change in or development of such a policy (Participant S, 2015).

Organizational constraints were described in the interview script as “some government officials may not be open to the idea of adopting new technology; some may feel that their job/position is threatened.” Several participants indicated that there is a clear link between crowdsourcing/social media policy development and organizational constraints, specifically the acceptance of, and openness to, new technology (Participants A, F, H, O, 2015). In one case, changing existing or developing new policies

was likened to “giving up power” by decision makers (Participant A, 2015); a sentiment shared and voiced by scholars in the government-ICT adoption realm (Reddick & Norris, 2013). In other cases, participants themselves stated that they would not use social media or initiate any policy change themselves, instead they were waiting for the policies to change from higher up (i.e. top-down change) (Participants B, F, O, P, 2015). Alternatively, other participants stated that extra work and pilot testing must be done to demonstrate the value of social media and crowdsourcing to decision makers in order to inspire policy change and development (i.e. bottom-up change) (Participant A, 2015; Participant T, 2015).

Aside from the existing corporate social media policies, or lack of existing social media engagement policies, participants suggested that higher-level legislation also impedes social media and crowdsourcing adoption in Canada. In Ontario, the Emergency Management Civil Protection Act was identified by two participants from the county-level as blocking county-level governments’ ability to partake in emergency response; county agencies can only act in an emergency when called upon by municipal governments within the county (Participant E, 2015; Participant N1, 2015). A second legislative barrier that is quite unique to Canada is the Official Languages Act (1969), which mandates that English and French are the official languages of Canada, and that all Federal agencies are required to provide their services in both languages. This introduces a unique challenge to the Federal agencies that want to adopt social media practices as they would be required to engage with citizens in both languages in a timely manner. This bilingual communication over social media may not be possible due to time and human resources constraints (Participant F, 2015; Participant L, 2015). Additionally, Canada’s multiculturalism, instituted by the Canadian Multiculturalism Act (1985), enables citizens to maintain their culture and heritage, thus allowing them to continue communicating in their first languages (not necessarily English or French). This can introduce another challenge in terms of language, as one county-level Community Emergency Management Coordinator described:

“The other thing, multicultural[ism], how many languages would you, if it’s public facing ... it would have to be English and French in Canada. In a lot of the bigger cities, [city] has a very large Arabic population, Spanish speaking population, so you would have to think about, from the public side, what are the other issues when it comes to reporting?” (Participant F, 2015).

The final concern related to organizational constraints raised by participants was a lack of support from higher-tiered government agencies (Participants E, F, N1, 2015). One county-level Communications and Marketing Coordinator provided a direct comparison between the USA and Canada in terms of federal and provincial support in Emergency Management and crowdsourcing:

“... as far as in Canada anyway, I don't think we're there with respect to those applications as the States are, I mean I guess FEMA actually has an application where they use crowdsourcing and will post information. We're not there yet, and we don't have that sort of level of support from our own [National] emergency management agencies” (Participant N1, 2015).

They also hinted towards organizational culture being a factor in these difference:

“So I think it's more of a culture and I guess, a mindset that we have to get into, and we'll probably have to do it at the local level rather than rely on a provincial application or even a federal application” (Participant N1, 2015).

The last statement aligns with suggestions made by the federal-level participant that crisis crowdsourcing for response purposes is currently best suited for municipal-level governments instead of the federal government (Participant L, 2015). Additionally, one of the provincial-level participants also suggested that such an application would be more advantageous for municipal governments rather than provincial governments (Participant T, 2015). This is because the municipal governments are interested in the “detailed management of an event” and the province’s role is to ensure that the municipality has “support” (i.e. financial aid) and is “successful” (Participant T, 2015). Therefore, unlike in the USA with federal agencies like FEMA and the USGS leading the way in crisis crowdsourcing efforts, it is clear from the participants’ responses that these efforts in Canada will have to start at the lower-tiered government agencies.

Resources

Similar to the organizational constraints and policy issues, questions about the resource constraints posed by government agencies were initially separated into three categories in the interview script: financial, human resources, and technological. The results in Figure 11 show that 85% of participating agencies face financial limitations, 57% face human resources limitations, and 36% face technological constraints. Interview results show human resources and technological limitations are closely linked to financial resources (Participants B, E, F, J, K, O, R, S, T, 2015).

The two primary concerns around human resources were training and time. Some participants were concerned about the amount of training required to ensure that staff know how to effectively monitor and manage social media or collect crowdsourced information (Participants N2, J, T, 2015). A public safety official from the provincial level described their agency's experience with social media monitoring before and after receiving adequate training:

“When we set our duty officers who aren't experts at social media to work, the quality of what we were getting back was less than what we wanted, simply because they weren't necessarily looking in the right place. So we went to ... our professional communications staff that are used to doing this and they put us on the right track, so they ... helped us identify the keywords that we were looking for, helped us know where to look, which sites to routinely monitor and those sorts of things. So you've probably got expertise within your organization already, as you put this into the context of emergency management, you just need to bring the two together” (Participant T, 2015).

The last sentence in the above statement is especially interesting as this is the direction that one county-level agency in a separate province is following: The Community Emergency Management Coordinator remains in close contact with their agency's Communications and Marketing Coordinator during emergencies to share critical information and updates (Participant N1, 2015; Participant N2, 2015).

The amount of time it would take to monitor social media or other crowdsourced information during an emergency was another concern raised by participants. Five participants specifically highlighted their concerns around how much time social media monitoring or other crowdsourcing methods would take (Participants F, H, K, O, N1, 2015). There is a fear that in an emergency the volume of posts by users will spike, and officials will not be able to “keep up” with all of the information being posted. It also appears that while social media monitoring and crowdsourcing can be effective tools in collecting information from the public during an emergency (Participants A, H, L, T, 2015), social media monitoring is still viewed as a “time waster” by participants or agencies. As a result, participants believe that they would be unable to justify their time spent monitoring social media to taxpayers (Participant F, 2015; Participant K, 2015).

While there are currently few technological limitations in monitoring social media for most of the participating agencies (only 36% identified it as a challenge), there could be in the future if a large scale disastrous event were to occur resulting in “information overload,” especially for smaller municipalities who have fewer resources (Participants O, P, R, S, 2015). Thus, appropriate plans must be put in place to address the “information overload” concerns (Participants O, P, S, T, 2015). These plans involve ensuring that the appropriate technology required and adequate staffing are available (Participants A, O, P, S, T, 2015).

Agencies adopt different social media models in their emergency management operations. These models fall into three general categories: “in addition to your normal duties”, “all in”, and “let’s get together” (Newton, 2014). Some participating agencies have adopted the “in addition to your normal duties model” by assigning specific social media monitoring tasks to existing positions (Participants A, K, N1, N2, O, S, T, 2015). Other participating agencies are creating new positions specifically for social media communications (Participant L, 2015; Participant S, 2015), and even developing entire teams (Participant R, 2015). Thus, these agencies are following the “let’s get together model” by recognizing that social media is integral to other areas of emergency management operations. Alternatively, creating outside partnerships with other organizations, such as CanVOST, NGOs, and 211 were also identified as solutions to existing resource limitations (Participants H, J, R, 2015). The “all in” model gives all members of the organization the freedom to use social media to communicate with the public (Newton, 2014); none of the participating agencies are using this model.

Privacy and Security

Privacy and security issues related to crowdsourcing and social media were a concern for only 36% of participants. This is primarily because most of the participating agencies (12 out of 14) engage in social media; the participants indicated minimal privacy and security concerns with social media. Participants argued that since citizens voluntarily post information on social media, there are no issues with privacy because it is publicly available. The information posted on social media often does not include any personally identifiable information (PII). However, the participants who do not actively engage in

social media for emergency management operations indicated that there are concerns that would have to be addressed with standard operating procedures if their agency were to engage in social media (Participant B, 2015; Participant J, 2015).

While there were very few concerns with the use of social media, concerns did exist around adopting an active crowdsourcing application and publically displaying the spatial information. Displaying that information publicly poses risks to the privacy and safety of both the citizens and the governments. It could publicize community and government vulnerabilities, and enable vandals and looters (Participant F, 2015; Participant J, 2015). There are also concerns about privacy of individuals or businesses and people taking unwanted photos or videos of damaged property (Participant F, 2015; Participant R, 2015), as described by a city-level Manager of Emergency Planning:

“The other issue though is just sort of like more individual taking a picture of someone's home or someone's private property or of an individual themselves, I think is a big issue and I don't know how you balance that out. That's a good question, I'm not sure how to address that” (Participant R, 2015).

The personal safety of citizens is also a concern, as citizens continuously attempt to capture photos or videos of real hazards like tornadoes, other severe weather, and floods, with no regard to their own personal safety (Participant F, 2015; Participant L, 2015).

3.4.2 Evaluating an Active Crowdsourcing Template

There was no evidence provided by the participants that government agencies in Canada are currently working towards an active crowdsourcing application for emergency information communication. In many instances, participants revealed that agencies are just beginning to experiment with the use of social media for both information dissemination and information gathering. The above barriers and constraints primarily relate to social media, with some participants describing potential barriers and constraints that a hypothetical crowdsourcing application could bring. With this in mind, participants were asked to comment on a list of criteria for a hypothetical crowdsourcing application and rank the importance of each criteria from 0 (“not important”) to 6 (“most important”). The average importance rankings are displayed in Table 8.

Table 8. The average importance of each feature proposed by the lead researcher for a hypothetical emergency crowdsourcing application. Importance was ranked from 0 (“not important”) to 6 (“most important”), see Legend.

| FEATURES | AVERAGE IMPORTANCE |
|----------------------------|--------------------|
| REPORTING FORM | 4.5 |
| WEB-MAP & SPATIAL ANALYSIS | 4.3 |
| ATTACHMENTS | 4.2 |
| LOGIN CREDENTIALS | 3.3 |
| PRIORITY CLASSIFICATION | 3.2 |
| STATUS UPDATES | 2.7 |
| ROUTING | 2.5 |
| POP-UP WINDOWS | 2.5 |

Legend:

| Most important | Very important | More important | Important | Somewhat important | Less important | Not important |
|----------------|----------------|----------------|-----------|--------------------|----------------|---------------|
| 6 | 5 | 4 | 3 | 2 | 1 | 0 |

The three highest ranked features were reporting form (4.5), spatial attributes (4.3), and attachments (4.2). This is not surprising, since credibility and liability of social media/crowdsourced information was a concern for 79% of participating agencies. A reporting form would ensure that the quality of the information gathered is held to a standard, thus increasing the credibility. In addition, the participants indicated that photo and video attachments and spatial data can also increase credibility (see Section 3.4.1).

Login Credentials an Indicator of Openness to New Technology

The fourth highest ranking feature for a crowdsourcing application was login credentials. This is also indicative of the concerns amongst the participating Canadian agencies around credibility and liability. While this feature did not make it into the top three, a deeper analysis of the variation in responses produces interesting results. The distribution of the importance rankings is displayed in Figure 12.

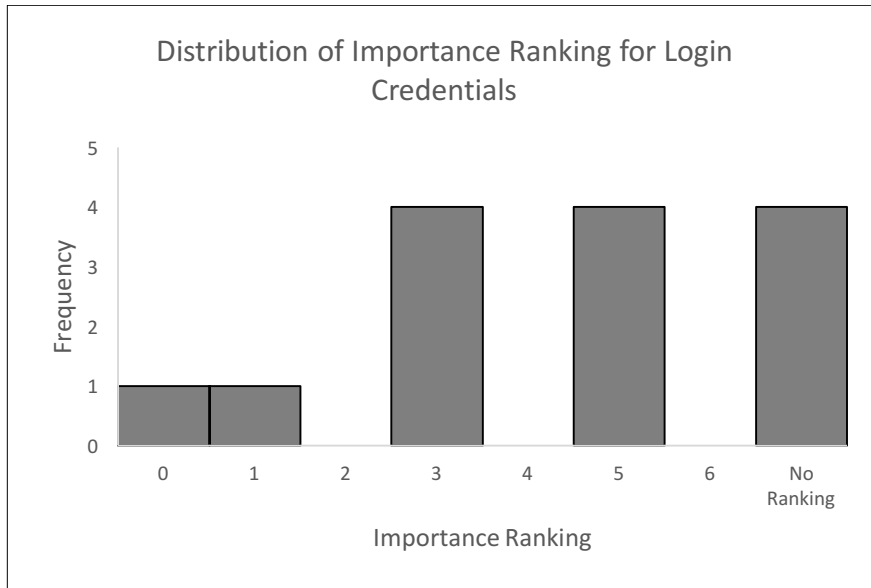


Figure 12. Distribution of the importance rankings of login credentials, where 0 represents “Not Important” and 6 represents “Most Important.”

The distribution in Figure 12 indicates a large variation in the participants’ importance rankings of the login credentials. Two of the four participants who ranked login credentials as 5, or “very important”, were found to not engage in social media for gathering information (i.e. passive crowdsourcing), and only use social media for information dissemination (Participant B, 2015; Participant J, 2015). The other two participants do engage in social media monitoring, but consider it a lower priority in their emergency operations (Participant K, 2015; Participant P, 2015). Conversely, all of the participants who gave login credentials an importance ranking of 3 or lower (3 = “Important,” 2 = “Somewhat important,” 1 = “Less important,” or 0 = “Not important”) do engage in social media for both information dissemination and passive crowdsourcing. Interestingly, the participant that gave login credentials a ranking of 1, or “less important”, assigned this ranking based on previous experience. The participant’s agency already uses an application and online “self-serve” platform that allows citizens to communicate with the agency. Initially these tools required citizens to create login accounts, and the agency found that the tools were not being used. Once the agency removed the login requirements, the usage increased by 300% within the first month (Participant O, 2015). The participant who assigned login credentials with the lowest possible ranking (i.e. “not important”) indicated that a login system would be a limiting factor, and that any crowdsourcing system should be “as wide open as possible” in order to allow the general public to participate (Participant T, 2015). The agency that

this participant represents uses social media for passive crowdsourcing, and has assigned social media monitoring and mining as an official task in the EOC, and brings in communication professionals in times of emergency (Participant T, 2015).

The ranking of login credentials is an indicator of an agency's level of experience with crowdsourcing technology (active and passive), as well as of the agency's openness to new technology (i.e. change). Agencies who gave login credentials a high importance ranking are less experienced with social media/crowdsourcing, and potentially unwilling to try new technology without approval from "higher up" first (e.g. Participant H, 2015; Participant P, 2015). Agencies who gave login credentials a low importance ranking are already engaging in passive crowdsourcing through social media, and even creating specialized teams for it (e.g. Participant O, 2015; Participant T, 2015). Agencies who gave login credentials a more intermediate importance ranking appear to be experimenting with social media, and are in the early stages of using it for passive crowdsourcing (e.g. Participants A, N1, N2, R, 2015). The only Canadian agency to use an active crowdsourcing model, a federal agency, ranked login credentials as 3, or "important" (Participant L, 2015). This is likely because the active crowdsourcing model that the agency employs still requires participants to be trained and listed in the agency's database, and thus, credentials of the participants are present to ensure credibility (Participant L, 2015).

The results suggest that, in a hypothetical crowdsourcing application, there is a link between an agency's level of social media/crowdsourcing engagement and the importance of login credentials. Agencies with a low level of social media engagement (i.e. do not use it, or only use it for information dissemination) tend to rank login credentials as of higher importance than agencies who are highly engaged in social media/crowdsourcing (i.e. actively monitor social media, develop social media teams, practice active crowdsourcing). However, this generalization comes with a limitation: the requirement for login credentials is also dependent on the purpose of the crowdsourcing application and the type of data being gathered. For example, the participating federal agency that practices active crowdsourcing to collect severe weather reports requires that the information gathered be highly credible, thus, only information from trained and registered volunteers is accepted. This is because the information is used "on the

fly” to update current severe weather watches and warnings. In order to do this, the information must be highly credible and accurate.

The Importance of Credibility

It is apparent that, based on the importance ranking results of crowdsourcing features, participating government agencies are deeply concerned with the credibility of crowdsourced information. Anything that can increase the credibility of the data, such as photographs, videos, locations, and standardized forms, are highly important to the participating government agencies. While login credentials can help increase the credibility of the information, participants were not in agreement on whether login credentials are important or not; there is a concern that the requirement for login credentials will deter users.

3.5 Crisis Crowdsourcing in the Canadian Emergency Management Realm

The results in Figure 10 indicate that participating Canadian agencies primarily rely on telephone, 211 and 311 call centres, email, and social media for emergency information communication, with only one agency using an active crowdsourcing model in addition to social media, email, and telephone. All levels of government engage in social media; however, the level of engagement varies. Some of the agencies use it primarily for information dissemination, while others use it for passive crowdsourcing of “live” emergency information. It is apparent from the results that there is not yet a clear place for crisis crowdsourcing in the emergency management realm.

3.5.1 Factors Impacting Crisis Crowdsourcing in Canada

The adoption of new technology is a challenge for most government agencies as they often have limited resources and funds to support the adoption and maintenance. Government agencies are funded by taxpayers, as such they remain accountable to the taxpayers and must be able to justify decisions around resource allocation, including the adoption and support of new technology. Crowdsourcing and social media are examples of new technology that has emerged in the emergency management realm and have been adopted by many NGOs for response efforts, and even government agencies

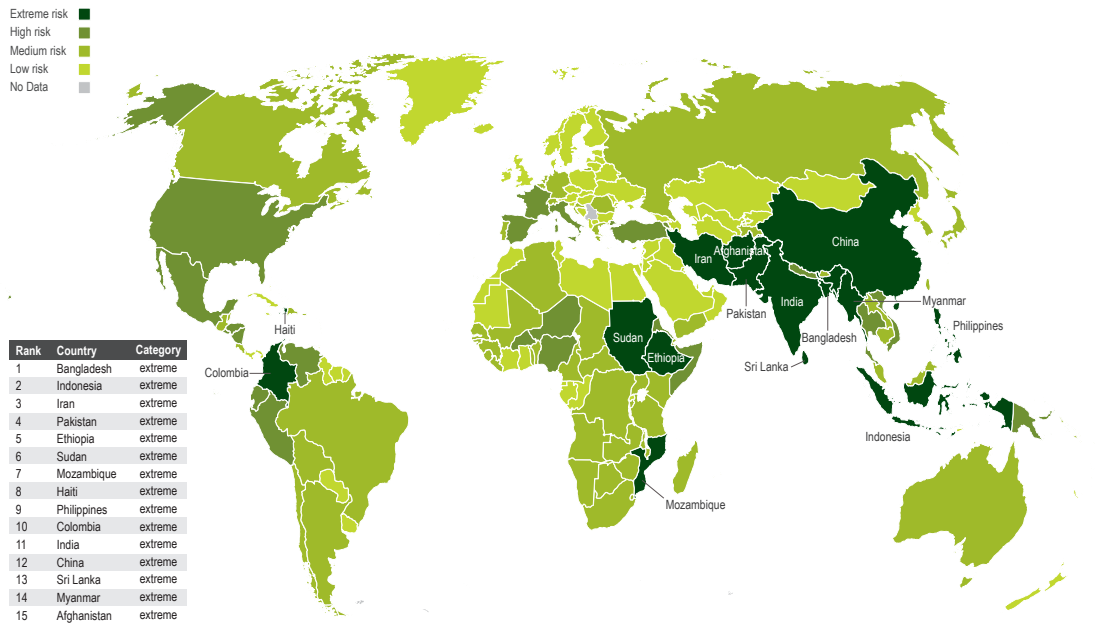
in the USA (e.g. Did You Feel It? by the USGS). However, in Canada there is a clear lag in the adoption of crowdsourcing, even social media. Through discussions with participants from all levels of government within the Canadian emergency management realm, several reasons were revealed to explain why crisis crowdsourcing is not a priority, or a reality in some cases, for the participating government agencies in Canada:

1. Hazard Risk and Exposure
2. Feasibility
3. Culture and Demographics

Each of these factors is discussed below.

Hazard Risk and Exposure

Many participants regularly stated during interviews that they have not yet experienced large-scale crisis events in their jurisdictions. It is widely accepted within the global disaster management realm that Canada's risk to natural disasters is quite low in comparison to other countries, shown in Figure 13. According to Verisk Maplecroft, Canada faces a medium risk to natural disasters and associated economic losses (Verisk Maplecroft, 2010a, 2010b). However, this does not negate the risk that Canadians do face with natural and man-made disasters.



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Figure 13. Natural Disasters Risk Index (2010) from Verisk Maplecroft. Canada falls in the medium risk zone to natural disasters (Verisk Maplecroft, 2010b).

Public Safety Canada hosts a publicly accessible national disaster database (i.e. the Canadian Disaster Database). The data indicates that the frequency of certain disasters is on the rise in Canada, particularly meteorological disasters, as shown in Figure 14. In this dataset, meteorological events include severe winter and summer storms, tornadoes, hurricanes, floods, and wildfires. The data also shows that the trends in geological hazards have remained steady, while technological events like hazardous chemical incidents have increased slightly since the late 1970's. Similarly, data from the Centre for Research on the Epidemiology of Disasters International Database shows an increasing trend in the cost of disasters in Canada, as shown in Figure 15. It is suggested that these trends are largely a result of population growth, increased development within floodplains, and climate change (Etkin et al., 2010).

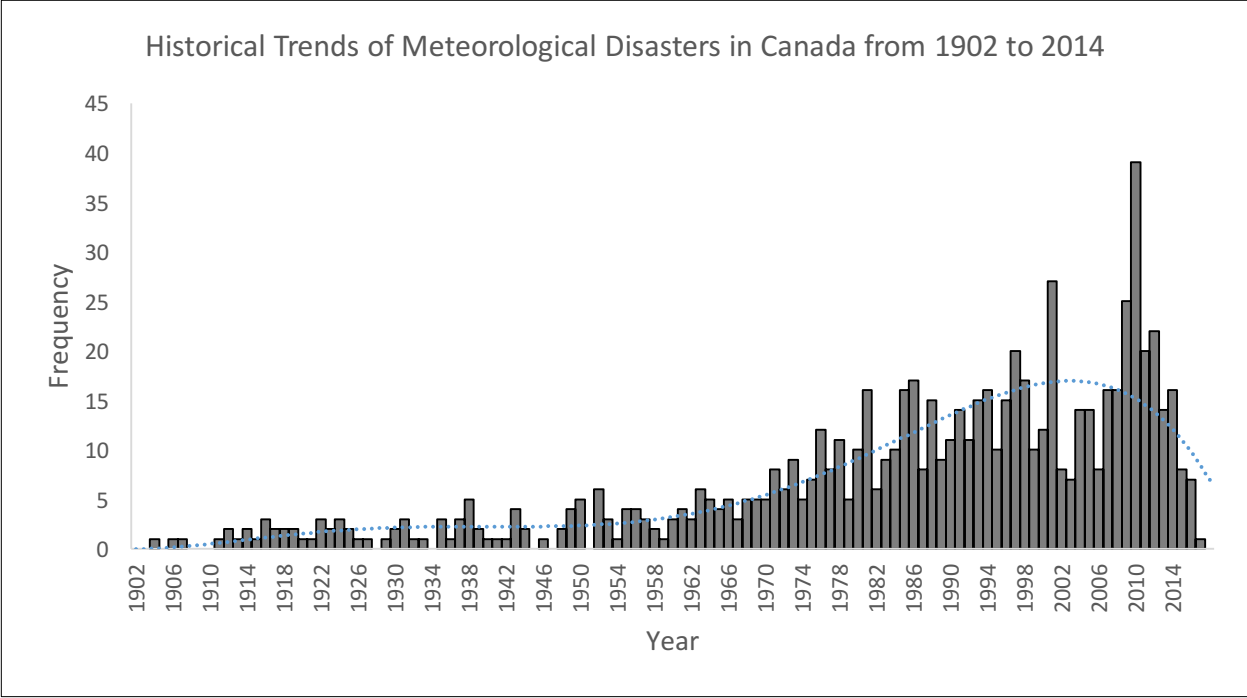


Figure 14. Historical trends in meteorological disasters in Canada show an increase since 1900 to 2014 (data from the Public Safety Canada Canadian Disaster Database).

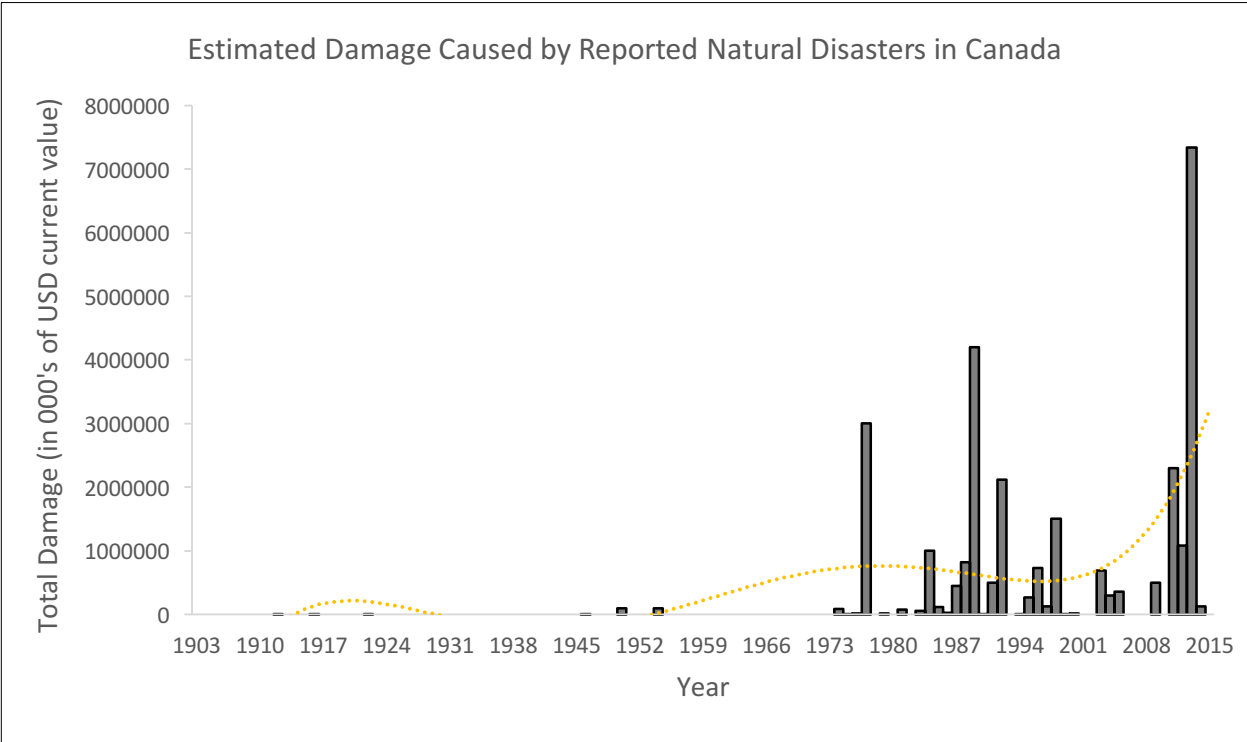


Figure 15. The cost of reported natural disasters in Canada shows an upward trend since the early 1970's (data from the Centre for Research on the Epidemiology of Disasters International Disaster Database).

Many of the participating agencies have yet to experience a large-scale crisis event which might trigger a need to consider or evaluate the use of social media or any other crowdsourcing method (Participant N1, 2015; Participant S, 2015). As a result, many agencies have been slow in adopting these practices. Despite the increasing trends in the frequency and cost of disastrous events in Canada, many of the participating agencies have yet to start formulating plans to incorporate crowdsourcing into their emergency operations. This may be due to issues of feasibility, and culture and demographics.

Feasibility

Government agencies typically have limited resources (e.g. time, staffing, and funds) to spend on new ventures and receive their funds from citizens (i.e. taxpayers), which are used to support staffing, technological resources, and time resources. As such, the government agency's primary objective is to remain accountable to the public and to provide services that are deemed necessary by the public. When an agency decides to adopt or experiment with any form of crowdsourcing application, they must be able to justify this decision to the taxpayers, and fully understand the demands and needs for a crowdsourcing application. Many participating agencies are unsure of how much of their resources will be needed to develop and maintain a crowdsourcing application. However, the agencies who have not yet fully adopted social media as a form of passive crowdsourcing could learn from those who have, and in the process, learn best practices and estimate resource needs based on the experience of other agencies. Social media appears to be an appropriate starting point for emergency information communication between government and citizens.

Culture and Demographics

Cultural barriers also play a role in slowing down or preventing the adoption of crisis crowdsourcing, either through social media or with an active platform. The participants' descriptions of organizational constraints and policy issues indicate that certain cultural aspects of both the agencies and of the public (i.e. lifestyle, demographics), and even at the national level, could be impeding the adoption of crisis crowdsourcing in Canada.

Federal legislation in Canada, as identified earlier in section 3.4.1 introduces some unique barriers to the adoption of crowdsourcing applications in Canada. While acts like the Canadian Multiculturalism Act and in the Official Languages Act are in place to protect and support Canadians of various cultural backgrounds and languages, it can be difficult for government agencies to accommodate all of the various cultures that make up the Canadian portrait. There are large groups across the country whose primary language is not English, but range from French to Arabic, Chinese, and more. Excluding or marginalizing these groups by only providing a crowdsourcing service in English or French would introduce further problems for the government agencies. While there is no requirement for governments agencies to go beyond providing services in English and French, it is important for agencies, especially at the municipal level, to recognise the cultural landscape of their jurisdiction and to make every possible effort to connect and engage with their diverse populations.

The organizational culture within some participating agencies appears to be slowing down the adoption of crowdsourcing, and in some cases even social media, while the culture in others is driving the adoption of crowdsourcing practices. Some participants indicated that they are taking the top-down approach to introducing new technology and methods like crowdsourcing and social media. Alternatively, other participants are following the bottom-up approach to driving policy change around social media; they emphasized the importance of testing out new technology through pilot tests and gathering enough evidence to present their arguments for crowdsourcing to decision makers (i.e. elected officials). The bottom-up approach appears to be more successful than the top-down approach in terms of timeliness and prompting change. As one Community Emergency Management Coordinator said, “if you’re not doing it, you’re already about twelve years behind the rest of society. So, governments need to understand that” (Participant A, 2015).

The demographics of certain population groups and their geographic regions can also impact the user base of any sort of crowdsourcing application, be it social media or a specialized application. Age is an important factor in the digital engagement of citizens. Findings from a study in the USA conducted by the Pew Research Centre found that in 2015, 90% of young adults (18 to 29 years old) reported using social media, while 35%

of surveyed Americans aged 65 years or older reported using social media (a significant increase from 2% in 2005) (Pew Research Centre, 2015). The study also found that, while rural populations are less likely to use social media than urban populations, trends are showing an increase in social media usage for these rural populations as currently 58% of rural populations use social media (Pew Research Centre, 2015). Even though these numbers represent American citizens and not Canadian citizens, it can be assumed that the numbers for Canada would be similar. At the time of writing, no data is publicly available to confirm this. To address the cultural differences that exist by age and geography, at least two participants in this study emphasized the importance of using personal networks and remaining in touch with younger populations if older citizens are not on social media (or the internet) themselves (Participant A, 2015; Participant K, 2015); citizens are responsible for developing their own information sources (Participant A, 2015).

3.5.2 Classifying Canadian Emergency Management Crisis Crowdsourcing Readiness

Based on the results presented and the preceding discussion, there is potential for agencies to assess their readiness to adopt crisis crowdsourcing practices. Several factors contribute to an agency's adoption of new technology, in this case crisis crowdsourcing adoption. The following section will present these factors as general areas of concern. The purpose is to identify the unique barriers that an agency faces in considering crisis crowdsourcing. Once the barriers have been identified, the agency can take measures to address or mitigate these barriers, thus ensuring the success of the crisis crowdsourcing adoption. The three general areas of concern, which incorporate all of the reasons that are described above are hazard risk factors, organizational factors, demographic factors. Hazard risk factors incorporate agency-led hazard identification and risk assessments to determine the level of risk posed by specific hazards in the community. Organizational factors address feasibility by questioning resource availability; it also considers internal culture, and level of government. Demographic factors take into account population age and public lifestyles (i.e. urban, quasi/peri-urban, rural lifestyles) that may impact user base.

Hazard Risk

The level of risk that a community faces to specific hazards can determine whether there is a need for a robust crowdsourcing application. Local governments can complete hazard risk assessments to determine the risk of their communities. These assessments can originate at the provincial level, to determine the provincial risk to hazards, and lower-tiered governments can assessments for their own communities. This appears to be the case in Canada, where some provincial and territorial agencies have made their provincial risk assessments available online (e.g. Manitoba Office of the Fire Commissioner, n.d.; Northwest Territories Municipal and Community Affairs, 2014; Ontario Ministry of Community Safety & Correctional Services, 2012a). Some provincial agencies even provide tools and guides for lower-tiered governments to conduct local Hazard Identification and Risk Assessments (HIRA) (e.g. Alberta Emergency Management Agency, 2016; British Columbia Ministry of Public Safety and Solicitor General Provincial Emergency Program, 2004; Nova Scotia Emergency Management Office, 2010; Ontario Ministry of Community Safety & Correctional Services, 2012b). However, a basic internet search did not reveal any information for the remaining, unnamed provincial agencies including Saskatchewan, Quebec, New Brunswick, Prince Edward Island, the Yukon Territories, and Nunavut. Therefore, it is not clear whether these assessments are required or mandated by the provincial or federal government.

More research and testing is needed for the appropriate integration of hazard risk factors into the readiness assessment. The readiness assessment framework may be adapted based on the results of an agency's own hazard risk assessment. For example, the agency may include fewer or more hazard types, or different hazard types. Knowing which hazards pose a higher risk in a given agency's jurisdiction can help in the design of the crowdsourcing application which then can be catered to include certain features or information that are associated with a specific hazard. For example, if an agency is at a higher risk to flooding hazards, the application can have more of a focus on flooding hazards and damage. If wildfires pose a higher risk, then the application can be more suited to wildfire hazards and damage.

Organizational Factors

Several organizational factors were identified as barriers to government adoption of crisis crowdsourcing. These factors are resources, level of government, and internal culture. Assessing these factors for individual agencies can identify which are the most significant barriers, to ensure that they are addressed adequately. Additionally, classifying the agency's current methods of communicating emergency management information with the public can provide a preview of the current efforts (if any) the agency has made in adopting social media or any other crisis crowdsourcing method. The four organizational factors that should be considered when looking into new crisis crowdsourcing practices are listed and described in Table 9.

Table 9. Organizational factors contributing to a government agency's crisis crowdsourcing readiness.

| Current methods/practices of gathering crisis information | |
|--|---|
| Current approaches to communication | Description |
| Incoming: Telephone Outgoing: Traditional (television, radio, newspaper), 211/311 | Agencies primarily rely on incoming reports from citizens via telephone; agencies have a call centre (e.g. 311, 211) or a corporate telephone line. |
| Incoming: Telephone, social media monitoring Outgoing: Social media, 211/311 | Agencies partake in some social media monitoring, but still rely on telephone reports for actionable items in emergency operations. Agencies regularly release alerts and other messages over social media, some agencies also employ 211 or 311 call centres for citizens to phone in for information. |
| Incoming and outgoing: social media engagement, actionable items, 311 application | Agencies regularly engage with citizens over social media by releasing alerts and statements, answering questions, and/or receiving reports and entering them into emergency operations as actionable items after verification. Some agencies also use a specialised 311 application to receive reports from citizens via their mobile devices. |
| Fully developed crowdsourcing application or method | Agencies have a fully developed crowdsourcing application or method integrated into emergency operations. This could be passive crowdsourcing in the form of social media harvesting (i.e. a program developed to monitor social media and retrieve relevant information for further analysis), or active crowdsourcing through an application publicly accessible to citizens to receive live reports from the ground, or simply a process developed to receive reports through telephone or email from a group of citizens (e.g. "storm spotters"). |
| Resources available for crisis communication | |
| Resources available to: | Description |
| No budget, no new positions or additional tasks/responsibilities | Agencies do not have sufficient resources to explore the use of social media or any crowdsourcing process for emergency operations. |
| Assign additional tasks | Agencies have the resources (i.e. time and manpower) to assign specific social media tasks to existing positions, as an additional duty in times of emergency. |
| Ensure proper training | Agencies have the resources to provide proper training to existing officials who have been assigned the task of social media monitoring. |

| | |
|--|--|
| Create new positions and/or teams | Agencies are creating new positions specifically for social media monitoring/crowdsourcing practices. Some agencies are even developing specialised teams for these purposes. |
| Level of government adopting crisis crowdsourcing | |
| Level | Description |
| Federal | Federal government agencies in Canada face challenges with federal legislation such as the Official Languages Act and the Multiculturalism Act. In addition, federal agencies are less inclined to adopt crowdsourcing methods since it is the municipal government agencies who are primarily involved in emergency response. |
| Provincial | Provincial agencies also view crisis crowdsourcing efforts to be more beneficial at the lower-tiers; provincial agencies are there to support municipal agencies during a crisis event, but do not get heavily involved in response and recovery efforts. |
| County | In some provinces, county-level agencies are prevented from becoming involved with the response and recovery of a crisis event, and must be called upon by the impacted municipality within the county before the county can act. Thus some county agencies are less inclined to direct resources to crisis crowdsourcing practices if they cannot act on the information. However, some county-level agencies still actively engage in social media to maintain situational awareness for alerts and public statements. |
| Municipal | Municipal governments are the most impacted agencies during an unfolding crisis event, and they are the most involved in the response and recovery of a crisis, as well as the mitigation/risk reduction and preparedness to specific hazards. Thus it is more likely that crisis crowdsourcing efforts in Canada will start at this level. |
| Organizational culture for change | |
| Type of change | Description |
| Top-down change | Agencies who are following the top-down approach to introducing new methods, practices, and technology into the government agency may be slower, and potentially less successful, in adopting crisis crowdsourcing practices. |
| Bottom-up change | Agencies who follow the bottom-up approach to internal change tend to inspire policy change faster and successfully. These agencies are more likely to succeed in adopting crisis crowdsourcing in a timely manner. |

To determine the readiness based on the organizational factors, the agency in question can assess each of the factors described in Table 9 and identify which ones are significant barriers to current or future crowdsourcing efforts. Once the agency knows which factors are a hindrance, they can create solutions to address them.

Demographic Factors

The demographics of a community's population can impact the successful launch of a government crisis crowdsourcing application. The age of a population group can influence the digital divide phenomena within a given area. In addition, the lifestyle setting of a given population can influence the level of digital engagement (i.e. urban bias). Population age and lifestyle setting are described in Table 10.

Table 10. Demographic factors that can influence a government agency's crisis crowdsourcing readiness.

| Average age of population | |
|--|--|
| Most prominent age group | Description |
| Ageing | Older populations tend not to embrace technology as openly as younger populations; the digital divide is enhanced in these older groups. Governments with large ageing populations are less likely to succeed in launching a crisis crowdsourcing application, or even in engaging over social media as the residents cannot be reached as fully through this technology. These groups prefer to connect through telephone or in person. |
| Young | Younger populations tend to embrace new technology openly and willingly. They are more likely to connect through social media and other methods enabled by their mobile devices. This increases the chances of successfully launching a crisis crowdsourcing application. However, there is a limitation in the level of interest that younger populations take in government action and communication. |
| Lifestyle setting of the general population | |
| Category | Description |
| Rural | Rural populations are less likely to engage in online networks and tools; there is typically less digital participation amongst rural populations. Thus government agencies with large rural populations are less likely to succeed in launching a crisis crowdsourcing application. |
| Quasi/peri-urban | More information needed on the digital engagement of populations inhabiting areas outside of urban centres, but are not rural. |
| Urban | Governments of large urban centres are likely to have better success in launching a crisis crowdsourcing application as there is a large population size to increase the number of users. Additionally, urban centres tend to harbour a younger demographic, that is enthusiastic about new technology. |

Understanding the lifestyles and demographics of the residents in a given agency's jurisdiction will allow the agency to assess how difficult it may be to build a strong user base for the application, which can determine the agency's successful launch of the application. If demographic factors are a barrier to the successful launch of a crisis crowdsourcing application, the agency may try raising awareness and digital literacy through publicly hosted workshops and other public outreach endeavours.

Determining Crisis Crowdsourcing Readiness

The complete assessment of each of the three areas of concern (organizational, demographic, and risk) can indicate a given agency's readiness to adopt crisis crowdsourcing. This assessment process is visualised in Figure 16. Each of the three areas of concern influences a government agency's capability and potential for successfully designing and launching a crowdsourcing application. The first step in the process is to complete a hazard risk assessment. If it is determined that an agency's jurisdiction does not face any significant risk to hazards, then it may be that there is no real need for a crowdsourcing application. If this is the case, there is no further need to continue with the readiness assessment process. However, if the hazard risk is determined to be significant, then there is an opportunity to introduce crisis crowdsourcing to manage the risk. The second step, then, is to assess the organizational and demographic factors. If organizational factors are deemed as significant barriers to the agency's efforts, the agency can initiate internal changes that can ease the development of an application (i.e. creating or updating policies, etc.). If demographic factors are the most prevalent barriers to the successful launch of a crowdsourcing application, the agency can make efforts in increasing the digital education and awareness of the citizens through workshops and training sessions, and also by providing free internet services and access at public centres such as libraries and community centres.

The assessment framework is a proposed guideline, or rubric, to determining an agency's readiness to adopting crisis crowdsourcing. The scheme provides a simplified method of identifying specific barriers to an agency's crisis crowdsourcing efforts, and in turn provides an opportunity to address those barriers. There is not enough specific information on the hazard risk assessment factors or demographic factors to assess the participating agencies of this study, however, the results show that they must be considered when designing a crowdsourcing application. For example, the participants were not asked to discuss the population demographics of their areas, nor were they asked to provide information on their agency's risk assessments, but these factors were brought up by the participants during the interviews and identified as important considerations. Therefore, they are included in the assessment framework. This

assessment framework can be used to design future studies and assist agencies in their crisis crowdsourcing efforts.

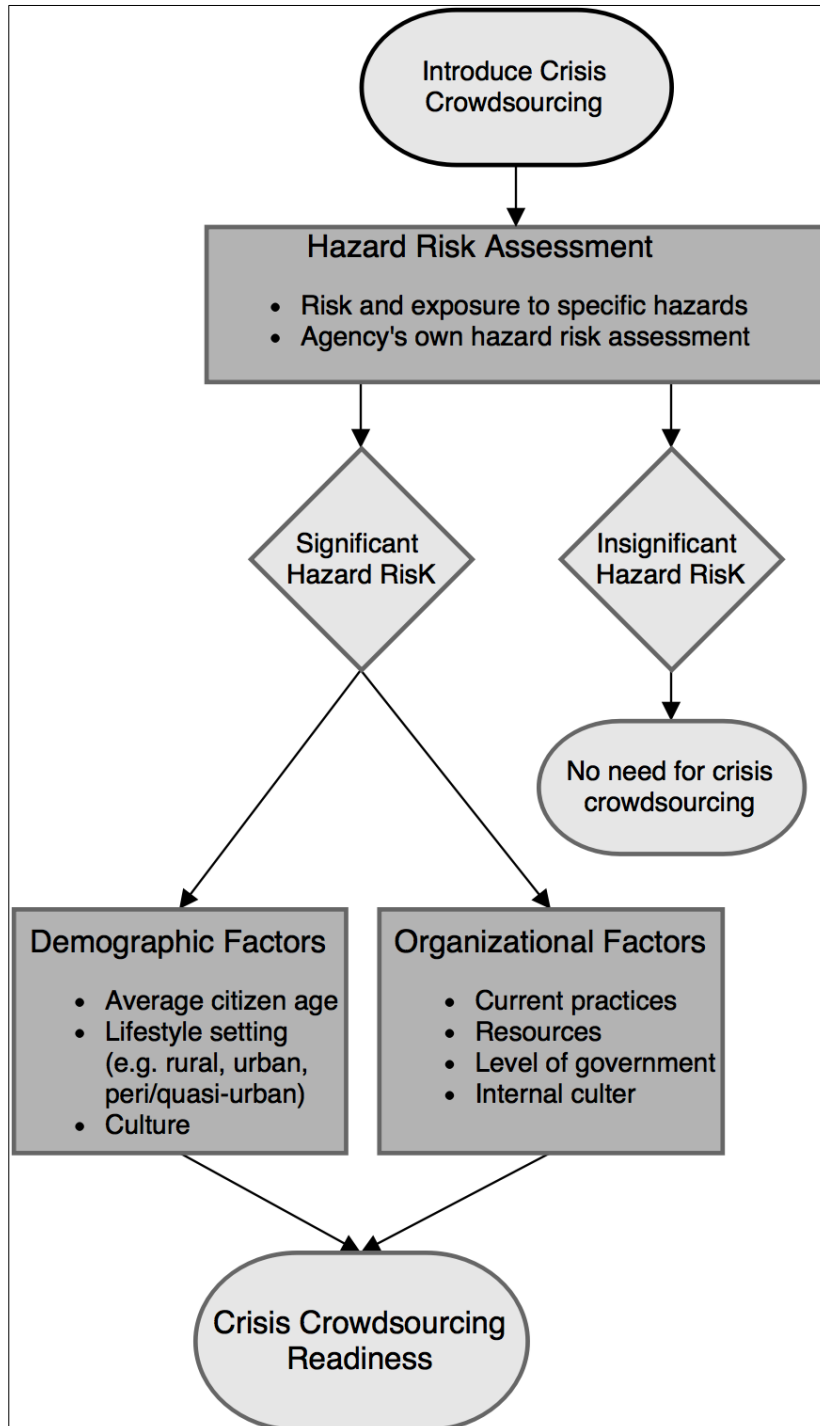


Figure 16. The assessment framework is introduced as a two-step process, where the first step is completing a hazard risk assessment for the agency's jurisdiction. If determined that there is no significant risk, then there is no need for crisis crowdsourcing. If determined that there is no significant risk, then there is no need for crisis crowdsourcing. If there is a significant hazard risk, then the agency should further explore the options for crisis crowdsourcing. Assess the demographic and organizational

factors is the next step in the process, and can help agencies identify specific barriers to crisis crowdsourcing adoption.

3.6 Easing the adoption of crisis crowdsourcing

Adopting crisis crowdsourcing in the government emergency management realm in Canada presents several barriers and constraints that are quite unique to Canada. The three broad categories of barriers and constraints that are impeding this new technological and sociological development within government agencies are: hazard risk and exposure, organizational factors, demographics. Some participating agencies have been able to address and overcome these barriers while others have not yet made an active effort. From the participating agencies that have made some progress in crisis crowdsourcing efforts, it appears that the most feasible method is passive crowdsourcing through social media. With this in mind, the participants were asked to provide their insights and ideas on how to improve and ease the adoption of crisis crowdsourcing in Canada.

3.6.1 Follow a Bottom-Up Approach to Inform Policy Change

The first recommendation that is being proposed, based on insights from the participants whose agencies follow bottom-up change and based on the experiences of participants from agencies that follow top-down change, is for agencies to follow a bottom-up approach to adopting new technology. The participating agencies who have successfully adopted social media tended to follow a bottom-up approach to inspire policy changes, while those who have not explored the social media path appear to be following a more top-down model, where they are waiting for elected officials and decision makers to instigate the changes themselves. The bottom-up approach appears to be more successful, as it enables “enthusiasts” in the agency to run pilot tests, and gather data in support of policy change, which can then be presented to the elected officials and decision makers to allow them to practice informed decision making. These findings support other findings in the literature, which indicate that the adoption of social media by government agencies is a result of experimentation by those social media enthusiasts within the agency or by stakeholders (Mergel, 2012; Newton, 2014).

3.6.2 Build Partnerships in Advance

Many participants emphasized the importance of having a system in place before it is actually needed when a crisis strikes (Participants A, E, O, P, S, T, 2015). However, some agencies may not have the adequate resources for a full-fledged social media/crowdsourcing project. As such, these agencies should start building partnerships with neighbouring jurisdictions and digital volunteer agencies like CanVOST. Some agencies are large enough to have sufficient resources for building specialized social media monitoring teams or creating new social media positions (Participant R, 2015). However, other agencies may not have the adequate resources or support to create these new positions and teams (Participant R, 2015, Participant S, 2015). As such, these smaller agencies should seek out partnership opportunities with other agencies who already have a social media/crisis crowdsourcing capacity. This could be partnerships with neighbouring government agencies; with CanVOST; with NGO's such as the Red Cross, Crisis Commons, Standby Task Force, or Humanity Road; or partnerships with 211 or 311 call centres⁴ (Participants H, J, R, 2015). In fact, one county-level Community Emergency Management Coordinator indicated that they have had to assist other municipalities in social media monitoring (Participant A, 2015). During the 2013 Alberta floods, this participant's agency was able to assist in the social media monitoring with their communications team, even though they are in a completely different province and "were completely unaffected by that incident" (Participant A, 2015). The CEMC continued to outline the value of building partnerships with other agencies: "and then when we get inundated with an incident, we're able to call on our partners or other communities to help us monitor social media" (Participant A, 2015).

Building partnerships with other agencies within and outside of a given region offers many benefits. It enables resource and information sharing which then helps to break down the "silo effect." The silo effect refers to the inability of departments within an organization to communicate and collaborate with each other (Tett, 2015). The silo effect is present in the emergency management realm, and resulted in "one of the biggest communication failures during the 9/11 event" as described by a county level Director

⁴ 211 is a publicly funded information service in Ontario that operates separately from government agencies and is used by some agencies to provide public service information to citizens through their online database and their 24/7 phone line. 3-1-1 is a non-emergency number that many jurisdictions in both Canada and the USA adopt to provide a direct information line to local government agencies.

of Emergency Services; while the various response services (police, fire, and ambulance) were all on scene, they did not communicate on the same radio channels, so they could not collaborate with each other (Participant J, 2015). The silo effect exists in the Canadian emergency management realm as well:

“Many organizations in [the province] sit there as silos, there’s no information sharing between, there’s not the ability to sort of cross contaminate ... because everyone holds onto their information ... So somebody who is doing something really well may not be sharing it with the others, or the others may not be aware of it” (Participant J, 2015).

Fortunately, the introduction of social media and other crowdsourcing practices can help break down this silo effect. One county-level CEMC already proved that barriers created by the silo effect can be broken down by using social media to aid in the response of an event that was not even happening in the same province (Participant A, 2015). The agency was able to share their personnel and expertise with another agency across the country during an extreme, catastrophic event.

Virtual Operations Support Teams (VOST) provide another opportunity for building partnerships and breaking down the silo effect. The first Virtual Operations Support Team was developed in the USA by an emergency manager in 2011 (St. Denis, Hughes, & Palen, 2012). Since 2011 it has grown across the USA and has aided in the response to various large-scale disasters, such as the 2011 Shadow Lake Fire in Oregon (St. Denis et al., 2012). VOST employs “trusted volunteers” whose jobs are to establish and monitor social media communications and complete tasks that can be done remotely (St. Denis et al., 2012). The trusted volunteers are usually emergency managers who have signed up and received training from all over the country. The Canadian counterpart to VOST is CanVOST, which was developed around the same time as VOST in the USA (Participant H, 2015). CanVOST works with other response agencies during an event to monitor information being posted and shared on social media, and turn it into actionable intelligence for the agencies they are working for (Participant H, 2015). In the fall of 2014, CanVOST participated in a simulated hurricane event in eastern Canada; the simulation was a success and CanVOST was able to demonstrate their value for informing decision-making by the responding agency that they were working for (MacKenzie, 2015; Participant H, 2015). A year later, in the spring of 2015, a second simulation was run in conjunction with emergency management agencies and VOSTs

from both the USA and Canada, as part of the Beyond the Border Action Plan released in 2011 (Cotter et al., 2015). This simulation provided an opportunity for agencies from both countries to cooperate and collaborate together, as it is accepted that disasters have the potential to cross political borders, so there is a need for cross-border agencies to be able to work together (Cotter et al., 2015). The simulation results proved that coordination and collaboration between emergency management agencies and “digital volunteers” like VOST/CanVOST between two countries can “improve recovery operations measurably” with interoperable tools and social media (Cotter et al., 2015). This is yet another example of breaking down the silo effect, at the international level.

Less than a year later, CanVOST was able to apply their simulation results in a real life situation, the 2016 Fort McMurray wildfire disaster. In May 2016, CanVOST was enlisted by the Alberta Emergency Agency (AEMA) to aid in the monitoring of social media during the event (Normand, 2016). The role of CanVOST, as mandated by the AEMA, was “fairly limited (but important) to Social Media monitoring, message amplification, correcting misinformation etc.” (Black, 2016). In an email sent out to teams from the Standby Task Force and Humanity Road, the author indicated that this was CanVOST’s “first direct engagement” with an official agency (Black, 2016). While the agency in question (i.e. the AEMA) limited the scope of CanVOST’s contribution, they were happy to complete the mandate and fulfil their overall goal of building trusted relationships with government agencies (Black, 2016). The performance of CanVOST’s efforts in this disaster is yet to be documented and evaluated in a formal report. No comment was available from participants of this study as interviews were conducted several months before the disaster occurred. Further investigation into the use of social media by government agencies involved in the disaster shows that the Regional Municipality of Wood Buffalo (where Fort McMurray is located) was extremely active in sending out alerts over Twitter and also connecting with people in need to ensure that they were taken care of (Mertz, 2016). This recent example indicates both the importance of government agencies partnering with other agencies, and also of connecting and engaging with citizens in real time during a crisis.

The examples provided demonstrate the benefits of building partnerships with other emergency management agencies (both government and non-government). However it must be stressed that these partnerships must be built well in advance of a crisis event, so that plans are in place and everyone is ready to act in a timely manner (St. Denis et al., 2012; Participants A, E, O, P, S, T, 2015). For example, in the year leading up to the Fort McMurray wildfire disaster, the AEMA and CanVOST participated in exercises together (Black, 2016), thus forming a partnership well in advance of the wildfire disaster.

3.6.3 Build a Crisis Crowdsourcing Validation Toolbox

The credibility of crowdsourced crisis and social media information is a concern for participating Canadian government agencies, and these agencies indicated that they would not, or do not, use this information for actionable decisions until it has been validated. To address these concerns, agencies should include validation tools in their toolbox for collecting and analyzing any form of crowdsourced information (Participant H, 2015; Participant L, 2015). These tools are described in Table 11.

Table 11. Validation tools that should be added to emergency managers' social media monitoring toolbox.

| VALIDATION TOOL | EXAMPLES | DESCRIPTION OR PURPOSE |
|----------------------------------|--|--|
| MULTIPLE SOCIAL MEDIA PLATFORMS | Twitter, Facebook, YouTube, Periscope, Vine, Instagram, Flickr | Crosscheck posts across all platforms |
| SOCIAL MEDIA MANAGEMENT SOFTWARE | Hootsuite, Sprout Social, Tweetdeck | Conduct hashtag and geo-fenced searches, remove re-tweets, monitor trends (Participants A, F, H, P, T, 2015) |
| GEOGRAPHIC INFORMATION | Geotagged posts and geo-fenced search results plotted on a map | Corroborate reports that are nearby, different angles/perspectives provided from different locations |
| ATTACHMENTS | Photos, videos | Provide a better impression of the extent of damage and impact on a municipality |
| USER INFORMATION | Posting history, number of followers | Information on user accounts provides an indicator of “who they are,” and indicates their history of posting valid or invalid information |
| TRUSTED SOURCES | News, radio, credible users | These sources have previously been verified and deemed credible, their information is trustworthy |
| CROWDSOURCING VERIFICATION TOOLS | Verily (https://veri.ly/) | Online platform that enlists volunteers to verify social media information about a specific humanitarian crisis event (Popoola et al., 2013) |

Factors that increase the credibility of crowdsourcing information were identified by participants as trends (i.e. increasing numbers of reports about an incident), photographs, and geographic information, and available information on the user's account (Participants E, H, L, O, 2015). Sharing pictures and videos provides an added level of credibility, however verification of these photos and videos themselves must be practiced due to the issue of fake photos described previously (Participant H, 2015; Participant L, 2015). Geographic information allows agencies to plot the information onto a map, where trends can be identified (Participant H, 2015), and officials can determine whether a user is credible based on information provided on their social media account, such as number of followers, and history of putting out valid information (Participant H, 2015).

It is important to build a list of trusted sources because it is easier to accept information from sources that have already been verified and are considered credible than from unknown sources (Participants F, H, J, K, L, P, R, 2015). It was also mentioned by two participants that social media, in particular, can be self-correcting in nature (Participant S, 2015; Participant T, 2015). For example, one city-level Emergency Preparedness Coordinator described how they will see citizens correct each other on social media; the citizens will often question or debate each other's posts and provide updated or corrected information based on their own ground-truthing (Participant S, 2015). Similar conclusions have been made in the literature that support these participants' sentiments (Goodchild, 2008; Hall, Chipeniuk, Feick, Leahy, & Deparday, 2010). However, since there is still the possibility for rumours to continue to spread despite the self-correcting nature of social media and other crowdsourcing platforms, agencies still "need to be prepared to correct the information" (Participant T, 2015).

To address concerns around the correctness and accuracy of crowdsourced information, agencies can formulate "reporting guidelines" for citizens to follow when reporting information over social media or any other crowdsourcing platform, as was done by the participating federal level agency to increase the quality of reports received through Twitter (Participant L, 2015). Additionally, agencies can implement verification methods if they are feasible (Burns & Shanley, 2012; Johnson & Sieber, 2013). In general, however, it has been found by experienced users of crisis crowdsourcing that the data is often just as accurate, or more accurate, than authoritative data (Burns & Shanley, 2012). As

such, while concerns about crowdsourced data credibility and quality are legitimate, agencies can address these concerns by implementing validation tools such as those listed in Table 11 so that they can continue to explore and experiment with crowdsourcing and social media for emergency management.

3.7 Conclusions

The literature shows that there are many barriers and constraints associated with the government adoption of crisis crowdsourcing and social media for crisis communication. The results for this study provide a Canadian perspective to these barriers and constraints, and identify barriers that are unique to Canadian agencies. Participating agencies in Canada are most concerned with the credibility of crowdsourced information, and are seeking out ways to ensure that the information is credible. Participating agencies who have little to no experience with social media tend to have a greater distrust of crowdsourced information than those who are fully engaged with social media for information dissemination and monitoring.

When a government agency is looking into developing a crowdsourcing model for crisis communication, they must assess three general areas of concern that can determine the success of the project. These three areas of concern are organizational factors, demographic factors, and hazard risk factors and are presented in the form of a readiness assessment scheme. Based on the assessment of these factors, the agency can pinpoint the most prevalent barriers to the crowdsourcing project, and formulate plans to address them.

In response to the barriers and constraints that were identified, some solutions were formulated to ease the adoption of crisis crowdsourcing by Canadian agencies. Agencies should adopt the bottom-up model for inspiring change and launching crisis crowdsourcing projects as they are more likely to succeed. However, some agencies may simply not have the adequate resources to fully implement a crisis crowdsourcing model, as such, these agencies should build partnerships with neighbouring government agencies, 311 and 211, and NGO's such as CanVOST and the Red Cross. In this way, government agencies can benefit from resource and task sharing. Finally, a validation toolbox can help ease concerns around the credibility of crowdsourced information.

Chapter 4

Concluding Remarks and Future Research

4.1 Summary of Conclusions

This research characterized the current state of crisis crowdsourcing by participating government agencies in both the USA and Canada and classified the application of crisis crowdsourcing into all phases of the disaster management cycle. Further analysis provided a deeper understanding of the current barriers that participating Canadian agencies face with this new technology and provided recommendations to address these barriers.

The results of Chapter 2 prove that participating agencies in the USA are clearly ahead of the participating agencies in Canada in the crisis crowdsourcing realm, with Canadian participants focusing primarily on social media for crisis communication. Participating federal agencies in the USA are the most active in pursuing crisis crowdsourcing projects, with some participating state- and county-level agencies following their example. With the Canadian participants, however, the primary focus for crisis communication is with social media; it is being used for information dissemination, sentiment analysis, rumour control, reputation management, response, and for enhancing situational awareness. Crisis crowdsourcing has a place in all phases of the disaster management cycle. While a disaster is unfolding, participating agencies make use of crowdsourcing in the response phase to enhance situational awareness and facilitate quick decision making. In the recovery phase, crowdsourced information can inform situational reports which can then be used to apply for disaster relief aid and support from higher-tiered government agencies. In the pre-disaster phases (mitigation/risk reduction and preparedness), crowdsourced information can be used to develop a long term picture of trends, which can then enhance planning and prediction models. It can also be used to verify and update short term alerts. There is an opportunity for active crowdsourcing to be directly used for mitigation/risk reduction and preparedness, yet many agencies have yet to capitalize on this.

In Chapter 3, a focused perspective on Canadian crisis crowdsourcing efforts is provided with regards to the barriers constraints that these agencies face. The most common concern that participating Canadian government agencies have with crisis crowdsourcing is the credibility of the information that is contributed by members of the general public. Thus, a toolbox consisting of the various tools that can be used to validate the credibility is presented. Organizational factors, demographic factors, and hazard risk are all potential barriers to the implementation of a crisis crowdsourcing project. Guidelines to assessing a given agency's crisis crowdsourcing readiness based on these three general areas of concern is introduced. The scheme provides an opportunity for agencies to assess their own readiness to crisis crowdsourcing adoption, and quickly determine which barriers or constraints are hampering their progress. Agencies who are extremely limited in resources may consider building partnerships with neighbouring governmental agencies and NGO's such as CanVOST, to reap the benefits of resource sharing.

Crisis crowdsourcing in the government emergency management realm comes not only with the apparent benefits that continue to be documented in the literature, but also with many barriers and constraints, that range from general crowdsourcing challenges to more specific challenges in the emergency management realm, particularly for governments. The understanding and characterization of these barriers and constraints is the first step in the successful development and launch of a government crisis crowdsourcing application, especially in Canada.

4.2 Recommendations

There is room for more improvement and recommendations towards social media crisis crowdsourcing practices for government emergency management. The combined findings of the two core chapters reveal an opportunity for new approaches to adopting social media for emergency management and crisis crowdsourcing. The first approach is for "beginner" agencies to start with a limited range of approaches. The second approach is for "veteran" agencies to mentor "beginner" agencies. The third approach is for the private sector to become involved.

Start with a Limited Approach

The results from Chapter 2 show that a number of agencies followed a progressive approach to adopting social media for emergency management. Many agencies first used social media as another method of getting information out to the public. As their experience with social media progressed, they found that social media offers another method of connecting and engaging with the citizens and getting information back from them. For the agencies who are yet to commit to social media for emergency management, they can first experiment with it as an “information out” tool. Once agencies are comfortable with using social media to send out their information, they can begin monitoring social media for rumours and to gauge the public response and perception to the agency’s social media posts. Agencies should consider using social media management tools like Hootsuite, Tweetdeck, and Sprout Social, to enhance their social media experience. These tools allow agencies to track the spread of their information their “retweets” and “shares” so that agencies can gauge the size of their audience. These social media management tools also allow agencies to filter public posts on social media based on trends, hashtags, and location. These filtering features allow emergency management agencies to follow an unfolding event on social media, which can augment their situational awareness.

Once an agency has gotten comfortable with social media for emergency management, and is considering going a step further with an active crowdsourcing model or application, the agency can first experiment with existing applications. Agencies that already have a 311 system in place, usually municipally agencies, they can consider developing a specialised application for accepting reports into their 311 database. Other similar applications include “SeeClickFix” and “Ping Street.” If agencies already have one of these apps developed, they may want to consider adding an emergency management component to the application rather than developing a stand-alone crisis crowdsourcing application. An example of an emergency management component could be allowing citizens to report storm/flood/other related damage caused by an event, allowing citizens to submit current conditions during an unfolding event (which would then be forward to the agency’s emergency management department), and offering emergency preparedness tips in the application.

Receive Mentorship from Experienced Agencies

There is an opportunity for agencies new to the social media and crisis crowdsourcing realm to learn from more experienced agencies. The results of Chapter 2 show that agencies in the USA are proactive in pursuing crisis crowdsourcing projects. If it is deemed practical by the agencies involved, there is potential for these more experienced agencies in the USA to mentor inexperienced agencies in the USA and Canada. A mentorship program offers the added benefit of reducing the “silo effect” described in Chapter 3. Cross-border training and learning has already begun between the USA and Canada, as demonstrated by the Canada-U.S. Enhanced Resiliency Experiment (Cotter et al., 2015). In this case, the purpose of the experiment was to identify ways of using social media and other situational awareness tools to improve communication and coordination in the event of a cross border disaster such as a hurricane. This example demonstrates that cross-border training is possible and beneficial to global emergency management efforts. Expanding on such exercises by creating a mentorship program between those agencies that are experienced in crisis crowdsourcing and social media and those that are inexperienced but want to learn more offers a new way of facilitating information and knowledge sharing amongst emergency management agencies in North America and globally.

Private Sector Support

Private sector involvement in crisis crowdsourcing efforts offers two opportunities: 1) for companies to offer consulting and development services to government agencies for designing and developing a specialised application, and 2) for large corporations leading the technology industry to undertake crisis crowdsourcing efforts for humanitarian purposes. The first opportunity may not be feasible for many agencies as consulting services often require a fee. However, the second opportunity may be feasible for large corporations like Google and Facebook, who generate revenue from advertising. Google’s Crisis Response team and toolset (<http://www.google.org/crisisresponse/about/resources.html>) and Facebook’s Safety Check (www.facebook.com/about/safetycheck). Google’s Crisis Response team and toolset (www.google.org/crisisresponse) offers services for sending out alerts to at-risk or impacted communities (i.e. “Google Alert”), for locating missing people (i.e. “Google People Finder”), and for displaying critical information geographically (i.e. “Google Crisis

Map”). Emergency management agencies (both government and non-government) and internet users all benefit from these tools, from users receiving location-based alerts to agencies getting their information out to the public and locating missing people. The Safety Check feature on Facebook is location-based and activates for users who are currently in a region experiencing an unfolding crisis. When a crisis is detected for a specific area, Facebook users receive a notification asking “Are you safe?” Currently, the only options are for users to select “Yes, I’m safe” or “I’m not in the area” (Gleit, Zeng, & Cottle, 2014). The feature does not appear to have an option for users to request help if they are not safe. An opportunity presents itself for Facebook to add another aspect to this feature that allows users to indicate that they are not safe, that they require aid. Based on the needs identified, Facebook can redirect these requests to the appropriate response agencies to connect users with responders.

4.3 Key Research Contributions

This research offers empirical evidence gathered through interviews with emergency management officials from government agencies in Canada and the USA to characterise crisis crowdsourcing methods used by government agencies. Additionally, the empirical evidence proves that crisis crowdsourcing in the disaster management cycle. The vast majority of the existing literature on crisis crowdsourcing and social media for emergency management are focused on American practices, with some recent literature emerging from Australia. As such, the focus on Canadian agencies and their associated crisis crowdsourcing/social media barriers and constraints broadens the existing empirical literature on crisis crowdsourcing/social media practices by offering a new perspective from Canadian government agencies.

Following the characterisation of crisis crowdsourcing in government emergency management and the disaster management cycle, an assessment framework is presented for agencies to determine their own readiness to adopting crisis crowdsourcing. The framework is supported by key findings from the interviews and is intended to draw attention to the many barriers that exist in three key areas for consideration: hazard risk, organizational culture, and population demographics. The intent is for this

framework to provide agencies with a starting point when venturing into the crisis crowdsourcing realm.

4.4 Future Research

While this research provided insight into the factors influencing crisis crowdsourcing adoption by government agencies in North America, particularly in Canada, future research is needed to address additional questions and gaps in this field. These future research directions lie in understanding the citizen drivers of participation and engagement, applying crowdsourcing directly in the mitigation/risk reduction and preparedness phases of the disaster management cycle, and in linking the use of crisis crowdsourcing with hazard risk. These three directions are discussed below.

Crowdsourcing for the Pre-Disaster Phases

Much of the focus on crisis crowdsourcing is in the post-disaster response and recovery phases. This is clearly demonstrated in the results of both the literature review and of the interviews conducted for this study. There is a clear gap in the direct use of crowdsourcing in the pre-disaster phases. While it was proven in this study that crowdsourced information can feed back into the mitigation/risk reduction and preparedness phases, there is no documented use of any crowdsourcing project specifically designed for these two phases, except for one: the USGS iCoast application. When citizens participate in this project, they raise their own awareness and knowledge of the coastal hazards associated with hurricane damage. Further research can identify other opportunities for using crowdsourcing to improve the mitigation/risk reduction and preparedness phases in emergency management.

Crisis Crowdsourcing: A Product of Hazard Risk

The results of this study suggest that the adoption of a crisis crowdsourcing application is linked to the hazard risk faced by a given government agency and its citizens. Certainly the widespread adoption of crisis crowdsourcing in the USA is an indicator of this, as many applications are designed for specific hazards (e.g. earthquakes, hurricanes, and severe weather) at the federal level, while other applications are better suited for general hazards at the county- or municipal-level. The USA typically

experiences a higher risk to these specific hazards than in Canada, thus it makes sense for government agencies in Canada to not commit resources to developing similar applications. However, Canadians still experience their share of hazards, such as flooding, earthquakes, and severe winter and summer weather. It is worth determining whether the risk to these hazards in certain locations is worth committing the resources to a robust crisis crowdsourcing project. The first step in this direction of research may be to adapt the assessment framework introduced in this study to better account for the hazard risk and exposure. This can be completed with individual case studies of local government agencies.

Citizen Drivers of Participation and Engagement

While some government agencies may express an interest in starting a crisis crowdsourcing initiative, they may be unsure as to whether there is a strong enough user base to ensure the initiative's success. As shown in the results of this study, government agencies are hesitant to venture into the crisis crowdsourcing realm because of the amount of resources such a venture would take. In order to commit these resources to any such project, government agencies must be able to justify the project to the citizens (i.e. the taxpayers); they must be able to justify the use of what may be limited resources. If there is uncertainty as to the success of the project due to an insufficient user base, then it is not worth it for the agency to move forward with it. Therefore, it is important that government agencies understand their potential users before they fully commit to any crowdsourcing project.

More research is needed with regards to understanding what drives citizens to participate in crowdsourcing projects, and how to increase their engagement. This type of research is similar to market research. In understanding the target audience, the developer of the product (in this case the government agency developing a crowdsourcing application) can cater to the desires of the users (i.e. the citizens and taxpayers). Further research is needed in formulating ways to increase citizen participation and engagement. In instances where the digital divide is present, research can determine the cause behind this phenomena (i.e. financial limitations, poor internet access in rural communities, choice, digital illiteracy, etc.). When the causes are determined, solutions can be formulated to reduce the digital divide, such as providing

workshops to educate citizens, and ensuring that internet is freely accessible in public spaces like libraries and community centres. For citizens that choose to remain disconnected other non-digital avenues may be explored to ensure the involvement and engagement of these citizens. One example is for local governments to coordinate participatory mapping events where citizens can share their local knowledge by drawing on paper maps or by learning how to operate new software (Lauriault & Mooney, 2014). for citizens to partake in risk reduction and planning efforts. Such projects have proven to be beneficial in enabling citizen participation in risk reduction and planning efforts and in incorporating local knowledge into official practices (Brown, Kelly, & Whittall, 2014; Haklay et al., 2014).

Social media was found to be an important tool for many government agencies in Canada for crisis communication. There is room for future research in understanding the citizen sentiment on government use of the information they post on social media (e.g. is it the citizens' intent for governments to use their information? What are their expectations of government agencies who use this information?). Because many internet users are already connected to social media, this raises the question around whether they are willing to start using yet another application. Further research can determine whether citizens prefer to passively contribute via social media or if there is interest in actively contributing through a specialized application, given that they are fully aware of what the information is used for and how they would benefit from it.

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Appendix A

List of Participants

- Participant A. (2015). Community Emergency Management Coordinator, County Level, Canada. Telephone interview on June 30, 2015.
- Participant B. (2015). Community Emergency Management Coordinator, County Level, Canada. Telephone interview on July 7, 2015
- Participant C. (2015). Director of Operations, Federal Level, USA. Telephone interview on July 17, 2015.
- Participant D. (2015). Oceanographer, Federal Level, USA. Telephone interview on July 29, 2015
- Participant E. (2015). Emergency Services Coordinator, County Level, Canada. Telephone interview on July 29, 2015.
- Participant F. (2015). Community Emergency Management Coordinator, County Level, Canada. In-person interview on July 31, 2015.
- Participant G. (2015). Supervisory Research Geophysicist, Federal Level, USA. Telephone interview on August 3, 2015.
- Participant H. (2015). Team Lead, Provincial Level, Canada. Telephone interview on August 4, 2015.
- Participant I. (2015). Postdoc Fellow, Federal Level, USA. Telephone interview on August 5, 2015.
- Participant J. (2015). Director of Emergency Services, County Level, Canada. Telephone interview on August 11, 2015.
- Participant K. (2015). Community Emergency Management Coordinator, City Level, Canada. Telephone interview on August 12, 2015.
- Participant L. (2015). Warning Preparedness Meteorologist, Federal Level, Canada. Telephone interview on August 14, 2015.
- Participant M. (2015). Strategic Initiatives Coordinator, City Level, USA. Telephone interview on August 14, 2015.
- Participant N1. (2015). Community Emergency Management Coordinator, County Level, Canada. Telephone interview on August 18, 2015.
- Participant N2. (2015). Communications and Marketing Coordinator, County Level, Canada. Telephone interview on August 18, 2015.
- Participant O. (2015). Customer Service Supervisor, City Level, Canada.

Telephone interview on August 27, 2015.

Participant P. (2015). Manager of 911 and Emergency Planning, County Level, Canada. Telephone interview on August 28, 2015.

Participant Q. (2015). Retired Fire Chief, City Level, USA. Telephone interview on September 22, 2015.

Participant R. (2015). Manager of Emergency Planning, City Level, Canada. Telephone interview on October 9, 2015.

Participant S. (2015). Emergency Preparedness Coordinator, City Level, Canada. Telephone Interview on November 4, 2015.

Participant T. (2015). Executive Director of Public Safety Initiatives, Provincial Level, Canada. Telephone interview on November 6, 2015.

Participant U. (2015). Senior Systems Analyst/GIS Unit Lead Manager, County Level, USA. Telephone interview on December 11, 2015.

Appendix B

Interview Script

Background on Participant and Application/Process:

1. Please describe your position at [organization].
2. Please describe the applications or methods used by your organization to collect reports of damage or requests for aid during a crisis/disaster.
 - a. Follow up (if not already brought up): Does your organization also collect reports through phone calls and/or email? If so, please describe process and frequency and quality of these reports.
3. When was the application/method implemented?
4. Please describe your experience with the [emergency/disaster crowdsourcing] application or method currently used by your organization.
5. Please describe what the crowdsourced information is used for (for example, sending out damage assessment crews or repair/response crews, disseminating aid, verifying current conditions with warnings/forecasts, risk mapping, etc.).

Assessment of application/method:

6. How does the quality and quantity of this information compare to that of data collected through traditional methods such as phone calls and emails?
7. Who is responsible for managing the data gathered from the application/process? How is it managed?
8. How does the organization respond to these requests and/or reports?
9. How would you like to measure the success of the application? What does success look like?
10. Please describe how and why the project/application has or has not been successful.
11. What are some recommendations for future government crowdsourcing/VGI projects for emergency management?

Advantages, Disadvantages, Challenges, and Improvements:

12. I have constructed a list of the challenges and disadvantages that I've identified in the literature associated with the adoption of crowdsourcing for emergency management. Could you please comment on the relevance of each of these challenges to your organization's application/method? And if there were specific challenges that I missed, please describe them (See table 1 for list).
13. How did you address/overcome these challenges or barriers?
14. I have also constructed a list of advantages and improvements associated with adopting crowdsourcing for emergency management, please comment on their relevance (See table 2 for list).

Criteria for building a government-managed emergency crowdsourcing application:

15. I have designed a template for the design of a government crowdsourcing application for emergency management (Table 3). Could you please comment on the importance and frequency of use for each criterion, as well as additional comments that may come to mind? If there are certain tools/functions that are missing that you think are important, please describe them.

Table 1: Challenges & Barriers

| Challenges/ Barriers/ Disadvantages | Description/Explanation | Comments | How to address/ overcome |
|--|--|----------|--------------------------------|
| Technological limitations | The government may not have the space to store, manage, and process large volumes of data that can result from a crowdsourcing app. | | |
| Policies | There may be existing policies in place that do not allow governments to interact with its citizens through crowdsourcing applications or other digital technologies. | | |
| Privacy & Security | The government is responsible for protecting the privacy and security of its citizens' information; a crowdsourcing app using VGI could compromise this privacy & security. | | |
| Credibility & Liability | Government organizations are often hesitant with adopting crowdsourcing because of concerns surrounding credibility and liability. The data would most likely be used for quick decision-making, and sometimes for updating alerts and warnings. Thus, it is important that this information is accurate and credible. | | |
| Transparency & Accountability | The government may not have the capacity to respond to a large number of requests; the citizens may become displeased with the government's response services, and thus decrease trust rather than increase it. | | |
| Financial Limitations | The government may not have the financial resources to manage, and process large volumes of data, as well as respond to reports in a timely manner. | | |
| Human Resources Limitations | The government may not have the human resources to manage, and process large volumes of data, as well as respond to reports in a timely manner. | | |
| Organizational Constraints (e.g. resistance to change) | Some government officials may not be open to the idea of adopting new technology; some may feel that their job/position is threatened. | | |
| Digital Divide | Can introduce bias in the dataset and excludes marginalised populations. | | |
| Power outages & other service disruptions | Citizens can't report if the power has been wiped out or if there are disruptions in network services; must find alternatives for these scenarios. | | |
| Dealing with time-sensitive data | This data is very time-specific and event-specific, therefore it can expire after a certain amount of time or after the damage has been cleared up. Need to find a way to deal with this, e.g. response crews update the data while in the field, or citizens update their report status after 24 hours. | | |

Table 2: Improvements & Advantages

| Improvements/Advantages | Description/Explanation | Comments |
|--|--|----------|
| Enriching the dataset with geographic attributes and photos of damage | Citizens submit georeferenced photos of the damage for response crews and other government officials to view live on a map. | |
| Improving, communication and response crew dissemination, and overall response times | Points plotted onto a map would allow response crews to find the best (i.e. shortest) routes to damage locations. | |
| Improve communication between government and citizens | Another avenue for citizens to submit damage reports to; can open up the dialogue between the government and its citizens; government can provide status updates on reports in the app for citizens to monitor. | |
| Transparency & Accountability | The app would make the government more accountable to its citizens by showing the citizens the current status of their reports; the citizens can see whether the government includes their volunteered information in their decision making process. | |

Table 3: Template & Criteria

| Tools/ Functions | Description | Importance Ranking | Frequency of Use | Comments |
|-----------------------------|---|-------------------------------|-----------------------------|-----------------|
| Login credentials | Two-tiered reporting system where the citizens log in to submit reports, the government officials log in to view and edit reports. Citizens can only edit their own reports. | | | |
| Reporting form | To standardize the incoming data for ensuring quality. Reporting form would include damage classification, location, description, comments/concerns, contact information. Contact information is only viewable to government officials. | | | |
| Attachments | Citizens can attach photos of the damage for response crews to plan and prepare accordingly. | | | |
| Web-map & Spatial Analysis | For visualization of spatial patterns of reports. | | | |
| Routing | Accessible only for government officials, to plan the "best" routes to damage locations, which would decrease response time and improve planning for response crews. | | | |
| Pop-up windows | To view the information submitted for each report. | | | |
| Status updates | The government can update the locations with status reports for the citizens to monitor their progress. | | | |
| Priority Classification | Government officials can prioritise the reports based on the information and photos provided in the reporting form. Would need some classification criteria. | | | |

Appendix C

Interview Recruitment Materials

Recruitment Email

Good morning,

My name is Sara Harrison and I'm a graduate student working under the supervision of Dr. Peter Johnson in the Geography and Environmental Management Department at the University of Waterloo. I obtained your name and contact details through your organization's website and am contacting you because I'm conducting a study to investigate the potential of and challenges associated with governments adopting a crowdsourcing application for collecting damage reports and requests for aid during a crisis to improve the organization's emergency management processes.

Participation in this study involves scheduling time for a semi-structured interview in which pre-constructed questions will be asked and your responses will be audio-recorded for further analysis. The questions will relate directly to your organization's existing crisis response services and the methods that are used for collecting damage reports from citizens (for instance, a call centre). Questions will also be asked surrounding any crowdsourcing application and/or method that your organization has already implemented, to establish an understanding of how the application is being used and to measure the success of its implementation. Participation in this study would take approximately 45 minutes of your time. I would like to assure you that the study has been reviewed and received ethics clearance through a University of Waterloo Research Ethics Committee. I have attached an Information Letter in PDF format for you to learn more about this study.

However, the final decision about participation is yours.

If you are interested in participating, please contact me at sara.harrison@uwaterloo.ca with a date and time at your convenience for when you would like to participate. I will then send a confirmation email indicating that you have been scheduled for this time. If you have to cancel your appointment, please email me at the email above.

Sincerely,

Sara Harrison
Master of Environmental Studies (MES) Candidate
Geography and Environmental Management
University of Waterloo
sara.harrison@uwaterloo.ca

Information Letter

University of Waterloo

Date

Dear **(insert participant's name)**:

This letter is an invitation to consider participating in a study I am conducting as part of my Master's degree in the Department of Geography and Environmental Management at the University of Waterloo under the supervision of Dr. Peter Johnson. I would like to provide you with more information about this project and what your involvement would entail if you decide to take part.

In recent years, crowdsourcing and volunteered geographic information (VGI) have become valuable communication tools between citizens, governments, businesses, and scientists. Disaster and emergency management has become one of the most prominent uses of crowdsourcing and VGI, as it provides emergency responders with timely and accurate information on ground conditions during a crisis. However, many of these crowdsourcing and VGI applications are developed either by members of the affected public or by non-governmental organizations. In times of crisis, government organizations are expected to obtain and disseminate the most up to date information, yet many governments have yet to adopt crowdsourcing specifically for improving their own emergency management services. Results from my undergraduate thesis revealed this potential for governments to adopt crowdsourcing for emergency management. The purpose of this study, therefore, is to understand why governments may or may not want to adopt a crowdsourcing application, assess the challenges associated with adopting such technology, and develop a framework for government adoption of crowdsourcing applications to improve emergency management.

This study will focus primarily on government organizations that already have, or will launch soon, emergency management applications with a crowdsourcing component. In addition, governments that have an emergency management application without a crowdsourcing application will also be investigated as they have the potential to include crowdsourcing in the future. Finally, governments that have not launched any application, but actively engage with social media to collect information from users on current ground conditions will also be included in the study. It is likely that there is a tradeoff in reporting quality through such applications when compared to traditional reporting methods such as phone calls or emails. Through my interviews, I will determine how the quality of reports influences the way the reports are handled. Interviews with representatives from various government organizations will also allow for comprehensive case study comparison between different governments. Therefore, I would like to include your organization as one of several organizations to be involved in my study. I believe that because you are actively involved in the management and operation of your organization, you are best suited to speak to the various issues, such as current crisis response services and methods of damage reporting, and adopting a crowdsourcing application.

Participation in this study is voluntary. It will involve an interview of approximately 45 minutes in length to take place in a mutually agreed upon location, or over the phone. You may decline to answer any of the interview questions if you so wish. Further, you may decide to withdraw from this study at any time without any negative consequences by advising the researcher. With your permission, the interview will be audio recorded to facilitate collection of information, and later transcribed for analysis. Shortly after the interview has been completed, I will send you a copy of the transcript to give you an opportunity to confirm the accuracy of our conversation and to add or clarify any points that you wish. All information you provide is considered completely confidential. Your name will not appear in any thesis or report resulting from this study, however, with your permission anonymous quotations may be used. Data collected during this study will be stored on a password protected computer, in a safe room. Only researchers associated with this project will have access. While researchers will maintain your confidentiality, because of the few numbers of individuals expert in this topic, it may be possible for a motivated individual to identify you

If you have any questions regarding this study, or would like additional information to assist you in reaching a decision about participation, please contact me at 705-794-8196 or by email at sara.harrison@uwaterloo.ca. You can also contact my supervisor, Dr. Peter Johnson at 519-888-4567 ext. 33078 or email peter.johnson@uwaterloo.ca.

I would like to assure you that this study has been reviewed and received ethics clearance through a University of Waterloo Research Ethics Committee. However, the final decision about participation is yours. If you have any comments or concerns resulting from your participation in this study, please contact Dr. Maureen Nummelin in the Office of Research Ethics at 1-519-888-4567, Ext. 36005 or maureen.nummelin@uwaterloo.ca.

I hope that the results of my study will be of benefit to those organizations directly involved in the study, as well as to the broader research community. I very much look forward to speaking with you and thank you in advance for your assistance in this project.

Yours Sincerely,

Sara Harrison
Master of Environmental Studies Candidate
Department of Geography and Environmental Management
University of Waterloo

Consent Form

By signing this consent form, you are not waiving your legal rights or releasing the investigator(s) or involved institution(s) from their legal and professional responsibilities.

I have read the information presented in the information letter about a study being conducted by Sara Harrison of the Department of Geography and Environmental Management at the University of Waterloo. I have had the opportunity to ask any questions related to this study, to receive satisfactory answers to my questions, and any additional details I wanted.

I am aware that I have the option of allowing my interview to be audio recorded to ensure an accurate recording of my responses.

I am also aware that excerpts from the interview may be included in the thesis and/or publications to come from this research, with the understanding that the quotations will be anonymous.

I was informed that I may withdraw my consent at any time without penalty by advising the researcher.

This project has been reviewed by, and received ethics clearance through a University of Waterloo Research Ethics Committee. I was informed that if I have any comments or concerns resulting from my participation in this study, I may contact the Director, Office of Research Ethics at 519-888-4567 ext. 36005.

With full knowledge of all foregoing, I agree, of my own free will, to participate in this study.

YES NO

I agree to have my interview audio recorded.

YES NO

I agree to the use of anonymous quotations in any thesis or publication that comes of this research.

YES NO

Participant Name: _____ (Please print)

Participant Signature: _____

Witness Name: _____ (Please print)

Witness Signature: _____

Date: _____

Feedback Letter

University of Waterloo

Date

Dear **(Insert Name of Participant)**,

I would like to thank you for your participation in this study entitled Developing a Framework for and Assessment of Government Adoption of Crowdsourcing and Volunteered Geographic Information to Improve Emergency Management Services. As a reminder, the purpose of this study is to understand why governments may or may not want to adopt a crisis response crowdsourcing application, assess the challenges associated with adopting such technology, and develop a framework for government adoption of crisis response crowdsourcing applications.

The data collected during interviews will contribute to a better understanding of the necessary requirements and challenges associated with government adoption of crowdsourcing applications for crisis response.

Please remember that any data pertaining to you as an individual participant will be kept confidential. Once all the data are collected and analyzed for this project, I plan on sharing this information with the research community through seminars, conferences, presentations, and journal articles. If you are interested in receiving more information regarding the results of this study, or would like a summary of the results, please provide your email address, and when the study is completed, anticipated by August 2016, I will send you the information. In the meantime, if you have any questions about the study, please do not hesitate to contact me by email or telephone as noted below. As with all University of Waterloo projects involving human participants, this project was reviewed by, and received ethics clearance through a University of Waterloo Research Ethics Committee. Should you have any comments or concerns resulting from your participation in this study, please contact Dr. Maureen Nummelin, the Director, Office of Research Ethics, at 1-519-888-4567, Ext. 36005 or maureen.nummelin@uwaterloo.ca.

Sara Harrison

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