Toward a Better Understanding of Complex Emergency Response Systems: An Event-Driven Lens for Integrating Formal and Volunteer-Based, Participatory Emergency Responses

by

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ABSTRACT

Traditionally, emergency response is in large part the role and responsibility of formal organizations. Advances in information technology enable amateurs or concerned publics to play a meaningful role in emergency response. Indeed, in recent catastrophic disasters or crises such as the 2010 Haiti earthquake and the 2011 Japan earthquake and nuclear crisis, participatory online groups of the general public from both across the globe and the affected areas made significant contributions to the effective response through crowdsourcing vital information and assisting with the allocation of needed resources. Thus, a more integrative lens is needed to understand the responses of various actors to catastrophic crises or disasters by taking into account not only formal organizations with legal responsibilities, but also volunteer-based, participatory groups who actively participate in emergency response. In this dissertation, I first developed an "event-driven" lens for integrating both formal and volunteer-based, participatory emergency responses on the basis of a comprehensive literature review (chapter 1). Then I conducted a deeper analysis of one aspect of the event-driven lens: relationships between participatory online groups and formal organizations in crisis or disaster situations. Specifically, I explored organizational and technical determinants and outcomes of forming such relationships (chapter 2). As a consequence, I found out three determinants (resource dependence, shared understanding, and information technology) and two outcomes (inter-organizational alignment and the effectiveness of coordinated emergency response) of the relationship between participatory online groups and formal organizations and suggested seven hypotheses. Furthermore, I empirically tested these hypotheses, focusing on the 2015 Nepal earthquake case (chapter 3). As a result, I found

empirical evidence that supports that shared understanding and information technology improve the development of the relationship between participatory online groups and formal organizations. Moreover, research findings support that the development of the relationship enhances inter-organizational coordination. Lastly, I provide implications for future research (chapter 4). This dissertation is expected to contribute to bridging the disconnect between the emergency management literature and the crisis informatics literature. The theoretical insight from inter-organizational relations (IOR) theory provides another contribution.

DEDICATION

This dissertation is dedicated to my God, my parents, and my wife and son.

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TABLE OF CONTENTS

Page

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

AN EVENT-DRIVEN LENS FOR ORGANIZING EMERGENCY RESPONSE IN THE NETWORKED AGE

Technology accelerates the creation of just-in-time governance efforts while also lowering the barriers for joining such efforts to an increasingly diverse set of actors who can make a meaningful contribution. For example, large-scale crises such as natural disasters (earthquake and hurricane) and manmade crises (terrorism and ethnic violence) are extreme events that necessitate responses at multiple scales by an increasingly diverse set of actors. Traditionally, emergency preparedness and response are in large part the role and responsibility of formal organizations such as public emergency management agencies and police and fire departments under related laws and regulations. For instance, in the United States, the Federal Emergency Management Agency (FEMA) is responsible for developing emergency management plans, such as the National Response Framework, and for coordinating response to natural disasters at the federal level under the Robert T. Stafford Disaster Relief and Emergency Assistance Act. State and local governments also have their own similar departments or agencies. In reality, it is increasingly rare for a single department or agency to address catastrophic disasters and crises due to a lack of capacities and resources to be prepared for every possible type of catastrophe. Thus, when a catastrophe occurs, multiple public agencies across local, state, and federal governments are mobilized and deployed to respond to the disaster. Also, formal nonprofit organizations such as the American Red Cross and the Salvation Army and for-

profit corporations collaborate with public agencies to offer rescue and relief services to the affected people.

Importantly, because of concurrent advances in a variety of technologies (information, communication, and artificial intelligence), communities now regularly emerge where amateurs or concerned publics can play a meaningful role in the response through crowdsourcing vital information, assisting with the allocation of needed resources, or other efforts that had once been led by formal organizations. In recent catastrophic disasters or crises such as the 2010 Haiti earthquake, the 2011 Japan earthquake, tsunami, and nuclear crisis, and the 2015 Nepal earthquake, participatory online groups of the general public from both across the globe and the affected areas made significant contributions to the effective response. As a novel phenomenon in the digital era, these volunteer-based, participatory groups provide a vital component of emergency responses. They fill information gaps on crisis or disaster conditions and the affected people's needs, voluntarily mobilize, allocate, and deliver relief resources, and help coordinate formal organizations' tasks and activities in complex, urgent disaster situations. These participatory online groups are a kind of virtual community consisting of digital volunteers loosely connected across the world through information and communication technologies (hardware devices and software applications).

Specifically, these online groups create a reporting system through which the affected people can submit their requests for rescue or aid and the information of crisis or disaster conditions by using various technologies. These online groups also gather, verify, and visualize a large amount of crisis- or disaster-related data from social media, mainstream media, satellite imagery donated by for-profit companies, and reports from

the ground by using open source web platforms, crowdsourced human computation, and artificial intelligence. This information processed by these online groups increase situational awareness of the current state of crises or disasters, the affected peoples' needs and requests, and which organizations were working on what and where to meet the unmet needs of the affected people. By providing real-time, verified, and reliable crisis or disaster information, these online groups enable the affected communities (local residents affected by crises or disasters and local community-based nonprofit organizations) to quickly mobilize aid resources and help the affected communities, public emergency management agencies and first responders to make timely and effective decisions about rescue missions and relief services. While once considered unique or of little consequence, these online groups' efforts are now an anticipated and legitimate part of the overall response to catastrophes (Meier, 2015).

In the digital age, with the emergence of participatory online groups enabled through information and communication technologies and advanced computing, emergency response systems became more complex and dynamic. Thus, a more integrative lens is needed to understand the responses of various actors to catastrophic crises or disasters by taking into account not only formal responders with legal responsibilities, but also volunteer-based, participatory groups who actively participate in emergency response. In this chapter, I first describe existing formal emergency response based on formal organizations and their emergency response plans, procedures, and policies. Then I illustrate volunteer-based, participatory emergency response, focusing on the roles, characteristics and contributions of participatory online groups in recent catastrophic crises or disasters. Finally, I suggest an "event-driven" lens for integrating

formal and volunteer-based, participatory responses. For this purpose, I conducted a comprehensive literature review on emergency management, disaster policies, crowdsourcing, digital humanitarianism, volunteered geographic information, and disaster sociology.

The event-driven lens consists of three components: formal emergency response; volunteer-based, participatory emergency response; and relationships and interactions between institutionalized formal organizations and participatory online groups in response to crisis. Also, the event-driven lens is a five-phase model including preparedness, response I (mobilization and emergence), response II (production and delivery), response III (outputs and outcomes), and early recovery. Therefore, I explain how formal and participatory actors prepare for and respond to a crisis or a disaster in each of these five phases. I also suggest five propositions.

Formal and Volunteer-Based, Participatory Emergency Responses

Formal Emergency Response

Formal emergency response is a process in which institutionalized organizations at all levels of government and across the public, nonprofit, and for-profit sectors conduct a wide range of activities and tasks to respond to a crisis or a disaster (Haddow, Bullock, & Coppola, 2008). Typical examples of such activities and tasks include search-and-rescue missions, emergency medical services, and relief services (foods, water, and temporary shelters). Basically, formal emergency response relies on the roles and responsibilities of (networks of) formal organizations, and coordination among these organizations including public emergency management departments or agencies, fire and

police departments, institutionalized nonprofit organizations such as the American Red Cross and the Salvation Army, and for-profit corporations such as private utility companies, the Home Depot and Walmart. These organizations are characterized by formal rules and hierarchical structures. This section describes a traditional view on formal emergency response, focusing on the Incident Command System (ICS). Then a current view on formal emergency response is illustrated (i.e. a mixture of the command and control system and networked governance).

Traditional view: The command-and-control system. The traditional formal emergency response is one type of the bureaucratic, command-and-control system. The key properties of the traditional emergency response are clearly determined objectives, policies, and procedures guiding organizational activities; formal, hierarchical organizational structures for decision making; and division of labor (Schneider, 1992). A strategic tool or mechanism for formal emergency response called the Incident Command System (ICS) was developed by local forest firefighting agencies in California in the 1970s. Since the inception of an initial version of the ICS called FIRESCOPE (FIrefighting RESources of California Organized for Potential Emergencies), the ICS has spread across the United States (Buck et al., 2006; Cole, 2000; Harrald, 2006). In the 1980s, FIRESCOPE became a standard protocol for fighting wildfires in the U.S. Forest Service, evolving into the National Interagency Incident Management System (NIIMS) (Harrald, 2006). Then, the U.S. National Park Service, the U.S. Coast Guard, and the U.S. Federal Emergency Management Agency adopted the ICS for their various tasks and deployments for emergency response.

Basically, the ICS is a "military-like" model for organizing and coordinating emergency management personnel and first responders in crisis or disaster situations. Also, the ICS is inherently a closed system that assumes environmental chaos rather than external feedback and resources from the environment for continuity and recovery of a system (Harrald, 2006). The ICS is based on the classical scientific management approach with rational bureaucratic principles. Hence, the ICS is characterized by linear, top-down, centralized, rule-based organizational structures and decision making processes (Drabek, 1985; Kettl, 2003; Schneider, 1992). According to Buck and colleagues, the ICS includes some of the following elements:

> standardized job descriptions with a training program for those positions; common terms for equipment and supplies; a structured chain of command from the specialist on the ground to the incident commander with unity of command emphasized and each person in the organization reporting to one boss; authority commensurate with responsibility, and task assignments made rationally to the person most qualified for the assignment regardless of rank in the organization; span of control limited to the number of people that one person can effectively control; [and] sectoring of work to insure efficiency, effectiveness and safety (2006, p. 1).

Current view: Mixture of the command-and-control system and networked governance. If a crisis or a disaster (particularly, a catastrophic incident) occurs, multiple organizations across all levels of government and the public, for-profit and nonprofit sectors need to collaborate with one another to respond to a crisis or a disaster. Thus, the formal emergency response system becomes a large network of multiple organizations

(Kapucu, Arslan, & Demiroz, 2010; Kapucu, 2006b; Waugh, 2000). Also, an urgent, complex disaster requires multiple organizations involved to respond to the disaster in a rapid and coordinated manner (Comfort, 2007). Donald Moynihan calls this situation "a crisis management paradox: Crises not only require an inter-organizational response but also require traits unusual in networks: rapid and decisive coordinated action" (2008, p. 206). To resolve this paradox, the ICS serves as a centralized coordination mechanism among multiple organizations involved, operating as an inter-organizational hierarchy.

Over the past four decades, the Incident Command System (ICS) has evolved into integrative nationwide response policy tools and coordination structures including the National Incident Management System (NIMS) and the National Response Framework (NRF). The NIMS provides a standard template of incident management for all types of crises and disasters. Importantly, the two key elements of the NIMS are ICS for on-scene operational response and inter-organizational coordination for off-scene supports. For the on-scene ICS, a variety of public agencies (fire, law enforcement, and emergency medical services) across all levels of government, nonprofit organizations, and for-profit corporations are mobilized to constitute a network of responding organizations, mostly following predetermined agreements and procedures. These organizations and their personnel are assigned into command staff positions (public information, safety, and liaison) and general response sections in the field (operations, planning, logistics, and finance/administration). All of these organizations and personnel are controlled and coordinated by an Incident Commander. "The ICS organizational structure is modular, extending to incorporate all elements necessary for the type, size,

scope, and complexity of an incident….When the need arises,…these Sections may have several subordinate units" (DHS, 2008, p. 91).

As another element of the NIMS, off-scene inter-organizational coordination called Multi-Agency Coordination Systems (MACS) "is to coordinate [a variety of supporting] activities above the field level and to prioritize the incident demands for critical or competing resources, thereby assisting the coordination of the operations in the field" (DHS, 2008, p. 64). Unlike the on-scene ICS based on unified command and control, the off-scene MACS is a collaborative decision making process for providing timely supports and assistance to first responders on the ground, mostly following predefined standard operating procedures and protocols.

Another important emergency response policy tool and structure is the National Response Framework (NRF) that was initially created in 2008 and updated in 2013. The NRF is built on key concepts and principles identified in the National Incident Management System (NIMS). Specifically, the NRF aims to align key roles, authorities, and responsibilities of formal organizations from the public, nonprofit, and for-profit sectors regarding how to mobilize and deliver specific resources and capabilities required to respond to a crisis or a disaster across all levels of government and the sectors (DHS, 2013). Since the NRF is built on the NIMS, the NRF also relies on two coordination mechanisms among multiple organizations: The Incident Command System (ICS) and inter-organizational cooperation. On one hand, the NRF defines the organizational structures of local, state, and federal response operations based on the ICS. On the other hand, the NRF describes detailed procedures and coordination structures for building and

maintaining a wide range of partnerships and collaboration across federal departments and agencies, the three levels of government, and the sectors.

An important response coordination mechanism for inter-organizational cooperation under the NRF is the Emergency Support Functions (ESF). Unlike the ICS, each organization "perform[s] the required function using their own procedures and resources" under the ESF agreements (Buck et al., 2006, p. 16). The federal ESFs are groups of formal organizations across the sectors at the federal level for bundling and delivering response resources and capabilities. The federal ESFs consist of 14 key functional areas, including mass care and emergency assistance, search and rescue, firefighting, public health and emergency medical services, public safety and security, and energy infrastructure. One or two federal departments and agencies are in charge of each functional area as ESF coordinators. In addition to ESF coordinators, a lot of organizations are involved in each functional area, serving as primary or supporting agencies.

In addition to the ESFs, there are many other types of collaborative arrangements for formal response between neighboring jurisdictions (city, county, or state), across the levels of government, and across the sectors. A typical example of these collaborative arrangements is the Emergency Management Assistance Compact (EMAC). The EMAC is a state to state mutual aid agreement for mobilizing and delivering personnel and equipment to the affected areas (Kapucu & Garayev, 2011; Waugh, 2007).

In this section, I illustrated a traditional view on formal emergency response based on the Incident Command System (ICS) and a current view that emphasizes both the ICS and collaborative governance across the levels of government and the sectors. I

note that both traditional and current views on formal emergency response stress the importance of institutionalized formal organizations (public agencies, nonprofit organizations, and for-profit corporations) as key responding actors in crisis or disaster situations. Moreover, both views rely on established laws, regulations, and procedures.

Volunteer-Based, Participatory Emergency Response

For the past four decades, disaster sociologists have researched volunteer-based, emergent groups of individuals and their behavior in response to crisis. Most prior studies have focused on emergent collective behavior at the local community level before, during and after a crisis or a disaster (Drabek & McEntire, 2003; Drabek, 1985; Helsloot & Ruitenberg, 2004; Kreps & Bosworth, 1993; Rodriguez, 2006; Stallings & Quarantelli, 1985). Thus, the disaster sociology literature has provided useful knowledge on collective behavior and organizational structures of volunteer-based, emergent groups of individuals. But, most prior studies in disaster sociology have investigated relatively small groups of the affected people who helped each other in extreme events. Few studies have paid attention to large-scale collaboration enabled by information and communication technologies and artificial intelligence in response to crisis.

In the fields of disaster informatics, digital humanitarianism, emergency communications, and computer science, many scholars and practitioners recently began to note the contributions and potentials of participatory online groups in crisis or disaster situations (e.g., Crowley, 2013; Palen et al., 2010; White, Palen, & Anderson, 2014; Zook, Graham, Shelton, & Gorman, 2010). Participatory online groups of individuals are volunteer-based, virtual communities that perform collective responses by using information, communication, and computational technologies. Participatory online

groups of publics are characterized as loosely connected, decentralized, and emergent communities from both across the globe and crisis- or disaster-affected areas.

Responding activities and contributions of participatory online groups. In recent crisis or disaster situations, participatory online groups often times made significant contributions to addressing crisis or disaster situations through setting up a reporting system from the ground, performing crisis-mapping, disseminating crisis information to the affected people, creating online base maps, translating, and coordinating the mobilization and delivery of relief resources.

Setting up a reporting system from the ground. Participatory online groups often times set up a reporting system through which local people affected by crises or disasters can submit their needs and requests for assistance and their testimonies on the current state of crises or disasters (e.g., Ushahidi-Haiti platform in the aftermath of the 2010 Haiti earthquake). This reporting system allows for the affected people to send their requests and testimonies through a variety of information and communication technologies available to them in urgent crisis or disaster situations, including short message service (SMS), email, social media (Facebook, Twitter, YouTube, Flickr, and Instagram), online report forms on the website, and the emergency call center. This reporting system aggregates and stores all the reports from different sources. As a result, the affected people likely play an active role in crisis or disaster situations, rather than passive victims or recipients of relief aid (Nelson, Sigal, & Zambrano, 2010).

Crisis-mapping. In most cases participatory online groups perform crisis mapping consisting of data collection, verification, geo-location and visualization (e.g., Sinsai.info in the aftermath of the 2011 Japan earthquake and nuclear crisis) (Caquard, 2013;

Shanley, Burns, Bastian, & Robson, 2013). Participatory online groups gather and process a wide range of crisis or disaster data. The data includes current crisis or disaster conditions (e.g., the status of floods, earthquakes, or volcanic eruptions), the affected people' needs and requests for aid and rescue, relief resources available to those affected by crises or disasters (e.g., foods, water, and field medical clinics), the locations of the formal or informal refugee camps of people internally displaced, and who-is-doing-what-where called 3W in humanitarian disaster response (i.e. which organizations are doing what, where to meet unmet needs of the affected communities?). Such information comes from a variety of sources: a reporting system from the ground, social media (Facebook, Twitter, YouTube, etc.), community-based communication networks (e.g., local community radios), mainstream media, and official situation reports. Also, participatory online groups verify the collected information by calling, texting, or emailing the affected people. To maximize the usefulness of the collected data, participatory online groups seek to find geographic coordinates (latitude and longitude) of the collected data. Finally, participatory online groups visualize and publish the data on digital base maps, such as Bing, Google Maps and OpenStreetMap[1]. Hence, the affected communities, first responders, emergency management agencies, and international or local humanitarian organizations likely recognize clearly what is going on in the field in real-time.

Disseminating disaster information to the affected communities. In some cases, participatory online groups do not only gather a wide range of crisis information from the ground, but also return the information directly to the affected communities (e.g.,

[1] OpenStreetMap means both a global community of open-source mapping and its digital map products (www.openstreetmap.org)

QuakeMap in the aftermath of the 2015 Nepal earthquake) (Liu & Palen, 2010; Meier, 2009). The affected people can subscribe to particular types of warnings and information useful "to seek shelter [or other relief resources], evacuate the area, or take other protective measures" (B. R. Lindsay, 2011, p. 3). Such warnings and information are disseminated to subscribers via automated email or short message service (SMS).

Creating and updating digital base maps. The accurate, detailed base maps of the affected areas are crucial for public agencies and first responders to effectively address crises or disasters. In recent crises or disasters such as the 2010 Haiti earthquake and the 2015 Nepal earthquake, participatory online groups created the most accurate online base maps of the affected areas within a few weeks. Thousands of online volunteer mappers use collaborative mapping tools to collectively create the post-disaster maps based on satellite imagery donated by for-profit imagery providers or international organizations (Crowley & Chan, 2011; Meier, 2011; Nelson et al., 2010; Roche, Propeck-Zimmermann, & Mericskay, 2011). Moreover, in most cases such voluntary mapping projects are carried out under an open source software license (e.g., the Creative Commons), thus the published base maps can be immediately and freely used for first responders' search-and-rescue missions and other humanitarian aid purposes.

Translating. When the affected people and international first responders use different languages, such language barrier is likely to seriously delay first responders' rescue and relief efforts. Participatory online groups sometimes mobilize volunteer translators around the world and help international first responders and the affected people effectively communicate with each other (e.g., Mission 4636 in the aftermath of

the 2010 Haiti earthquake) (Hester et al., 2010; Meier & Munro, 2010; Munro, 2010; Sutherlin, 2013).

Coordinating the mobilization and delivery of relief resources. In many cases participatory online groups make a significant contribution to the effective mobilization and delivery of relief resources, particularly before public emergency management agencies and humanitarian nonprofit organizations reach out to the affected communities or when these agencies and organizations lack their capacities to effectively address crises or disasters (e.g., community-based participatory online groups such as 311help in the aftermath of the 2011 Japan earthquake and nuclear crisis). Participatory online groups often use social networking sites (e.g., Facebook Groups) or open source online platforms to self-organize the mobilization and delivery of relief resources. For example, filling out an online form on social networking sites or online platforms, the affected people can submit their requests for relief, specifying the types of needs (foods, water, medical services, first aid kits, transportation, temporary shelters, and volunteers), their locations, and contact information. Local people or aid organizations also post the information of relief resources and services they can donate. All the information (both requests for help and donation lists) is published online. Thus, those in need and those who donate aid resources can easily reach out to each other to receive or offer aid resources.

The Importance of Considering Both Formal and Volunteer-Based Participatory Responses

Formal emergency response is relatively effective in dealing with small-scale or routine emergencies, but often severely delayed and ineffective in addressing large-scale,

catastrophic crises or disasters. According to Leonard and Howitt (2005), formal organizations and their collaborative networks "functions best when it is directed at a well-defined, reasonable consistent or clear prioritized set of purposes" (citied in Buck et al., 2006, p. 5). However, the formal emergency response systems likely operate poorly in large-scale crises or disasters "which often involve…multiple hazards occurring in close temporal and spatial succession with multiple agent-generated demands…[and] with…multiple responding agencies,…attempting to satisfy often conflicting goals that cannot be anticipated and reconciled" (Buck et al., 2006, p. 5). The formal response systems characterized by hierarchical decision making, standard operating procedures, and internal communication channels likely have difficulty responding to or fail to deal with catastrophic crisis or disaster situations (Crowley & Chan, 2011; Yuan, Guan, Huh, & Lee, 2013). Such difficulty or failure of formal organizations is caused primarily by the lack or absence of information on the current state of crises or disasters (e.g., fatalities, injuries, damages, and the needs of those affected) and on real-time response efforts (i.e. which organization is working on what, where). The formal emergency management systems often do not have open communication channels that aggregate or prioritize local intelligence from outside sources and share the intelligence with the affected people (Yuan et al., 2013). Hence, there are often disconnected communications not only within a network of formal organizations, but also between formal organizations and the affected people on the ground. Such communication problems likely result in inefficient coordination (e.g., the duplication of response efforts) among public agencies, first responders in the field, local or international nonprofit organizations, and the affected people on the ground (Kapucu, 2006a).

Indeed, these problems were apparent in recent catastrophic disasters. For example, during Hurricane Katrina that struck the Gulf Coast of the U.S. in 2005, a lack of information on the ground seriously delayed the response of emergency management agencies and nonprofit or for-profit organizations involved. "[D]uring Katrina, federal, state, and local government agencies and private organizations did not know what actions to take in the response, did not have any guidance on how to coordinate and interrelate their activities,…and had no system to track and share information" (Jaeger et al., 2007, p. 593). Also, when a 7.0 magnitude earthquake struck Haiti in 2010, formal emergency management agencies including the United Nations Office for the Coordination of Humanitarian Affairs (UNOCHA) collected disaster information through their institutionalized internal channels, while not taking into account outside information sources (e.g., affected Haitian people or local community leaders). As a result, those agencies faced information gaps that delayed emergency response (search-and-rescue missions and the delivery of relief resources), thus costing lives and creating security issues in the field (Heinzelman & Waters, 2010).

With advances in information, communication, and computational technologies, the role of participatory online groups has become more important for the effective response to crises or disasters. These online groups successfully supplement crisis or disaster information gaps, improve formal organizations' capacities to coordinate a lot of on-scene and off-scene activities, and help meet the affected people's needs in an efficient and timely manner. It is important to note that despite their contributions and potentials, volunteer-based, participatory groups do not replace formal organizations, but complement formal organizations. It is because their responding tasks and activities focus

primarily on the production of crisis- or disaster-related information, and these tasks and activities are likely active during a relatively short period in the immediate aftermath of a crisis or a disaster (e.g., one or two weeks). Thus, it seems that participatory online groups are unable to provide a wide range of responding tasks and activities that formal organizations perform—including search-and-rescue operations, emergency medical services, and law enforcement—during an entire response phase (e.g., one or two months). If participatory online groups perform responding tasks and activities by themselves, such responding tasks and activities may be insufficient and ineffective. Hence, one needs "modern" emergency response systems integrating both formal and volunteer-based, participatory responses. That is, if the strengths of both formal and volunteer-based, participatory emergency responses are incorporated, the capacity to deal with disasters or crises may be tremendously increased.

An Event-Driven Lens for Integrating Formal and Volunteered-Based, Participatory Emergency Responses

Recent catastrophic events led to the emergence of participatory online groups of publics. One can witness that the actual emergency response systems in the networked age are much more complex and dynamic than the existing emergency management literature and disaster policies have understood, because a wide range of formal and voluntary actors work together or independently in response to crisis. Thus, it is necessary to build a novel and extended lens for integrating both formal and volunteer-based, participatory responses. The novel lens, motivated by the current research, is called an event-driven lens, because crises or disasters serve as a focusing event that

suddenly bring about not only the activation of formal organizations and their latent networks across the levels of government and the sectors, but also the emergence of many participatory online groups from both across the globe and the affected communities to collectively respond to disasters or crises.

This event-driven lens consists of three dimensions (See Figure 1.1): (1) formal emergency response (i.e. how do formal organizations respond to catastrophic crises or disasters, following predetermined policies, procedures, and related laws? And what are the challenges and limitations of formal emergency response to large-scale crises or disasters?); (2) volunteer-based, participatory emergency response (i.e. how do participatory online groups collectively respond to disasters?); and (3) relationships between formal organizations and participatory online groups (i.e. what are the types of relationships between formal organizations and participatory online groups? And how and why do formal organizations and participatory online groups cooperate with each other or independently perform their response activities?).

Also, this event-driven lens is a phase model consisting of preparedness, response I (mobilization and emergence), response II (production and delivery), response III (outputs and outcomes), and early recovery. In the emergency management literature, preparedness means "planning how to respond in an emergency or a disaster, and developing capabilities for a more effective response" mostly prior to the occurrence of an emergency or a disaster (Waugh, 2000, p. 49). Response is "the immediate actions to save lives, protect property and the environment, and meet basic human needs" soon after crises or disasters occur (Bruce R. Lindsay, 2012, p. 3). In this event-driven lens, the response phase is divided into three sub-phases to help conceptually understand complex,

dynamic emergency response systems in the digital era: (1) mobilization and emergence (how are formal organizations and participatory online groups mobilized to respond to a crisis or a disaster according to laws and policies or spontaneously?); (2) production and delivery (how do formal organizations and participatory online groups create and deliver a variety of response services to the affected people?; and (3) outputs and outcomes (what are the outputs and outcomes of the response services created and delivered by formal organizations and participatory online groups?). Lastly, early recovery is actions intended "to restore essential services and repair damages caused by" a crisis or a disaster in the immediate aftermath of the response phase (Bruce R. Lindsay, 2012, p. 3).

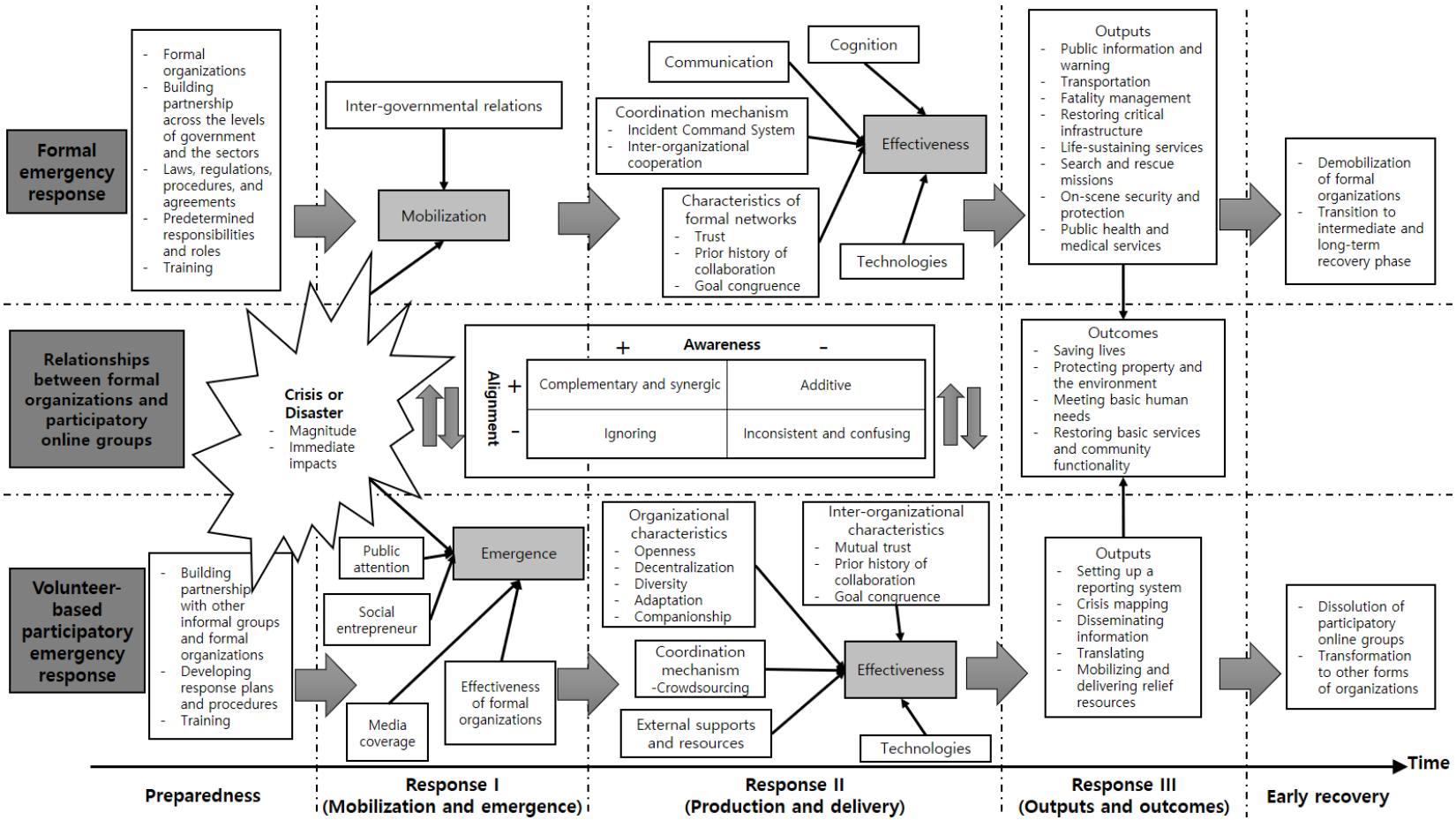

Figure 1.1. An event-driven lens for integrating formal and volunteer-based, participatory emergency response

Formal Emergency Response

Formal emergency response is an official system consisting of institutionalized organizations from the public, nonprofit, and for-profit sectors, their resources and personnel, established policies, procedures, plans, and agreements, and inter-organizational relationships and coordination mechanisms among these organizations.

Preparedness. A key feature of formal emergency response is dependence on (networks of) formal organizations across jurisdictions and the sectors (Schroeder et al., 2001). These formal organizations include public emergency management departments and agencies and other public organizations at the local, state, or federal level (the U.S. Federal Emergency Management Agency, the U.S. Forest Service, the U.S. Coast Guard, and the U.S. Army Corps of Engineering), first responders (police and fire departments and emergency medical services), institutionalized nonprofit organizations (the American Red Cross, the Salvation Army, World Vision, and National Voluntary Organizations Active in Disaster), and private corporations (private utility companies and the Home Depot).

Formal organizations create emergency response plans and frameworks under related laws, regulations and policies. These laws and policies determine the key principles and concepts of emergency management, the specific roles and responsibilities of each formal organization, and detailed procedures on how resources and personnel are mobilized, deployed and reimbursed (DHS, 2008, 2013; Kapucu & Garayev, 2011; Bruce R. Lindsay, 2012; Waugh, 2007). Formal organizations also build partnerships and collaboration for mutual aid agreement across jurisdictions and the sectors (e.g.,

Emergency Management Assistance Compact (EMAC)). The literature calls this phase preparedness (Haddow et al., 2008; Kapucu & Ozerdem, 2013; Waugh, 2000).

Response I (Mobilization and activation). Emergency response plans made in the preparedness phase are activated in the immediate aftermath of a crisis or a disaster. A variety of resources (personnel, funds, and equipment) are mobilized across the levels of government and the sectors according to the predetermined plans (DHS, 2013; Kapucu, 2009). Hence, the formal emergency response system becomes a large network(s) of formal organizations across jurisdictions and the sectors. The extent and process of the mobilization of formal organizations and their various resources are influenced by not only the predetermined response plans and policies, but also the magnitude and immediate impacts of actual or potential crises or disasters, such as casualties, injuries, internally displaced people, and collapsed buildings and roads (DHS, 2013; Harrald, 2006; Quarantelli, 2005). Responses to small-scale incidents are mostly handled at the local level. "As incidents change in size, scope, and complexity, response efforts must adapt to meet evolving requirements. The number, type, and sources of resources must be able to expand rapidly to meet the changing needs associated with a given incident and its cascading effects" (DHS, 2013, p. 6). Quarantelli (2005) emphasizes that one needs to differentiate catastrophes from disasters. In catastrophes such as Hurricane Katrina "[m]ost or all of the community built structure is heavily impacted....Local officials are unable to undertake their usual work role" (p. 3). Also, support from neighboring local jurisdictions may not be provided, because nearby localities are also impacted. Hence, responses to catastrophes require a wider range of

resources and support from state and federal governments and across the public, private, and nonprofit sectors.

Additionally, the mobilization and activation of formal response is shaped by the political dynamics of intergovernmental relations (i.e. relationships among local, state and federal governments). Basically, decisions about the mobilization of relief resources across the levels of government are made through "intergovernmental cooperation among the various parts of the complicated federal system by which the United States is governed" (Derthick, 2007, p. 37). Particularly, in large-scale crises or disasters where the federal government and its high-level officials are involved in making decisions about formal emergency response, the political dynamics related to intergovernmental relations, such as election cycles, the state governments' opposition to federalizing emergency response, and the presidential disaster declaration, influences the mobilization and activation of formal emergency response (Haddow et al., 2008; Quarantelli, 2005; Waugh, 2006).

> ***Proposition 1****: The mobilization of formal organizations and their resources across the levels of government and the sectors is determined by the predetermined response plans and policies made in the preparedness period, the magnitude and immediate impacts of actual or potential crises or disasters, and intergovernmental relations.*

Response II (production and delivery). Networks of formal organizations mobilized produce and deliver a variety of emergency response services to the affected people (e.g., search-and-rescue missions and emergency medical services). The effectiveness of networks of formal organizations in producing and delivering emergency

response services is influenced by cognition (timely, valid information), communication (information exchange and sharing), coordination (the Incident Command System or cooperative alignment), information technology and infrastructure (interoperability, decision support systems, and geographic information systems), and characteristics of networks of formal organizations (mutual trust, prior history of collaboration, and goal congruence). First, from an emergency management perspective, cognition is the capacity to collect, integrate, monitor, and assess timely, accurate, and valid information about changing crisis or disaster conditions and the status of operations at the multiple sites (Comfort, Oh, Ertan, & Scheinert, 2010; Comfort, 2007). Cognition is important to create a common knowledge base among formal organizations in crisis or disaster situations. Communication in emergency management is "reliable, systematic exchange of information within and among organizations" (Comfort, Dunn, Johnson, Skertich, & Zagorecki, 2004, p. 77). The concept of communication "means achieving a sufficient level of shared information [and meanings] among the different organizations and jurisdictions participating in disaster operations at different locations, so all actors readily understand the constraints on each and the possible combinations of collaboration and support among them under a given set of conditions" (Comfort, 2007, p. 191).

Coordination is a process of "aligning one's actions with those of other relevant actors and organizations to achieve a shared goal" (Comfort, 2007, p. 194). There are the two different types of coordination mechanism in networks of formal organizations: The Incident Command System (ICS) and cooperative decision making processes. The ICS that emphasizes unified command and control is used primarily for on-scene operational activities (Buck et al., 2006; Moynihan, 2008). All formal organizations and their

personnel involved in on-scene tactical and operational tasks perform their various missions under the authority of an Incident Commander. These operational activities are coordinated through hierarchical decision making structures, division of labor, span of control, and integrated communications among formal organizations. Unlike the on-scene operations, off-scene supporting organizations are coordinated through cooperative inter-organizational structures and procedures based on predefined multi-agency agreements and related policies like the Emergency Management Assistance Compact at the state level and the federal emergency support functions (ESF) (DHS, 2013; Kapucu & Garayev, 2011; Waugh, 2007).

Information technology and infrastructure, such as an integrative decision support system and geographic information system, can increase the effectiveness of formal organizations in dealing with a crisis or a disaster (Comfort, Sungu, Johnson, & Dunn, 2001; Hu & Kapucu, 2014). A well-designed, functioning information infrastructure enables crisis- or disaster-related data from multiple sources to simultaneously flow into a centralized database where the data is integrated and analyzed. Then, the data is transferred to relevant actors and organizations to coordinate their responding activities in real-time (Comfort et al., 2010). Therefore, such information technology and infrastructure can "enhance the capacity of multiple organisations to adapt their actions reciprocally to changing conditions of risk" (Comfort et al., 2004, p. 62). Lastly, networks of formal organizations mobilized are one kind of inter-organizational relations. Therefore, inter-organizational characteristics can influence the effectiveness of networks of formal organizations in dealing with a crisis or a disaster. According to the literature, the key characteristics of inter-organizational relations

include mutual trust (Emerson et al., 2012; Kapucu et al., 2013), prior history of collaboration (Ansell & Gash, 2008; Jap & Anderson, 2007), and goal congruence (Bryson et al., 2006).

> ***Proposition 2****: The effectiveness of networks of formal organizations mobilized in producing and delivering emergency response services is determined by cognition, communication, coordination, information technology and infrastructure, and inter-organizational characteristics of formal organizations.*

Response III (Outputs and outcomes). Outputs mean a variety of emergency response services produced and delivered by networks of formal organizations. These services include public information and warning (timely, accurate, reliable information about threat or hazard, response operations, and aid resources available); transportation services to evacuate people and animals and to deliver response personnel, equipment, and relief resources; fatality management services (body recovery and victim identification); restoring critical infrastructure within the affected areas (power, roads, and cell towers); life-sustaining services (hydration, feeding, and sheltering); search-and-rescue missions; on-scene security and protection through law enforcement within the affected areas; and public health and emergency medical services (DHS, 2013). The outcomes of effective formal emergency response are "to save lives, protect property and the environment, meet basic human needs, stabilize the incident, restore basic services and community functionality, and establish a safe and secure environment moving toward the transition to recovery" (DHS, 2013, p. i).

Early recovery. When response missions and activities are completed, the deployed personnel and resources are demobilized and reimbursed according to established procedures, processes, and plans (DHS, 2013; Harrald, 2006; Kapucu & Garayev, 2011; Waugh, 2007). During the transition to recovery, intermediate and long-term recovery plans, such as the National Disaster Recovery Framework at the federal level, are activated to restore, redevelop, and revitalize social and physical infrastructure within the affected areas.

Volunteer-Based, Participatory Emergency Response

Volunteer-based, participatory emergency response is a system consisting of large online groups of individuals from both across the globe and the affected areas, and technologies, and decentralized, open adaptable organizational structures.

Preparedness. Participatory online groups of the general public do not have enough time and resources to prepare for a crisis or a disaster in the same manner as formal organizations do before a crisis or a disaster occurs. The preparation of participatory online groups for a crisis or a disaster depends mostly on the characteristics of threats and hazards and the lifecycle of participatory online groups. If threats and hazards are constant (e.g., active volcanoes exist and frequently erupt), relevant participatory online groups are likely to prepare for a disaster in a more organized way (Gultom & Joyce, 2014; Motozuka & Kanki, 2013). Also, while some of participatory online groups are demobilized and even disappear, others are transformed into a new, more organized groups that prepare for other crises or disasters (Lin, 2012). These transformed groups likely develop their response plans and procedures. These groups also

train their members and build partnerships with other participatory online groups and institutionalized formal organizations to prepare for crises or disasters.

Response I (Mobilization and emergence). Many participatory online groups of publics spontaneously emerge in the immediate aftermath of a crisis or a disaster by using information and communication technologies to perform voluntary, collective response. Some participatory online groups (e.g., the Standby Task Force[2] and the Humanitarian OpenStreetMap Team[3]) that exist before a crisis or a disaster occurs and have their response plans activate their voluntary, collective response and mobilize various resources, following extant plans and procedures that are much more flexible than those of formal organizations. The emergence and mobilization of participatory online groups are influenced by the magnitude and immediate impacts of disasters, public attention, media coverage (mainstream media and social media), social entrepreneurs, and the effectiveness of formal organizations in dealing with a crisis or a disaster.

The magnitude and immediate impacts of a crisis or a disaster that serves as focusing events need to be considered to understand and explain how and why volunteer-based, participatory response to a crisis or a disaster is mobilized across the globe. A large-scale crisis or disaster is a typical example of a focusing event defined as a sudden, uncommon event that causes physical, economic, mental, and environmental harms on a relatively large scale (e.g., natural disasters, ethnic cleansing, and wars) (Birkland, 1997; Kingdon, 1995). Such a focusing event likely draws the attention of the general public to problematic conditions which cause or are caused by focusing events. If the harms caused

[2] http://www.standbytaskforce.org/

[3] https://hotosm.org/

by focusing events "appear more obvious [with] compelling images of destroyed buildings, or dead wildlife, [such focusing events] have considerable power to" immediately increase public attention to a problematic condition (Birkland, 1998, p. 55).

A high level of public attention across the globe to a crisis or a disaster acts as a key driver for the emergence and mobilization of participatory online groups. According to theories related to the mass media, agenda setting, and public discourse, only a few issues are considered as critical social issues and problems for public discourse, although "there is a huge "population" of potential problems" (Hilgartner & Bosk, 1988, p. 57). That is, "public attention is a scarce resource, allocated through competition" in public discourse arenas (Hilgartner & Bosk, 1988, p. 55). Also, a large-scale crisis or disaster likely receives national and international media attention. That is, a large-scale crisis or disaster dominates media coverage. Thus, the magnitude and immediate impacts of a crisis or a disaster influence public attention and media coverage and ultimately determine the likelihood of the emergence and mobilization of participatory online groups.

Contributors of participatory online groups can be categorized into a small group of key contributors and a large group of micro-contributors (Howe, 2009; Shirky, 2008; Tapscott & Williams, 2006). In disaster or crisis situations, key contributors create online platforms as communication channels and collect and process a large amount of crisis- or disaster-related information. This small group of key contributors called social entrepreneurs serve as builders, processors, and facilitators of participatory online groups. I note the important role of a small group of key contributors in the emergence phase of participatory online groups. Through posting open calls for volunteering on their social

media accounts or by using their personal social networks (e.g., college students), these key contributors mobilize large groups of micro-contributors who perform small, discrete tasks for volunteer-based, participatory emergency response.

Additionally, a lack of formal organizations' effectiveness in dealing with a crisis or a disaster can increase the likelihood of the emergence and mobilization of participatory online groups. Indeed, in recent crisis or disaster situations where there was a vacuum of crisis- or disaster-related information and the mobilization and delivery of formal organizations' relief resources were severely delayed, a lot of participatory online groups spontaneously emerged to supplement formal emergency response and meet the affected people's unmet needs by collecting and analyzing crisis or disaster information and coordinating the mobilization and allocation of relief resources in a self-organized manner.

> ***Proposition 3****: The emergence and mobilization of participatory online groups are determined by the magnitude and immediate impacts of a crisis or a disaster, public attention, media coverage, social entrepreneurs, and the effectiveness of formal organizations in dealing with a crisis or a disaster.*

Response II (Production). Participatory online groups create a variety of activities and tasks to help respond to a crisis or a disaster in a collective manner. These online groups integrate, verify, analyze, and visualize a wide range of crisis- or disaster-related information from multiple sources. The effectiveness of participatory online groups in dealing with a crisis or a disaster may be influenced by organizational characteristics (openness, decentralization, diversity, adaptation, and companionship), a

coordination mechanism (crowdsourcing), the characteristics of networks of participatory online groups (trust, goal convergence, and prior history of collaboration), the use of information, communication, and computational technologies, and external supports and resources from formal organizations.

Organizational characteristics. In many cases participatory online groups globally mobilize their members through open calls. Anyone who is interested in voluntary responding tasks and activities and have skills and resources related to the tasks and activities can freely participate in them. In this regard, participatory online groups are open systems. Also, these online groups tend to have horizontal, decentralized organizational structures because these online groups are one type of loose voluntary associations to collectively achieve common goals (Howe, 2009; Roche et al., 2011; Tapscott & Williams, 2006). Naturally, in most cases the decision-making power is distributed to members of these online groups. Without hierarchical control systems, members of participatory online groups tend to make decisions and behave to perform their voluntary tasks and activities.

Diversity is another feature of participatory online groups. Diversity means pluralism and heterogeneity in ideas, knowledge, opinions, skills, and resources (Bessant, 2005; Howe, 2009). Members of participatory online groups often times have diverse backgrounds regarding nationality, age, gender, race and ethnicity, education, occupation, and socioeconomic status. Such diverse backgrounds allow these members to bring to participatory online groups a variety of skills, intelligence, and resources useful to address a crisis or a disaster effectively. Also, in many cases participatory online groups are agile, fluid and flexible, not static. When participatory online groups sometimes

confront an unexpected problem regarding their collective response to a crisis or a disaster, these online groups quickly change their organizational structures and adopt new technical tools to resolve the problem (Crowley & Chan, 2011; Heinzelman & Waters, 2010; Meier, 2011).

Members of participatory online groups often share companionship and a sense of community (Howe, 2009; Ridings & Gefen, 2004). They enjoy working together and helping and learning from each other. Members of participatory online groups continue to improve the overall quality of other members' work by adding useful ideas or information and correcting mistakes (e.g., the Humanitarian OpenStreetMap team). The success of participatory online groups is based on "cultivating a robust community composed of people with a deep and ongoing commitment to their craft and, most important, to one another" (Howe, 2009, p. 180). Participatory online groups usually have shared ownership of their products and services (Howe, 2009; Tapscott & Williams, 2006). All the members of participatory online groups are creators and owners, although some would make more contributions than others would do. Their products and services are mostly published online under open-source licenses, such as Creative Commons[4] and the MIT License[5]. Individuals or organizations can freely use the products and services for their own purposes. In this regard, participatory online groups create public goods.

Coordination mechanism (Crowdsourcing and meritocracy). Participatory online groups are one type of crowdsourced community (Munro, 2013; Sutherlin, 2013; Zook et al., 2010). Crowdsourcing is a mechanism by which participatory online groups

[4] http://creativecommons.org/

[5] https://opensource.org/licenses/MIT

coordinate their collective action to effectively address a crisis or a disaster (Goolsby, 2010; Meier & Munro, 2010; N. C. Roberts, 2011). Crowdsourcing refers to a process in which many crowds (massive networks of volunteer contributors) freely participate, exchange their ideas, thoughts, and resources with one another, and collectively perform tasks of interest to them by using information and communication technologies. Such dynamic interactions and exchanges driven by voluntary commitments and collaborations have created considerable, positive innovations across the private, nonprofit, and public sectors. Today, for-profit corporations, nonprofit organizations, and public agencies actively use crowdsourcing to gain ideas, knowledge, and opinions from users, customers, and citizens and co-create innovative products and services (Noveck, 2009; Shirky, 2008; Surowiecki, 2005; Tapscott & Williams, 2006).

"Breaking labor into little units, or modules, is one of the hallmarks of crowdsourcing" (Howe, 2009, p. 49). That is, an enormous amount of work is broken into very small, discrete tasks and distributed to a large group of potential contributors. These contributors mobilized through open calls perform the tasks as much as they can do and want to do by using their spare cycles. In crisis or disaster situations, participatory online groups process a large amount of crisis- or disaster-related data from multiple sources. In most cases participatory online groups break such a massive amount of data-processing work into little units of tasks and distribute them to a large group of digital volunteers from both across the globe and the affected areas. For example, in the aftermath of a crisis or a disaster, the Humanitarian OpenStreetMap team, a global online group of volunteer mappers, first breaks a large amount of satellite imagery donated by formal organizations into little squares on a collaborative mapping platform called HOT Tasking

Manager[6]. Then a massive group of volunteer mappers across the globe collectively create online base maps of post-event areas. Indeed, in recent crisis or disaster situations, all activities and tasks of participatory online groups, including reporting disaster situations from the ground, crisis mapping, creating online base maps, translating, and mobilizing and delivering relief resources, were crowdsourced to vast groups of the general public. Based on their knowledge, skills, and resources, the general public collectively performed these activities and tasks. Also, in participatory online groups, their members' ideas, resources, and contributions are often times assessed on the basis of quality, usefulness, and creativity, rather than the ladder of hierarchy, race, gender, and age (Boulos et al., 2011; Howe, 2009; J. A. Roberts et al., 2006). In this regard, participatory online groups are based on meritocracy.

Characteristics of networks of participatory online groups. In crisis or disaster situations, participatory online groups often times build collaborative partnerships with other participatory online groups to increase their capacities to respond to a crisis or a disaster. In their partnerships, participatory online groups share financial, technical and human resources with each other. Such inter-organizational partnerships between participatory online groups are much more flexible, voluntary, and decentralized than those between formal organizations. Thus, such partnerships may be shaped by mutual trust, and goal convergence, and prior history of collaboration, rather than hierarchical and legal structures.

[6] http://tasks.hotosm.org/

Information, communication, and computational technologies. Participatory online groups rely on information and communication technologies (both hardware devices and software applications) and advanced computational technologies (i.e. artificial intelligence). First, information and communication technologies (ICTs) refer to "a diverse set of technological tools…used to communicate and to create, disseminate, store, and manage information" (Blurton, 1999, p. 46). Participatory online groups rely on ICTs to aggregate their members' knowledge, skills, and resources and to coordinate collective action (Howe, 2009). In this regard, participatory online groups are one type of virtual organization. A virtual organization is defined as "a group of individuals whose members and resources may be dispersed geographically, but who function as a coherent unit through the use of cyberinfrastructure" (Marsden, 2013, p. 55). Indeed, many participatory online groups that responded to recent crises or disasters did not have physical spaces and used only computer-mediated communication tools for their collective action (e.g., the Standby Task Force). Importantly, advancement in ICTs (i.e. the emergence of the Internet, mobile devices, and open-source software) enables mass collaboration among thousands of digital volunteers around the world without time and geographic limits (N. C. Roberts, 2011; Tapscott & Williams, 2006).

Specifically, ICTs used by participatory online groups include short message service (SMS) (FrontlineSMS[7]), local community radios, email, social media (Facebook, Twitter, YouTube, Flickr, and Instagram), video chat applications (Google Hangouts and Skype), document collaboration tools (Google Docs), text-based chat tools (Internet

[7] http://www.frontlinesms.com/

Relay Chat[8]), open source crisis-mapping platforms (Ushahidi[9]), collaborative mapping tools (OpenStreetMap[10]), and integrative team collaboration platforms (Slack[11]).

Additionally, participatory online groups sometimes utilize both advanced computational technologies (i.e. machine learning) for data mining and crowdsourced human computation for data verification and analysis. For instance, in the immediate aftermath of Typhoon Haiyan, a participatory online group called the Standby Task Force (SBTF) utilized an open source, automated data mining tool called Artificial Intelligence for Disaster Response (AIDR) developed by the Qatar Computing Research Institute (QCRI). The AIDR reduced over 250,000 disaster-related tweets to about 55,000 tweets through an automated algorithm. Then, these filtered tweets were uploaded to a micro-tasking platform called the Tweet Clicker. By using the micro-taking platform, a large group of online volunteers around the world tagged and categorized these tweets to identify actionable pieces of disaster-related data.

External supports. In many cases, participatory online groups receive human, technical, and financial resources from institutionalized formal organizations to respond to a crisis or a disaster. That is, formal organizations often times act as supporting partners for participatory online groups. These formal organizations provide technical supports, expertise, and infrastructure for creating and maintaining online platforms for participatory online groups' collective action. Also, these formal organizations (e.g., for-

[8] http://www.irc.org/

[9] http://www.ushahidi.com/product/ushahidi/

[10] http://wiki.openstreetmap.org/wiki/Main_Page

[11] https://slack.com/

profit satellite imagery companies or public agencies responsible for geospatial data) donate satellite imagery to participatory online groups. Particularly, post-crisis satellite imagery is essential to create post-crisis online base maps of the affected areas and to perform crisis mapping.

> ***Proposition 4****. The effectiveness of participatory online groups in dealing with a crisis or a disaster is determined by their own organizational characteristics, a coordination mechanism, the characteristics of networks of participatory online groups, the use of information, communication, and computational technologies, and external supports and resources from formal organizations.*

Response III (Outputs and outcomes). Participatory online groups create a wide range of information-related products and services (i.e. outputs). These products and services include: setting up a system to report crisis or disaster conditions from the ground; collecting, verifying, categorizing, geo-locating, and visualizing information about crisis or disaster conditions, aid resources available, the affected people's needs and requests, and the current status of operations (i.e. crisis mapping); disseminating crisis or disaster information to the affected communities in real-time; creating and updating online or offline base maps of the affected areas; translating; and coordinating the mobilization and delivery of relief resources. Ultimately, in many cases participatory online groups' voluntary, collective actions help "save lives, protect property and the environment, meet basic human needs, stabilize the incident, restore basic services and community functionality, and establish a safe and secure environment moving toward the transition to recovery" (DHS, 2013, p. i).

Early recovery. When immediate emergency response of participatory online groups is completed, these online groups become deactivated and finally disappear in some cases, because these online groups are not based on formal membership and organizational structures. But, in the other cases, participatory online groups are transformed into other forms of formal organizations (e.g., for-profit companies or nonprofit organizations) or loosely connected partnerships among participatory online groups and/or formal organizations (e.g., the Digital Humanitarian Network).

Relationships between Formal Organizations and Participatory Online Groups

Today, when a crisis or disaster occurs, many participatory online groups spontaneously emerge from both across the globe and the affected areas, while a lot of formal organizations are mobilized, following the predetermined response plans and procedures. In some cases, participatory online groups collaborate with formal organizations. Both parties share crisis- or disaster-related data and other resources with each other and coordinate their diverse response tasks and activities (Meier & Munro, 2010). But in other cases, participatory online groups independently perform their voluntary response outside of networks of formal organizations (Birowo, 2010).

Relationships and interactions between formal organizations and participatory online groups can be categorized into four types on the basis of whether both parties are aware of each other and whether there is alignment in formal and voluntary emergency responses (Stoll et al., 2010) (See Figure 1.2). Each type of relationships and interactions between both parties may lead to different outcomes of emergency response.

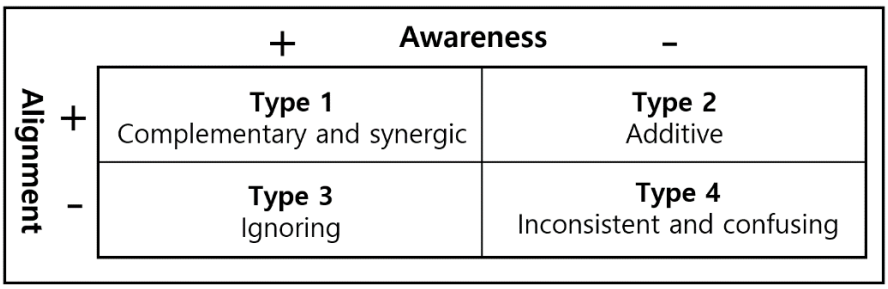

Figure 1.2. Relationships between formal organizations and participatory online groups

The first type of relationships is that formal organizations and participatory online groups are aware of each other and align their various response tasks and activities. This type of relationships is complementary and synergic, because both parties supplement each other's response efforts in a coordinated manner. For instance, participatory online groups collect and analyze crisis- or disaster-related information from multiple sources and share this information with formal organizations on the ground in real-time. Based on this information, formal organizations perform their response tasks and activities, such as search-and-rescue missions and the delivery of relief resources. After completing their response activities, formal organizations give participatory online groups an update on the current status of response operations in the field. In this complementary relationships, there are dynamic, rich interactions and flows of information and resources between formal organizations and participatory online groups. In this type of relationships, the effectiveness and efficiency of the overall emergency response system are likely to be maximized (Meier, 2015; Munro, 2013).

The second type of relationships is that formal organizations and participatory online groups are not aware of each other, and both parties' responses are additive. This type of relationships emerges mostly in situations where formal organizations and participatory online groups have different goals and target groups regarding emergency

response. For instance, in a large-scale natural disaster situation such as earthquakes and hurricanes, formal organizations tend to focus on official, large refugee camps by allocating and delivering relief resources to these camps. Instead, participatory online groups that particularly emerge from the affected areas often self-organize to meet the unmet needs of displaced people who stay in unofficial, small refugee camps to which formal organizations pay little attention. In this type of relationships, there is 'unintended' alignment in formal organizations' and participatory online groups' response efforts because both parties have different goals and target groups. But both parties cannot coordinate their responses in a synergic manner due to the lack of awareness regarding the existence and response efforts of their counterparts.

In the third type of relationships, formal organizations and participatory online groups are aware of their counterparts, but both parties do not reach out to and cooperate with each other. In this type of relationships, both parties likely have a different understanding of crisis or disaster conditions and of how to react (Aldrich, 2012; Birowo, 2011). Particularly, if a disaster or a crisis becomes politically sensitive problems or issues and formal organizations and participatory online groups have different political views and aims, both parties are unlikely to collaborate with each other. In such situations, both parties independently perform their response efforts and even compete with each other. Since there is the duplication of emergency response efforts between formal organizations and participatory online groups, the effectiveness and efficiency of the overall emergency response system cannot be maximized.

In the fourth type of relationships, formal organizations and participatory online groups are not aware of their counterparts. In addition, both parties' responses are

inconsistent and confusing due to false, outdated, competing information on crisis or disaster conditions, the affected people's needs, and the current status of response operations at multiple sites. Such a situation likely occurs in the immediate aftermath (24 to 48 hours) of a crisis or a disaster, particularly when a lot of formal organizations across the levels of government and the sectors are suddenly mobilized and deployed to the affected areas and numerous participatory online groups spontaneously emerge and begin their voluntary response, but there is the absence of integrative, updated information about responding actors (both formal organizations and participatory online groups) and their specific tasks and activities in response to crisis (Harrald, 2006). As a result, such disconnected relationships and communications between formal organizations and participatory online groups likely lead to inefficient, uncoordinated responses to a crisis or a disaster.

> ***Proposition 5***. *Formal organizations and participatory online groups can have the four types of relationships (i.e. complementary and synergic, additive, ignoring, and inconsistent and confusing). When formal organizations and participatory online groups have complementary and synergic relationships, the effectiveness and efficiency of the overall emergency response system in dealing with a crisis or a disaster are likely to be maximized.*

CHAPTER 2

BUILDING HYPOTHESES ON RELATIONSHIPS BETWEEN PARTICIPATORY ONLINE GROUPS AND FORMAL ORGANIZATIONS

In the first chapter, I suggested an event-driven lens for integrating both formal and volunteer-based, participatory emergency responses in the networked age. The event-driven lens consists of formal emergency response, volunteer-based, participatory emergency response, and relationships between participatory online groups and formal organizations. In this chapter, I conduct a deeper analysis of one aspect of the event-driven lens by focusing on relationships between participatory online groups and formal organizations. The event-driven lens provides a conceptual typology of relationships between participatory online groups and formal organizations on the basis of whether both parties are aware of each other and whether there is alignment in formal and volunteer-based, participatory emergency responses (i.e. complementary and synergic, additive, ignoring, and inconsistent and confusing). But there are many unanswered research questions about key determinants to shape these inter-organizational relationships and the outcomes of these inter-organizational relationships. Therefore, in this chapter, I have the following research questions: Why do participatory online groups and formal organizations form inter-organizational relationships in crisis or disaster situations? (i.e. what are key organizational and technical determinants to form these relationships?) And what are the outcomes of the formation of inter-organizational relationships between participatory online groups and formal organizations?

To answer these research questions, I employ the exploratory case study method (Eisenhardt & Graebner, 2007; Eisenhardt, 1989; Yin, 2003). This case study method is "a research strategy that involves using one or more cases to create theoretical constructs, propositions and/or…theory from case-based, empirical evidence" (Eisenhardt & Graebner, 2007, p. 25). The exploratory case study method is most appropriate in the early stages of theory development, particularly in a situation where there is "the lack of plausible existing theory [and]…empirical evidence" regarding an important, novel phenomenon (Eisenhardt & Graebner, 2007, p. 26). Thus, this chapter aims to build from actual cases hypotheses to explain why participatory online groups and formal organizations form inter-organizational relationships and what outcomes the formation of the inter-organizational relationships creates.

This research is important both theoretically and practically. First, the literature on participatory online groups is sharply increasing in the disciplines of computer science, geography, political science, public administration, media studies, and international development (e.g., Caquard, 2013; Crowley, 2013; Goodchild, 2007; Meier, 2015; Munro, 2013; Nelson et al., 2010; Roberts, 2011; Roche et al., 2011; Shanley et al., 2013; White et al., 2014). Most prior studies aimed to explore and describe key tasks and contributions of participatory online groups, organizational characteristics of these online groups, and challenges and limitations, viewing the emergence of participatory online groups as a novel phenomenon in the digital era. Although these prior studies provide useful information, knowledge, and practical expertise, there are several important research gaps. One of the most understudied areas in the literature is the determinants, processes, and outcomes of relationships between participatory online groups and formal

organizations. Therefore, this research can contribute to the literature by offering evidence-based research findings on relationships between participatory online groups and formal organizations. In addition, from a practical point of view, findings from this research can be useful for participatory online groups and formal organizations to build and manage partnerships and collaboration with each other to increase their capacities to deal with a crisis or a disaster.

Research Methods: The Exploratory Case Study Method

Epistemological Assumptions and Researcher Positioning

This study is grounded in a realist view of knowledge. According to this epistemological view, the nature of the social phenomena under investigation exists independently of researchers' perceptions and understandings about the phenomena. Hence, researchers and the social phenomena of interest are separate. And there are "the patterns, regularities, structures, or laws of behavior that characterize…[the world] and that generate the social…phenomena" (Willig, 2012, p. 11). In addition, knowledge about the social phenomena can be discovered and understood by skilled researchers with scientific methods. From this epistemological view, researchers are expected to take a role of an objective investigator or analyst akin to "that of a detective who uses his or her skills, knowledge, and experience to uncover hitherto hidden facts and who, through his or her labor, makes what appeared puzzling or mysterious intelligible" (Willig, 2012, p. 11). Therefore, from this realist view, this study is discovery-oriented to thoroughly and objectively explore a social phenomenon of interest and obtain accurate, detailed,

comprehensive knowledge of the phenomenon (i.e. relationships between participatory online groups and formal organizations in crisis or disaster situations).

The Exploratory Case Study Method

This study employs the case study research. "A case study is *an empirical inquiry* that investigates a contemporary phenomenon within its real-life context" (Yin, 2003, p. 13). The case study research is a comprehensive research strategy that aims to understand the complex dynamics of interest present within real settings (Eisenhardt, 1989; Yin, 2003). Therefore, the case study research is often characterized by a combination of a wide range of research methods (i.e. multiple data collection and analysis techniques) (Willig, 2008). In addition, the case study research can be used for diverse purposes of research: to develop new theories, propositions, and hypotheses; to provide a detailed description of a new phenomenon; and to test empirically existing theories (A. L. George & Bennett, 2005).

This research employs the exploratory case study method to develop hypotheses on relationships between participatory online groups and formal organizations in crisis or disaster situations. The exploratory case study method uses one or more cases to create theoretical constructs or variables and hypothesized relationships between constructs or variables on the basis of empirical findings from the selected cases (Eisenhardt & Graebner, 2007). The exploratory case study method is most useful in the early stages of theory development regarding a novel social phenomenon (Eisenhardt & Graebner, 2007). Sometimes, one is confused about the difference between the exploratory case study method and grounded theory, thus it is necessary to clarify the notion of the exploratory case study method and differentiate it from grounded theory. Indeed, these

two research strategies have similarities. Both research strategies create "theory by observing patterns within systematically collected empirical data [through]…recursively iterating between (and thus constantly comparing) theory and data during analysis" (Eisenhardt & Graebner, 2007, p. 30). However, regarding epistemological views, the exploratory case study method aims to create testable hypotheses and theory that can generalize to other settings based on realism or positivism/post-positivism (Eisenhardt, 1989; Yin, 2003), while grounded theory "argues that categories and theories…are *constructed* by the researcher through an interaction with the data" from interpretivist and social constructionist views (Willig, 2008, p. 45). Also, the exploratory case study method often uses both qualitative and quantitative data, but grounded theory relies primarily on qualitative data.

Case selection. In case study research, the investigator *purposely* selects a case or cases in a nonrandom manner (Creswell, 2009). Such case selection method is called theoretical sampling through which "cases are chosen for theoretical, not statistical reasons" (Eisenhardt, 1989, p. 537). In other words, "cases are selected because they are particularly suitable for illuminating and extending relationships and logic among constructs" (Eisenhardt & Graebner, 2007, p. 27). In this research, I take into account the following case selection criteria: the magnitude of a crisis or a disaster, the level of public attention to a crisis or a disaster, the mobilization of formal organizations, the emergence and contributions of participatory online groups, and the presence of secondary data. More specifically, I sought to select large-scale crises or disasters that received high levels of public attention at the national or international level. I also looked for cases in which large networks of formal organizations were mobilized, and participatory online

groups emerged and performed voluntary, collective responses. Lastly, I tried to find cases with sufficient secondary data from multiple sources. Based on the criterion, four cases were selected: the 2007-2008 Kenya post-election violence; the 2010 Haiti earthquake; the 2010 Indonesia volcanic eruptions; and the 2011 Japan earthquake and nuclear crisis. The case selection is based on the idea of the all-hazard model that emphasizes generic processes and activities are needed to address a variety of manmade crises and natural disasters (Waugh, 2000).

Data collection. Case study research uses multiple sources of evidence (Yin, 2003). This is one of the strengths of case study research. In this study, data comes from multiple secondary sources, including academic journal articles, thesis or dissertation, research and practical reports, news and magazine articles, and web documents (e.g., blog posts and online discussion forum archives). Table 2.1 illustrates specific data sources for each of the selected cases.

Table 2.1

Data Sources for Each of the Selected Cases

	Academic Article	Thesis/ Dissertation	Report	News Article	Web Document	Total (*N*=106)
2007-2008 Kenya	7	1	6	5	14	33
2010 Haiti	18	0	7	6	7	38
2010 Indonesia	6	1	6	0	2	15
2011 Japan	12	1	1	1	5	20

Data analysis. This research employs exploratory thematic analysis as a method of data analysis for developing hypotheses on relationships between participatory online

groups and formal organizations (Braun & Clarke, 2012; Gibson & Brown, 2009; Guest et al., 2012; Ryan & Bernard, 2003; Saldaña, 2013).

Thematic analysis. In exploratory thematic analysis, I follow a streamlined codes-to-theory model developed by Johnny Saldaña (2013). This model consists of codes, categories, themes/concepts, and theory (See Figure 2.1).

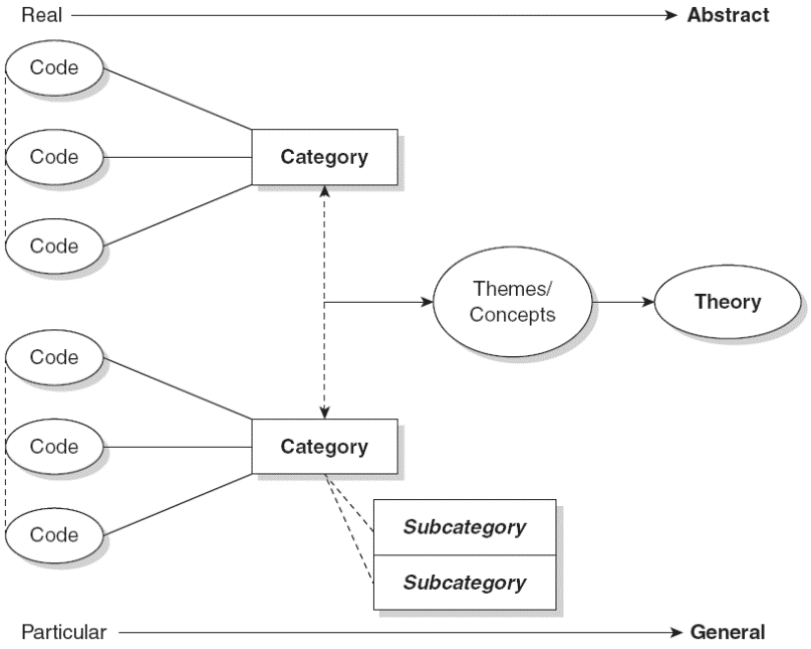

Figure 2.1. Streamlined codes-to-theory model (Saldaña, 2013, p. 12)

First of all, coding is a crucial aspect of thematic analysis (Basit, 2003; Saldaña, 2013). Coding is a process of segmenting, labeling, codifying, categorizing, and theme-ing the data in qualitative research. The researcher first segments the data and labels chunks or segments of the data with a term (i.e. a code) (Braun & Clarke, 2012). A code in qualitative research is "a word or short phrase that symbolically assigns a summative, salient, essence-capturing, and/or evocative attribute for a portion of language-based…data" (Saldaña, 2013, p. 3). Then, the researcher "organize[s] and group[s]

similarly coded data into categories" and arranges the coded data in a systematic order (i.e. codifying and categorizing) (Saldaña, 2013, p. 8). Each category would have subcategories that consist of multiple, lower-level codes. After that, the researcher searches for themes, identifying patterned response, similarity and overlap between clustered codes or categories (Braun & Clarke, 2012). Compared to codes and categories, themes (or concepts) are "more general, higher-level, and more abstract constructs" (Saldaña, 2013, p. 11). Interconnecting themes is a process of exploring relationships between themes to develop a plausible theoretical model and hypotheses (Braun & Clarke, 2012; Corbin & Strauss, 2008; Creswell, 2009; Saldaña, 2013). Also, "[a]n essential feature of theory building is comparison of the emergent concepts, theory, or hypotheses with the extant literature. This involves asking what is this similar to, what does it contradict, and why" (Eisenhardt, 1989, p. 544). Based on evidence from data and the literature, the researcher continues to shape and sharp a theory, "refining the definition of the construct…[and] discover[ing] the underlying theoretical reasons for why the relationship exists" (Eisenhardt, 1989, pp. 541–542). In reality, these steps of data analysis are overlapped and iterative. Therefore, the researcher needs to "systematically compare the emergent…[codes, categories, and themes] with the evidence and [the literature]," to recode and re-categorize the collected data, and to review potential themes (Eisenhardt, 1989, p. 541).

There are three approaches to data coding for thematic analysis: an inductive approach, a deductive approach, and a combination approach. The inductive approach is to "develop codes *only* on the basis of the emerging information collected" (i.e. the bottom-up, data-driven approach) (Creswell, 2009, p. 187). This approach is often used in

qualitative research based on grounded theory (Corbin & Strauss, 2008). Next, the deductive approach relies on "predetermined codes based on the theory being examined" (i.e. the top-down, theory-driven approach) (Creswell, 2009, p. 187). In a combination of both approaches, a preliminary coding scheme or codebook is developed based on the literature, but the researcher is allowed to change the coding scheme or codebook "based on the information learned during data analysis" (Creswell, 2009, pp. 187–188).

This research uses the combination approach to data coding. More specifically, a preliminary coding scheme was developed from inter-organizational relations (IOR) theory and the data sharing literature (e.g., Ansell & Gash, 2008; Azad & Wiggins, 1995; Emerson, 1976; Harvey & Tulloch, 2006; Oliver, 1990; Pfeffer & Salancik, 1978; Ring & Van de Ven, 1994; Wehn de Montalvo, 2003). Relationships between participatory online groups and formal organizations in response to crisis may be one type of inter-organizational relationships (i.e. building and maintaining partnerships and collaboration between two or more parties). Although the IOR theory mostly assumes relationships between institutionalized organizations, this theory can provide important insights into relationships between institutionalized organizations and online groups. Also, I note that participatory online groups and formal organizations often interact with each other through sharing a variety of information-related products and services in crisis or disaster situations. Thus, in the process of developing a preliminary data coding scheme, I considered possible determinants and outcomes of relationships between participatory online groups and formal organizations on the basis of inter-organizational relations (IOR) theory and the data sharing literature.

Table 2.2

Preliminary Data Coding Scheme

Domain	Code	Description
Determinant of relationship	Awareness	Whether participatory online groups and formal organizations are aware of their counterparts' existence, response activities and resources (Stoll et al., 2010)
	Legal and policy context	The context in which participatory online groups and formal organizations are embedded, including legislations, regulations, and policies, and procedures related to emergency management, global humanitarian assistance, e-government, privacy, and security, and intellectual property (Azad & Wiggins, 1995; Brass et al., 2004)
	Resource dependence	Participatory online groups and formal organizations are not self-sufficient to respond to a crisis or a disaster, thus both parties form partnerships and collaboration to obtain resources essential to their own response activities (R. M. Emerson, 1976; Pfeffer & Salancik, 1978)
	Technology and information management	Technical factors and capacities for converting, integrating, and distributing crisis- or disaster-related information between participatory online groups and formal organizations (Wehn de Montalvo, 2003a)
	Prior history of relationships	Prior success or failure of partnerships and collaboration in response to crisis (Ansell & Gash, 2008; Ring & Van de Ven, 1994)
	Shared understanding	Shared understanding of common problems (i.e. crisis or disaster) that participatory online groups and formal organizations and of how to address these problems (Ansell & Gash, 2008; Bentrup, 2001)
	Mutual trust	A common belief that partners (1) are honest to others in inter-organizational negotiations, decision-making, and actions; (2) "make good-faith efforts to behave in accordance with any commitments both explicit and implicit" (as cited in Thomson & Perry, 2006, p. 28); and (3) pursue mutual benefits instead of taking excessive advantage of others with opportunistic behavior (Huxham & Vangen, 2005; Koppenjan & Klijn, 2004)
Outcomes of relationships	Efficiency	Increased efficiency (i.e. cost saving) owing to the avoidance of duplicate efforts between participatory online groups and formal organizations at the system level
	Effectiveness	To which participatory online groups and formal organizations achieve aims of emergency response at the inter-organizational level, including saving lives, meeting human needs, protecting property and the environment, and restoring basic services and community functionality

Four Case Studies

In this section, I provide detailed descriptions of the four selected cases, focusing on the crisis or disaster contexts, volunteer-based, participatory emergency response, formal emergency response, and relationships between participatory online groups and formal organizations. Particularly, in the first chapter, I suggested a typology of relationships between participatory online groups and formal organizations in response to crisis. In this section, I apply the typology to these four case studies. That is, I categorize diverse relationships between participatory online groups and formal organizations into four types of inter-organizational relationships on the basis of whether participatory online groups and formal organizations are aware of each other and whether there is alignment in formal and volunteer-based, participatory emergency responses (See Table 2.3). This categorization is useful for understanding the determinants and outcomes of relationships between participatory online groups and formal organizations.

Case 1: The 2007-2008 Kenya Post-Election Violence

Kenya's 10th presidential election was held on December 27, 2007. On December 30, 2007, Samuel Kivuitu, chairman of the Electoral Commission of Kenya (ECK), announced that incumbent President Mwai Kibaki was the winner of the 2007 presidential election. Soon after the announcement, President Kibaki was sworn-in. But domestic and international observers described the election results as fraudulent, noting that "Orange Democratic Movement (ODM) candidate Raila Odinaga's lead of over one million votes strangely morph[ed] into a small margin of victory for the incumbent Mwai Kibaki" (Goldstein & Rotich, 2008, p. 4; Goldstein, 2008). Raila Odinaga and ODM rejected the results, strongly criticizing President Kibaki. "The public's realization of the

manipulation of the election results triggered the 2007/8 violence" between people who supported President Kibaki and his Kikuyu tribe and others who supported Raila Odinaga and his Luo tribe (Babaud & Ndung'u, 2012, p. 12). The post-election violence quickly spread across Kenya and lasted during January and February of 2008. The post-election violence "left about 1,5000 dead, many more injured and over 60,000 people internally displaced and in need of humanitarian assistance" (Babaud & Ndung'u, 2012, pp. 12–13).

Right after the announcement of the election results, the Minister of Internal Security, Hon John Michuki, ordered the immediate suspension of all live broadcasts, "argu[ing] false or biased reporting would result in even more ethnic-based violence" (Okolloh, 2009, p. 65). Under this condition, the mainstream media underreported the severity of the conflict owing to self-censorship and pro-government bias (Makinen & Kuira, 2008). As a result, there was a serious disconnect between Kenya's media coverage and the actual status of the bloody post-election violence. That is, there was the lack of information about what was happening in the field, although the post-election violence, such as riots, reprisal attacks, rapes, and killings by excessive police shootings, became worse in both urban and rural regions of Kenya. In such an information vacuum, local community-based organizations and international aid organizations had difficulty providing relief services and addressing inter-ethnic conflicts with their peacebuilding efforts.

The creation of Ushahidi. In spite of the failure of the mainstream media, Kenyan bloggers' internet media served as an important information source and communication channel. On January 3, 2008, Ory Okolloh, a Kenyan lawyer and prominent blogger, posted a suggestion on her blog *Kenyan Pundit* (Okolloh, 2008):

"Google Earth supposedly shows in great detail where the damage is being done on the ground.…Guys looking to do something – any techies out there willing to do a mashup of where the violence and destruction is occurring using Google Maps?" Within a few days, dozens of volunteer software developers and bloggers self-organized to build the website Ushahidi.com. On January 9, 2008 just six days after Okolloh's suggestion on her blog, Ushahidi was born, which means 'witness' or 'testimony' in Swahili. "There was no funding for the website at the time – everything was donated by volunteers, from donating server space, writing the code, donating the short code for SMS calls and helping gather the initial data to helping spread the world" (Okolloh, 2009, p. 66).

How did the Ushahidi platform work? The initial Ushahidi platform was simple. As incidents of violence took place in the field, local witnesses submitted their reports via SMS or the website itself. The reports easily went live, while SMS reports were manually entered by Ushahidi volunteers. These volunteers "prioritize[d] urgent messages, fact-check[ed] and confirm[ed] each submission before posting it in near real time" (Tavaana, n.d.). Each report provided a brief description of incidents (e.g., the location, date, and time of an incident) and was categorized by the types of incidents, including riots, looting, or rape. These incident reports were also geo-located and visualized on an interactive Google map (Tavaana, n.d.). In addition, the Ushahidi platform "compile[d] full analytical reports…[and] a full timeline of events" as well as information about peacebuilding activities and internally displaced people (Tavaana, n.d.). To create a more accurate picture of what was going, these volunteers sought to verify reports by calling or emailing those who submitted the reports and comparing the

reports with information from other sources (Okolloh, 2009). As the reports were fact-checked, the number of false reports for propaganda diminished.

Relationships between Ushahidi and formal organizations. In the crisis situation, Ushahidi volunteers actively tried to build partnerships with Kenyan nongovernmental organizations (NGOs) that had local contacts on the ground, such as community-based, nonprofit organizations (Zuckerman, 2008a). At that time, Kenyan NGOs provided trusted reports about violent incidents to Ushahidi (Zuckerman, 2008b). Also, by using their local knowledge, these NGOs in the field helped verify reports submitted to Ushahidi from the ground. Importantly, Kenyan NGOs aided in publicizing the existence of Ushahidi and generating reports from those who had difficulty getting access to the Internet (Zuckerman, 2008a). As a result, collaborating with Kenyan independent radio networks that "broadcast information on how to submit reports of violence" (Tavaana, n.d.), Kenyan NGOs helped increase the potential users of the Ushahidi platform from about 10 percent to 95 percent of Kenya's population. On the other hand, Kenyan NGOs (e.g., MMC Outreach and Peace Caravan) actively used the Ushahidi platform to identify communities in need, to allocate their relief resources to areas where these resources were most needed and to coordinate peacebuilding efforts. During the crisis, the Ushahidi team (i.e. a participatory online group) and Kenyan NGOs (i.e. formal organizations) were aware of each other (i.e. response activities and resources). And when the Ushahidi team reached out to Kenyan NGOs, their partnerships were quickly formed in the urgent crisis situation. After building their partnerships, there were dynamic interactions and flows of crisis-related information between the Ushahidi

team and Kenyan NGOs through the platform. As a result, the Ushahidi team and Kenyan NGOs coordinated their crisis responses.

Case 2: The 2010 Haiti Earthquake

On January 12, 2010, a 7.0 magnitude earthquake struck the island nation of Haiti. The earthquake left over 200,000 people dead and another 300,000 people injured. Over 70 percent of buildings in Haitian capital, Port-au-Prince and its surrounding regions collapsed. Particularly, "[c]rucial buildings and infrastructure were heavily damaged or destroyed, including Haiti's UN headquarters, the presidential palace, parliament building, and 28 of 29 government ministries" (Heinzelman & Waters, 2010, p. 2).

Soon after the Haitian earthquake, international disaster relief and humanitarian assistance organizations across the world, including the United Nations Office for Coordination of Humanitarian Affairs (UNOCHA), the U.S. Federal Emergency Management Agency (FEMA), and international non-governmental organizations, came to Haiti to launch their search-and-rescue missions and provide humanitarian aids to the affected people. But, these formal actors relied primarily on the traditional disaster-response system that collected "information about the crisis environment and the needs of the affected population" through their own internal channels (Heinzelman & Waters, 2010, p. 2). Naturally, "this system lacked the ability to aggregate and prioritize" intelligence from a variety of outside sources, particularly from the Haitian affected communities (Heinzelman & Waters, 2010, p. 3). Moreover, this system concentrated on standard protocols with regard to information gathering and disaster relief operations. Due to the standard protocols, valuable key informants, such as Haitian community

leaders, often failed to enter the UN Logbase where information about the current state of the disaster were collected and significant decisions about disaster response were made. As a result, these formal organizations struggled to gather and verify accurate information and make efficient and effective decisions about their disaster relief activities. Furthermore, such inaccurate and insufficient information caused the concern and confusion about security and "slowed emergency response costing lives and creating violence" on the ground (Heinzelman & Waters, 2010, p. 4).

Ushahidi-Haiti platform. Within two hours after the devastating earthquake struck Haiti, the Ushahidi-Haiti platform that enabled open-source, interactive mapping among multiple users was set up by Patrick Meier, the Ph.D. candidate in the Fletcher School of Law and Diplomacy at Tufts University and Ushahidi, Inc.[12]'s director of crisis mapping and strategic partnerships, and David Kobia, Ushahidi, Inc.'s cofounder and lead software developer. An initial operation center for the Ushahidi-Haiti platform was established in the living room of Meier's small apartment near Tufts University located in Medford, MA. In that operation center, a group of volunteers (two dozen Fletcher students) began to collect critical information about the disaster conditions from email, web, "social media sources, including Twitter, Facebook, and blogs, and traditional media sources to identify actionable pieces of information that could be of use for responders on the ground" and map the information on the Ushahidi-Haiti platform (Heinzelman & Waters, 2010, pp. 6–7). With Meier's urgent call for volunteers at the

[12] The Ushahidi team (David Kobia, Ory Okolloh, Juliana Rotich, and Ethan Zuckerman) that performed voluntary response to the Kenya's post-election violence established Ushahidi, Inc. as a nonprofit technology company in 2008. Ushahidi, Inc. develops and provides free and open source crisis mapping software.

Fletcher School, about 200 volunteer crisis mappers were mobilized. "The [volunteer] team developed a quick-and-dirty system for classifying, prioritizing, and geo-locating…[the collected information,] using a mix of Google Spreadsheets, Microsoft Excel, and Google Maps" (Crowley & Chan, 2011, p. 27). And as web traffic to the Ushahidi-Haiti platform abruptly increased across the world, Ushahidi, Inc.'s developers provided technical monitoring and supports for several weeks to maintain the platform effectively and stably.

Mission 4636 (SMS-based reporting system). The earthquake had destroyed about 70 percent of the cell phone towers in Port-au-Prince. But fortunately, Haitian telecommunications companies restored those towers within a few days after the earthquake. Thus, approximately over 80 percent of Haitian households were able to communicate with one another via cell phones at that time (Heinzelman & Waters, 2010). Several formal organizations across the globe (the U.S. State Department and Frontline SMS[13]), Haitian telecommunications companies (Digicel and DigiPoint), and Haitian NGOs worked together to launch a single, free short message service (SMS) reporting system from the ground called Mission 4636 within four days after the earthquake (Crowley & Chan, 2011; S. George, 2008). The Thomson Reuters Foundation, InSTEDD[14], and Signal FM (Haitian radio station) aided in publicizing the short code 4636 to disaster-affected people by using radio and other communication channels (Giridharadas, 2010; Hester et al., 2010). As a result, Haitians began to report their locations and urgent needs by using their own mobile phones on January 16, 2010. Also,

[13] http://www.frontlinesms.com/

[14] http://instedd.org/

many for-profit or nonprofit technology companies (ActiveXperts, Energy for Opportunity, Ushahidi, Inc., and Votident) offered a variety of technical supports to flow the SMS data from the Haitian telecommunications companies to the reporting system.

Unfortunately, approximately 90 percent of the messages were reported in Haitian Creole, although most international responders were using English or French. To deal with this challenge, Rob Munro, a computational linguist at Stanford University, called for volunteer translators in collaboration with Haitian communities. Within a week after the earthquake, over 1,000 volunteer translators were mobilized from the Haitian Diaspora across 49 countries, mostly through social media (Facebook) (Marsden, 2013; Munro, 2010). Moreover, Brian Herbert, Ushahidi, Inc.'s software developer, set up micro-tasking platforms (i.e. online open chat rooms) that enabled these volunteers across the world to share their geographic and linguistic knowledge with one another. By using the open chat rooms, these volunteers translated messages to and from Haitian Creole, English, and French and classified them (Corbane, Lemoine, & Kauffmann, 2012, p. 256). The volunteers also geo-tagged the messages, finding specific GPS coordinates.

A week after the earthquake, the Mission 4636 reporting system and the Ushahidi-Haiti platform were integrated to process disaster-related information more effectively (Crowley & Chan, 2011). Ushahidi, Inc.'s engineers developed an RSS feed that enabled international formal responders (particularly, the U.S. Marine Corps and the U.S. Coast Guard) to retrieve urgent disaster conditions and immediate needs and requests of the affected people. As a result, "[a] team of four to eight Coast Guard responders retrieved the information and disseminated it to forces on the ground for search-and-rescue operations. The Tufts support team worked directly with a Coast

Guard dispatcher to ensure that emergency reports were processed in a timely manner" (Nelson et al., 2010, p. 13).

Surprisingly, the average turnaround time from a Creole message submitted to Mission 4636 being translated, classified, geo-tagged on the Ushahidi-Haiti platform, and reported to first responders on the ground was less than 10 minutes. In addition to the U.S. Marine Corps and the U.S. Coast Guard, many other formal response organizations recognized the efforts of two participatory online groups, used real-time disaster data processed by these online groups, and established direct communication lines with these online groups for their response activities. Formal response organizations that collaborated with these online groups include the International Federation of Red Cross and Red Crescent Societies (IFRC), International Medical Corps, the United Nations Development Program (UNDP), the U.S. Agency for International Development (USAID), and the World Food Program (WFP). During the period between January 12 and the end of March 2010, over 20,000 messages were sent to the Mission 4636 system and about 3,600 reports were mapped on the Ushahidi-Haiti platform (Corbane et al., 2012).

OpenStreetMap (OSM). The devastating earthquake destroyed most of roads, bridges, and buildings in Port-au-Prince and its surrounding regions, and numerous camps for displaced Haitians and other humanitarian aid facilities (e.g., emergency medical centers) were set up rapidly across Haiti. In this situation, the existing maps of transportation and infrastructure systems in Haiti were useless. Naturally, a precise map of post-earthquake Haiti was necessary to both Haitian people in need and formal response organizations. Also, the map of post-earthquake Haiti was also essential for

participatory online groups (Mission 4636 and the Tufts support team) to geo-locate reports sent to their systems.

OpenStreetMap (OSM), sometimes called a Wikipedia for maps, is a collaborative project in which approximately 150,000 volunteer mappers aim to create a free, editable, and open map of the world. In the immediate aftermath of the earthquake, OSM mobilized over 600 volunteer mappers around the world to create a map of post-earthquake Haiti. These volunteer mappers first scanned offline atlases and maps and rectified and "traced roads, bridges, and buildings into the OpenStreetMap geospatial wiki" (Crowley & Chan, 2011, p. 30). Importantly, in the immediate aftermath of the disaster, DigitalGlobe, a for-profit satellite imagery company, GeoEye, another for-profit imagery company, and the Disaster Risk Management group at World Bank donated high-resolution satellite imagery of post-disaster Haiti (Heinzelman & Waters, 2010). Based on the donated imagery, the OSM volunteers collectively created the most accurate map of Haiti within two weeks. By mid-March 2010, international governmental organizations (the United Nations), international non-governmental humanitarian organizations, and other participatory online groups (Mission 4636 and the Tufts support team) used the OSM as the de facto source for Haiti map data (Crowley & Chan, 2011).

Relationships between participatory online groups and formal organizations. The Haiti earthquake response system was a large network of collaborative networks between participatory online groups and formal organizations. Such a large network among many formal organizations and participatory online groups was quickly formed in the immediate aftermath of the earthquake. Specifically, the U.S. State Department and FrontlineSMS contributed to the design and development of the SMS-based reporting

system in collaboration with Haitian telecommunications companies (Digicel and DigiPoint). The Thomson Reuters Foundation, InSTEDD, and Signal FM helped publicize the existence of the short code and how to submit reports to the affected communities. Three large groups of volunteers across the globe (i.e. the Tufts support team, Mission 4636's volunteer translators, and OSM volunteer mappers) collected, verified, translated, and geo-located disaster data from multiple sources and created digital base maps of post-disaster Haiti. These three participatory online groups were interconnected to one another during the Haiti earthquake response. Also, many for-profit or nonprofit technology organizations, such as ActiveXperts, Energy for Opportunity, Ushahidi, Inc., and Votident, helped set up integrative disaster information systems and provided technical advice and supports during the response period. Ultimately, actionable pieces of data processed by participatory online groups (e.g. urgent requests for rescue) were sent to first responders (e.g., the U.S. Marine Corps and the U.S. Coast Guard) on the ground in a timely manner and helped these first responders effectively coordinate their response activities. Hence, participatory online groups and formal organizations were not only aware of each other, but also quickly formed and expanded their collaborative networks within a few days. At that time, there was alignment in formal and volunteer-based, participatory emergency responses. During the earthquake response period, there were dynamic, rich interactions between participatory online groups and formal organizations (i.e. flows of information and resources). Each member of the large collaborative network contributed to the effective response by offering their expertise and resources to other members.

Case 3: The 2010 Indonesia Volcanic Eruption

Mount Merapi in Indonesia is one of the most active volcanos around the world. Recently, two big eruptions occurred in 2006 and 2010. Particularly, the 2010 eruption was the greatest eruption in 140 years and caused over 350 deaths and 400,000 people internally displaced. At that time, approximately, 70,000 people lived on the slopes of Merapi, which were considered as regions most vulnerable to volcanic eruptions. But they did not want to leave the slope regions due to environmental, economic, and cultural benefits, such as soil fertility, water availability, touristic areas, and shared tribal culture (Mei et al., 2013).

Despite ongoing hazards, Indonesian formal emergency management agencies seriously lacked their capacity to deal with natural disasters. Specifically, the formal agencies failed to set up an effective emergency information and communication system to gather the changing state of emergencies and disasters on the ground and disseminate the collected information to the public in real-time (Gultom & Joyce, 2014). As a result, local residents had difficulty receiving important disaster information and communicating with the agencies. The agencies were also characterized by closed, hierarchical decision making processes and structures, following their emergency management regulations and laws (Motozuka & Kanki, 2013). Local residents' needs, knowledge, and opinions were not reflected in the emergency management decision making process (Birowo, 2010).

Furthermore, during the 2010 eruption of Mount Merapi, the mainstream mass media, particularly television stations, failed to provide the affected people with accurate, objective, and useful information on disaster situations. Rather the mass media focused on sensational issues. The mass media obtained the information mostly from the formal agencies and did not represent the affected people's true concerns and reality (Saputro,

2014; Tanesia & Habibi, 2011). The formal agencies' lack of capacity and the mainstream media's failure motivated local residents of Mount Merapi and community-based organizations to create their own information network to address natural disasters.

JALIN Merapi. JALIN Merapi is a community-based, participatory online group. After the 2006 eruption, this online group was established and has been managed by Indonesian three community radios located on the slopes of Mount Merapi, including Lintas Merapi FM in Klaten, MMC FM in Boyolali, and K FM in Dukun-Magelang. Hundreds of local volunteers work with this online group and several Indonesian non-governmental organizations (NGOs), including COMBINE Resource Institution (a local NGO to build community-based information systems), the Indonesian Forum for Environment (an environmental advocacy NGO), and KOMPIP (a local NGO advocating for deliberative democracy), have supported JALIN Merapi by offering a variety of expertise and financial and technical resources.

Basically, JALIN Merapi aims to provide accurately and quickly local residents with information of the volcano's activities, serving as a community-based risk reduction system (Nugroho & Syarief, 2012). Dozens of observation posts surrounding the three community radio studios were built to visually monitor the activities of the volcano. Volunteers in charge of the observation posts regularly reported the volcano's activities and emergencies to the radio studios through walkie talkies. The community radios broadcasted the information collected from the observation posts as well as seismographic data from formal emergency management agencies (Birowo, 2010). At the end of November, 2010, JALIN Merapi also installed closed-circuit televisions (CCTVs)

to monitor the volcano's activities and lava[15] and lahar[16] flows (Motozuka & Kanki, 2013). All information was integrated and published on JALIN Merapi's website (http://merapi.combine.or.id/). Since its establishment in 2006, JALIN Merapi has served as a community-based, reliable information provider for residents surrounding Mount Merapi

Community-based response to Mount Merapi's eruptions. The 2010 eruptions of Mount Merapi forced those who lived within a 12 mile radius of the top of Merapi to evacuate to refugee camps. Within 2 weeks after the eruptions, the number of people internally displaced was increased to approximately 400,000 and over 600 refugee camps arose abruptly, spanning 7 districts surrounding Mount Merapi. However, the mainstream media paid attention only to a few major official refugee camps, ignoring many other camps that were geographically dispersed and were not easily accessible. More importantly, due to the lack of information on what was going in the field and capacity to deal with disasters, Indonesian formal emergency management agencies were inefficient in allocating and delivering relief resources for refugees (Saputro, 2014). To help resolve the problems, JALIN Merapi used a variety of information and communication technologies (ICTs) including radio streaming, walkie talkies, field information posts, short message service (SMS), instant messenger (e.g., shoutbox),

[15] Hot and molten rock flowing from a volcano

[16] Debris flows from a volcano

email, Twitter[17], Facebook[18], Google Docs, and the website[19]. JALIN Merapi tried to use both traditional and new communication tools because users and audience have their own media preferences at the different levels of technology adoption (Gultom & Joyce, 2014). Also, JALIN Merapi used Twitter to mobilize about 2,000 volunteers and coordinated their work through Facebook Groups. JALIN Merapi deployed volunteers at or close to refugee camps that were ignored by the mainstream media and did not received government aid, and the volunteers reported refugees' status and needs through walkie talkies or SMS. The affected people on the ground were also able to submit their information (e.g., camp location and the number of refugees) and requests for aid through SMS, instant messenger, or other communication tools. All sources of information from the ground were integrated on the website and were quickly transferred from one medium to others to reach out to the wider users and audience in Indonesia and across the globe.

JALIN Merapi was efficient in mobilizing humanitarian aid from Indonesian people and international aid organizations and in distributing the aid to the affected people in need. JALIN Merapi did not act as an intermediary of aid mobilization and distribution just like existing formal aid organizations did (e.g., the Red Cross or government agencies for humanitarian aid). Instead, JALIN Merapi made a direct connection between those who wanted to donate in-kind resources or money and the affected people in need by posting, verifying, and updating refugees' needs and status on Twitter and Google Docs (Saputro, 2014). The affected people submitted their requests

[17] https://twitter.com/jalinmerapi and https://twitter.com/jalinmerapi_en

[18] https://www.facebook.com/pages/Jalin-Merapi/115264988544379

[19] http://merapi.combine.or.id/?lang=id

for assistance through SMS, instant messenger, email, or Twitter. Importantly, those who submitted requests for aid were required to include their contact information, such as telephone number. Therefore, volunteers in charge of data verification contacted those who submitted the requests to ascertain whether the information was accurate and reliable. Sometimes, volunteers in the field visited those who submitted the requests for the purpose of data verification. "Keeping the accuracy of information was one of the most determining factors in drawing and maintaining attention and aid from the general public" (Nugroho & Syarief, 2012, p. 92). Along with data verification, volunteers in JALIN Merapi's media center located at COMBINE Resource Institution's office constantly uploaded and updated the information on Twitter in near real-time. Based on the information, Indonesian people and Indonesian or international aid organizations were able to identify which areas were lacking which goods and services. Such accurate and reliable information enabled Indonesian people and formal aid organizations to effectively allocate their resources to meet refugees' unmet needs.

Secondary disaster: Cold lava floods. After passing the emergency phase of Mount Merapi's eruptions, those who live along the rivers with upstream on the slopes of Mount Merapi were exposed to a secondary natural disaster (i.e. cold lava floods). The 2010 eruption made a large amount of cold volcanic materials (approximately 40 billion gallons). The volcanic materials are extremely dangerous in rainy season. When raining, the materials like big stones are mixed with water and are easily carried away along the rivers. Cold lava floods often destroy bridges and villages close to the rivers, thus resulting in thousands of people displaced (Tanesia & Habibi, 2011). In addition, many people who live along the rivers dig sand and stones in the rivers and sell them for their

living. Therefore, the condition of the rivers is important to those people's safety and livelihood.

As heavy rain and flooding begin, JALIN Merapi broadcasts real-time reports on the current status of rainfall, the rivers, and nearby roads. JALIN Merapi receives the information through walkie talkies from field volunteers who monitor the status at observation spots located along the rivers. The information is quickly disseminated to local residents who live along the rivers through radio streaming. The information is also posted and updated on Twitter, Facebook, and the website. In addition, JALIN Merapi provides early warnings and emergency information about evacuation paths and refugee camps (Birowo, 2010). Therefore, JALIN Merapi plays a crucial role of a community-based emergency information network for those who are vulnerable to cold lava floods.

Relationships between participatory online groups and formal organizations. Since its establishment in 2006, JALIN Merapi consisting of three community radios and their local volunteers have built and maintained collaborative partnerships with several Indonesian NGOs, including KOMPIP, the Indonesian Forum for Environment, and COMBINE Resource Institution (Motozuka & Kanki, 2013; Tanesia & Habibi, 2011). These NGOs have offered a variety of administrative, technical, financial supports to JALIN Merapi (Birowo, 2011). Particularly, COMBINE Resource Institution is an invaluable resource for JALIN Merapi. This NGO helped JALIN Merapi effectively mobilize and coordinate over 2,000 volunteers through social networking sites (Facebook Groups and Twitter) during the volcanic eruption response (Nugroho, 2011). This NGO built an integrative information system that enabled JALIN Merapi's volunteers to collate and process disaster data from multiple sources. This NGO also helped check the

accuracy of disaster data from the ground and publish the data on the website (http://merapi.combine.or.id). Thus, JALIN Merapi and Indonesian NGOs (particularly, COMBINE Resource Institution) were aware of one another and maintained robust collaborative relationships for the effective response to the volcanic eruption.

In contrast, JALIN Merapi and Indonesian formal emergency management agencies did not collaborate with each other, although both parties were aware of each other. Specifically, both JALIN Merapi and the formal agencies created data about disaster conditions and the affected people's needs. But the data was not shared with each other in a coordinated manner.

Case 4: The 2011 Japan Earthquake and Nuclear Crisis

On March 11, 2011, a magnitude 9.0 earthquake struck Japan. The earthquake also resulted in massive tsunamis with a maximum height of about 130 feet, which hit the pacific coast of the Japanese mainland called Honshu. The earthquake and tsunamis critically damaged the Fukushima Daiichi nuclear power plant, thus enormous amounts of radiation were leaked into the environment. In turn, the 2011 Japan disaster caused 20,000 deaths and destroyed numerous buildings, roads, rail lines, and other physical infrastructure. The total cost of the damage was over $235 billion (Aldrich, 2012; Arase, 2012). In the early days and weeks, the Japanese local and central governments had serious difficulty communicating with the affected communities. As a result, it was hard for the governments to collect and update information on what was happening in the field. The lack or absence of such information caused the governments' responses to the disaster to be severely delayed. In such a situation, many participatory online groups

emerged rapidly to collate and publish disaster-related information and to coordinate the mobilization and delivery of relief resources.

Information aggregation and self-organizations for relief. Participatory online groups for disaster information aggregation and aid mobilization and delivery include (1) jishinhelp.com[20], (2) anpi report[21], and (3) shinsai.info[22]. The first two online groups used Twitter data since Twitter was most popular at that time in Japan among social networking sites. Tweets on Twitter can be tagged with certain words "to link them to others of a similar theme through a function called "hashtags," a label that users put on their own tweets to associate information with certain keywords" (Slater et al., 2012, p. 100). In the disaster situation, Twitter users used the following keywords as hastags to request relief services and share individual safety and evacuation information: #j_j_helpme[23], #anpi[24], or #hinan[25]. Tweets with such hashtags were consolidated on jishinhelp.com and anpi report. Particularly, jishinhelp.com provided a search engine to help users to easily and effectively look for information they needed. While jishinhelp.com aimed to provide a wide range of information of safety, evacuation, and requests for help, anpi report focused on individual safety issues, reporting the names and addresses of missing people.

[20] http://jishinhelp.com/ (The site is now closed.)

[21] The site is now closed.

[22] http://www.sinsai.info/

[23] The first j stands for Japan and the second j for jishin that means earthquake in Japanese.

[24] Safety information

[25] Evacuation information

Additionally, the Japanese OpenStreetMap (OSM) community created shinsai.info to integrate disaster-related information from multiple sources in collaboration with other OSM volunteer mappers from both across the globe (particularly, Japanese students who studied in the United States) and Japan. The Japanese OSM community "received support from large corporations such as Amazon, Yahoo Japan, Glee, Heart Beats, NTT [(the Nippon Telegraph and Telephone Corporation)], and E5Gamers" (Hong, 2014, p. 15). Shinsai.info enabled people in the affected areas to submit their urgent requests for help by email and online forms on the website or by posting tweets with hashtags on Twitter. On shinsai.info, over 12,000 requests for rescue or aid were submitted from the ground. Shinsai.info also provided information about a variety of relief resources, including the locations of shelters and clinics, official announcements from the government, and related news articles. All the information and requests from ground were geo-located with GPS coordinates and visualized on shinsai.info. Over 200 volunteers both from across the globe and the affected areas participated in this crisis mapping project. In addition, over 500 OSM volunteer mappers both from around the world and Japan took part in creating post-disaster digital maps of the affected areas in the immediate aftermath of the earthquake. The OSM volunteer mappers draw and edited over 500,000 streets and roads within the two months after the disaster.

Also, many smaller, community-based, and action-oriented online networks arose by using social media and other online platforms. These online networks focused on particular issues and geographic regions (e.g., saving pets or mobilizing relief resources for local school students). These online networks enabled "the exchange of

needs and relief, ranging from the very small scale ("I have some clothes to donate – can anyone who is going up north take them?" or "We need interpreters who can speak Chinese to help local workers") to the larger ("Second Harvest Japan is brining five trucks to Ishinomaki and we need help unloading them")" (Slater et al., 2012, p. 100). One example of the community-based online networks is "311help," established by a local school in Tohoku, the northeastern region of the Japanese mainland. After the Japan disaster occurred, the school's students stayed in local shelters. The school posted the students' needs on 311help. Through 311help, local residents were able to recognize and provide requested items. Once the students' needs were satisfied, the items for the students was marked as complete. Like this, many local communities successfully self-organized and coordinated their local relief efforts in a decentralized way through simple online platforms.

Dealing with radiation issues: Safecast as a citizen-led sensor network. The 3/11 earthquake and tsunamis severely damaged the Fukushima Daiichi nuclear power plant. As a result, hydrogen explosions occurred on March 12 and 14, thus releasing massive radiation to the environment. Right after that, local residents were evacuated from 12 miles around the nuclear power plant. More importantly, the Fukushima local authority responsible for nuclear facilities and the central government had serious difficulty measuring radiation levels, although the information of radiation levels was crucial for determining evacuation zones and dealing with the nuclear crisis. Actually, all of 24 fixed radiation monitoring sensors in Fukushima did not work in the early days of the disaster, because the fixed sensors were damaged by tsunamis or ran out of fuel (Hemmi & Graham, 2014). The Fukushima local authority had also mobile monitoring

cars, but the monitoring cars failed to measure radiation levels and send the data because the mobile network was damaged and owing to lack of fuel. Moreover, since the Fukushima radioactivity data center was located within the evacuation zone, the data center was abandoned. The absence or lack of information on radiation levels made Japanese extremely concerned about their health and safety. But, Tokyo Electric Power Company (TEPCO), the operator of the nuclear power plant, and the central government downplayed the disaster's severity. Japan's Ministry of Education, Culture, Sports, Science and Technology (MEXT) responsible for monitoring radiation delayed in mapping and publishing radiation data online (Abe, 2014, p. 2). Also, official radiation data published by MEXT was too technical and did not cover enough locations, and the collection methodology of radiation data was opaque (Kera, et al., 2013). The government's nontransparent and inappropriate responses to the nuclear crisis led to Japanese citizens' mistrust in the government's capacity to address the nuclear crisis.

In such a situation, a participatory online group called Safecast emerged to help resolve the nuclear crisis. Right after the 3/11 earthquake, the three key founding members of Safecast, including Sean Bonner, a Los Angeles-based technology entrepreneur, journalist, and activist, Joi Ito, the Japanese director of the MIT Media Lab based in Boston, and Pieter Franken, the Dutch CTO of a Japanese financial institution, began talking about how to deal with the nuclear crisis regarding a lack of radiation data through email and Skype. Many other people, including Dan Sythe, the CEO of International Medcom, Inc.[26], Andrew Huang, Singapore-based American hacker and

[26] Produces radiation detection instruments and systems (https://medcom.com/)

hardware engineer, and Ray Ozzie, an American technology entrepreneur and the CTO of Microsoft, also involved the conversation. And these people who participated in the discussion determined to develop a new, low-cost radiation monitoring device. For that purpose, they worked with computer programmers, engineers, scientists, and designers at the Tokyo Hackerspace[27]. As a result, radiation monitoring devices called bGeigie Nano Kit was developed and supplied. In this regard, Safecast received funds from a variety of sources, such as the Kickstarter crowdfunding campaign ($36,900)[28], the John S. and James L. Knight Foundation ($2.2 million)[29], and other private donations.

Moreover, Joi Ito was introduced by Aaron Huslage, an open-source hardware designer and crisis response specialist to Marcellino Alvarez, the CEO of Uncorked Studios, a design and engineering firm based in Portland, OR[30]. Soon after the 3/11 disaster occurred, Alvarez created and was operating a website called RDTN.org. The site aimed to aggregate and map radiation data from the official public agencies and the general public who owned personal Geiger counters. Alvarez decided to collaborate with Safecast to help address the nuclear crisis. As a result, Safecast was able to use the newly developed radiation monitoring devices and the website to measure, map, and publish radiation data (Hemmi & Graham, 2014).

[27] Common workspace in which people with common interests in technology, science, and art meet together to socialize, develop a new device, and carry out their other collaborative projects (http://tokyohackerspace.org/)

[28] One of funding platforms for creative projects (https://www.kickstarter.com/)

[29] http://www.knightfoundation.org/

[30] http://uncorkedstudios.com/us

With the help of International Medcom, Inc., a producer of radiation detection instruments and systems, Safecast deployed over 800 mobile or static radiation monitoring devices and systems across Japan. As of May 2014, radiation data were collected from approximately 18,000,000 data points. The collected radiation data also include geo-location information (i.e. GPS coordinates of data points) and time information (i.e. when radiation data was measured). With the belief that data must be freely available and more data is better, the collected information was published on the website (http://blog.safecast.org/data/) under the Creative Commons public domain designation[31]. Thus, anyone could freely download the radiation dataset from the website and use the dataset for his or her various purposes. This radiation data project was also crowdsourced to the general public. Hence, people who had their own Geiger counters could upload their radiation data to the website. Safecast also provided their Application Programming Interface (API). By using the API, users could easily access, query, and add other data to the Safecast raw radiation dataset.

Furthermore, Safecast visualized the radiation data by providing a variety of maps on the website to help people recognize radiation levels. For example, the Safecast map[32] showed the radiation levels of over 18,000,000 data points collected by the Safecast team (i.e. both mobile or fixed censors), while the fusion map[33] and interpolation map[34]

[31] http://creativecommons.org/publicdomain/zero/1.0/

[32] http://safecast.org/tilemap/

[33] http://gamma.tar.bz/maps/main/

[34] http://gamma.tar.bz/maps/static/

depicted only the Safecast mobile data. And another map called the failed robot map[35] visualized the aggregated radiation data from different sources, including crowdsourced individual Geiger counters, the Safecast fixed sensor network, and government sensor networks.

All projects of Safecast were conducted by approximately 100 enthusiastic volunteers both from across the globe and Japan. The Safecast team worked together to develop radiation sensors, maintain and update the website, and collect, publish, and visualize radiation data. Over the first year, Safecast had no physical office space[36], so that the Safecast team used social media, Skype, and email to communicate with one another and coordinate their projects. That is, online chat rooms were their virtual headquarter. Information and communication technology is very crucial for not only their project coordination, but also communication between Safecast and the general public in Japan and across the world. Safecast used social media, such as Facebook, Twitter, and Google+, to keep people posted on their projects. In addition, through social media, particularly Google+, Safecast openly discussed on their projects with a wider community, including ordinary people, journalists, and nuclear experts. The open discussion helped address criticisms from radiation specialists, for example, regarding mobile sensors' data collection procedures, thereby improving the scientific credibility of the projects.

Relationships between participatory online groups and formal organizations. In the case of the Japan earthquake and nuclear crisis, participatory online groups (both

[35] http://japan.failedrobot.com/

[36] Safecast has now a fixed location in Tokyo.

the Japanese OpenStreetMap community and Safecast) had collaborative relationships with many for-profit corporations and nonprofit foundations. In partnerships with such formal organizations, participatory online groups received a variety of financial and technical supports essential to their voluntary, collective responses to the disaster. Specifically, Safecast collaborated with Keio University, International Medcom, Uncorked Studious, and the MacArthur Foundation (Abe, 2013, 2014; Bonner, 2012; Kera et al., 2013). These organizations offered expertise on interpolation and geographic data visualization, helped design and produce a low-cost Geiger counter called bGeigie Nano Kit, and provided funding for the volunteer-based radiation data project. In other words, these organizations acted as supporting partners for participatory online groups.

Also, the Japanese government recognized participatory online groups' efforts for addressing the earthquake and nuclear crisis (Aldrich, 2012; Appleby, 2012). The Minister of Education, Culture, Sports, Science and Technology responsible for monitoring radiation told reporters, "Citizen's groups have played a very important role in examining their neighbors closely. I really appreciate their contribution, as it's most important to eliminate as many hot spots as possible" (Aldrich, 2012, pp. 8–9). The Fukushima prefectural government used Safecast's data to create their world radiation map (Abe, 2013). Sinsai.info created by another participatory online group "was also recognized by the Japanese government, and the crisis map was embedded in the official website of the Japanese cabinet during the response period" (Hong, 2014, p. 15). Moreover, the post-earthquake online map of the affected areas created by OpenStreetMap volunteers "was shared on the National Research Institute for Earth Science and Disaster Prevention's website, All311" (Appleby, 2012, p. 36).

Despite such data sharing, more importantly, it is unclear whether participatory online groups and the Japanese government collaborated with each other in a coordinated manner to collectively respond to the disaster (Appleby, 2012). For example, the Safecast team did not directly work with the Japanese government because they wanted to be independent of and uninfluenced by the nuclear power debate in politics and owing to a lack of the government's transparency of data collection methodology (Abe, 2013, 2014). Thus, based on their own procedures and methodologies, Safecast and Japan's Ministry of Education, Culture, Sports, Science and Technology (MEXT) collected, visualized, and published radiation data, respectively. In this regard, there was no alignment or coordination in formal and volunteer-based, participatory emergency responses. Also, although participatory online groups created and updated useful disaster information in real-time (i.e. the crisis map (sinshai.info) and the post-earthquake digital map of the affected areas (OpenStreetMap)), there is little evidence that formal response organizations used such disaster information on the ground for their response activities, such as search-and-rescue operations and the delivery of relief resources (Appleby, 2012). Thus, it seems that participatory online groups were disconnected to formal response organizations in the field during the response period.

Building Hypotheses on Relationships between Participatory Online Groups and Formal Organizations

In the above four cases, there were different types of relationships between participatory online groups and formal organizations in crisis or disaster situations. These inter-organizational relationships fall mostly into two types of relationships:

complementary or ignoring (See Table 2.3). In this section, based on the results of the four case studies and the literature, I explore the determinants to form relationships between participatory online groups and formal organizations and how the formation of these inter-organizational relationships influence the outcomes of the responses to crises or disasters, thus developing hypotheses (See Figure 2.2).

Table 2.3

Typology of Relationships between Participatory Online Groups and Formal Organizations

		Awareness	
		+	-
Alignment	+	**Type 1 (Complementary and synergic)** - **Kenya**: The Ushahidi team and Kenyan NGOs - **Haiti**: The Tufts support team and international first responders - **Haiti**: Humanitarian OpenStreetMap Team, for-profit satellite imagery companies, and international first responders - **Haiti**: The Mission 4636 team, Haitian Telecommunication companies, nonprofit technology companies, and international first responders - **Indonesia**: JALIN Merapi and Indonesian NGOs	**Type 2 (Additive)** - **Indonesia**: JALIN Merapi and the Indonesian government regarding the mobilization and delivery of relief resources
	-	**Type 3 (Ignoring and uncooperative)** - **Indonesia**: JALIN Merapi and the Indonesian government - **Japan**: The Japanese OpenStreetMap community and the Japanese government - **Japan**: The Safecast team and the Japanese government	**Type 4 (Inconsistent and confusing)** - **Kenya**: The Ushahidi team and Kenyan NGOs in the immediate aftermath of the crisis - **Haiti**: The Tufts support team and international first responders in the immediate aftermath of the earthquake

Precondition for Building Relationships: Inter-Organizational Awareness

Inter-organizational awareness acts as a main precondition for building relationships between participatory online groups and formal organizations in crisis or disaster situations. Inter-organizational awareness means that participatory online groups and formal organizations recognize other actors' existence, aims, activities, and resources related to the response to crises or disasters (Stoll et al., 2010; Thellufsen et al., 2009). For example, in the Haiti case, the Tufts support team and international first responders, such as the U.S. Marine Corps and the U.S. Coast Guard, first needed to recognize each other to initiate collaborative relationships during the earthquake response. Particularly, I note that many participatory online groups emerged globally and a lot of formal response organizations both from across the globe and the affected countries were mobilized and deployed in recent large-scale crises or disasters, such as the 2010 Haiti earthquake. In such situations, inter-organizational awareness is more important to develop relationships between participatory online groups and formal organizations, because without inter-organizational awareness, both actors cannot reach out to each other and form their collaborative relationships.

More importantly, I note that inter-organizational awareness is a necessary but not sufficient condition for building relationships between participatory online groups and formal organizations. It was apparent in both the Indonesia case and the Japan case. Specifically, JALIN Merapi and the Indonesian emergency management agencies recognized each other's existence and response tasks and activities in the case of the 2010 volcanic eruption. But both parties did not collaborate with each other in a coordinated manner to effectively respond to the volcanic eruption. In addition, the Japanese

government agencies such as the Ministry of Education, Culture, Sports, Science, and Technology (MEXT) were aware of participatory online groups (i.e. the Japanese OpenStreetMap community and Safecast). But these government agencies did not coordinate their responses in collaboration with participatory online groups during the 2011 earthquake response period. Participatory online groups (particularly, Safecast) also were aware of the government agencies, but unwilling to reach out to the agencies to be independent of the nuclear power debate in politics (Abe, 2013, 2014; Appleby, 2012).

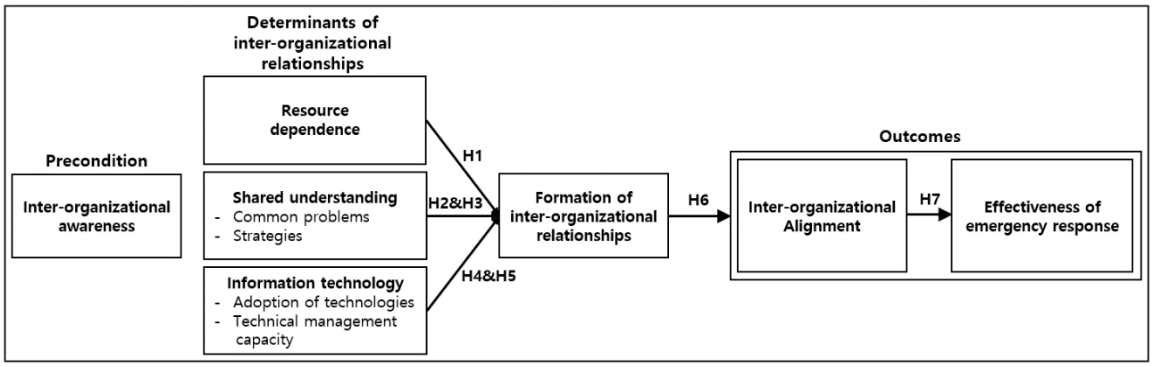

Figure 2.2. Conceptual framework of inter-organizational relationships between participatory online groups and formal organizations

Key Determinants of Inter-Organizational Relationships

I found out from four cases three key determinants of building relationships between participatory online groups and formal organizations in crisis or disaster situations: resource dependence; shared understanding; and information technology.

Resource dependence. Resource dependence was a key determinant to form collaborative relationships between participatory online groups and formal organizations. Resource dependence means that participatory online groups and formal organizations rely on each other to create and deliver a variety of tasks and activities in response to

crisis. First, in the Kenya case, the Ushahidi team and Kenyan NGOs were interdependent. Kenyan NGOs provided trusted reports on crisis conditions to the Ushahidi team, helped verify reports from multiple sources, and made a significant contribution to publicizing the existence of the Ushahidi platform and how to submit reports across Kenya. On the other hand, the Ushahidi team offered real-time information about crisis conditions and peacebuilding efforts to Kenyan NGOs. These NGOs used this information to coordinate their response tasks and activities in an efficient and effective manner.

Additionally, in the Haiti case, participatory online groups (the Tufts support team, the Mission 4636 team, and the OpenStreetMap team) and a large group of formal organizations mobilized and deployed were reliant on each other for the effective collective response to the devastating earthquake. On one hand, formal organizations provided a variety of resources to participatory online networks during the earthquake response period. Specifically, for-profit satellite imagery companies donated their satellite imagery of post-earthquake Haiti to the OpenStreetMap (OSM) team. Based on the donated satellite imagery, the OSM volunteers were able to quickly create digital base maps of post-earthquake Haiti. Also, Haitian telecommunications companies (Digicel and Digipoint) enabled the affected people on the ground to submit free text messages (e.g., requests for rescue and aid) to the SMS-based reporting system called Mission 4636. Many for-profit or nonprofit technology companies helped the Mission 4636 team and the Tufts support team integrate disaster-related data from multiple sources by providing technical advice and supports.

On the other hand, verified, translated, geo-coded disaster information created by participatory online groups (the Tufts support team and the Mission 4636 team) was directly sent to formal organizations, particularly international first responders in the field, such as the U.S. Coast Guard and the U.S. Marine Corps. International first responders used this information to coordinate their search-and-rescue operations. Also these first responders relied on digital base maps of post-earthquake Haiti, which were created by the OpenStreetMap volunteers, to coordinate and the allocation and delivery of relief resources in a just-in-time manner.

In the literature, resource dependence is regarded as an important factor to determine inter-organizational relations and data sharing behavior (R. M. Emerson, 1976; Pfeffer & Salancik, 1978; Thomson & Perry, 2006; Wehn de Montalvo, 2003a). According to the literature, organizations are not self-sufficient, thus organizations form inter-organizational relationships to obtain resources essential for their survival from external entities. There are two different perspectives: power and resource dependence theory (Hillman et al., 2009; Pfeffer & Salancik, 1978) and social exchange theory (Cropanzano, 2005; R. M. Emerson, 1976). According to power theories and resource dependence theory that view inter-organizational relationships as political or negotiated dynamics, there are asymmetries in resources between organizations. Such asymmetries in resources "prompts organizations to attempt to exert power, influence, or control over organizations that possess the required scarce resources" (Oliver, 1990, pp. 243–244). In contrast, social exchange theorists contend that resource scarcity leads to inter-organizational cooperation and collaboration (Oliver, 1990). But an important thing that both perspectives have in common is that resource scarcity or dependence generates the

formation of inter-organizational relationships to gain access to a required resources (Barringer, 2000).

> ***Hypothesis 1***. *When participatory online groups and formal organizations are more interdependent on each other in crisis or disaster situations, participatory online groups and formal organizations are more likely to build collaborative inter-organizational relationships.*

Shared understanding. A shared understanding was an important factor to develop collaborative relationships between participatory online groups and formal organizations across all the four cases. A shared understanding can be subdivided into two sub-concepts: common problems and strategies. A shared understanding of common problems means that participatory online groups and formal organizations agree with each other on crisis or disaster situations (i.e. causes and impacts of crises or disasters and the current status of crisis or disaster conditions). A shared understanding of strategies means that participatory online groups and formal organizations reach a consensus on how to resolve common problems that they face in crisis or disaster situations. First, in the Kenya case, the Ushahidi team and Kenyan NGOs reached a consensus on the lack of crisis information as a common problem (i.e. the current state of post-election violence) caused by the Kenyan government's suspension of all live broadcasts and the mainstream media' self-censorship. Also, the Ushahidi team and Kenyan NGOs had the shared understanding of the Ushahidi platform's usefulness to address such a lack of crisis information. So, the Ushahidi team and Kenyan NGOs collaborated with each other to collect, verify, and publicize crisis information.

In the Haiti case, both formal organizations (the U.S. State Department, FrontlineSMS, the Thomson Reuters Foundation, and Energy for Opportunity, and Ushahidi, Inc., and Haitian communications companies) and participatory online groups (the Mission 4636 team and the Tufts support team) recognized the importance of verified, timely disaster information, thus formal organizations and participatory online groups helped each other to set up and manage an integrative disaster information system that was considered as a key strategy for resolving the devastating earthquake. In the Indonesia case, JALIN Merapi's volunteers and Indonesian NGOs agreed that the Indonesian government did not have sufficient capacities to address the volcanic eruptions of Mount Merapi and the affected people's needs and concerns were often times overlooked by the government and the mainstream media (Saputro, 2014). Based on this consensus, JALIN Merapi's volunteers and Indonesian NGOs took collective action to build a community-based disaster information system to collect, verify, and publicize timely information about volcanic activities and the affected people's needs and requests for aid.

In contrast, in the Japan case, I note that the lack of a shared understanding of crisis or disaster conditions and of how to deal with crises or disasters decreased the likelihood of forming collaborative relationships between participatory online groups and the Japanese government. Specifically, the Safecast team (i.e. a participatory online group) paid attention to the severity of the nuclear crisis and considered the lack of radiation data as a main problem of the nuclear crisis. Thus, the Safecast team sought to help fill the gap by developing a Geiger counter and measuring and mapping radiation across Japan. Also, the Safecast team published how to measure radiation on the website

and social networking sites (Facebook, Twitter, and Google+) and openly discussed about their projects to receive feedback and expertise from a wider online community including ordinary Japanese, engineers, and nuclear experts. The Safecast team also uploaded the radiation data to their website under an open-source license called Creative Commons. So, anyone or any organization could download, modify, and share the data for free. That is, openness and transparency were key features of the Safecast team's strategy for resolving the nuclear crisis. In contrast, the Japanese government and Tokyo Electronic Power Company (TEPCO), the operator of the Fukushima Daiichi nuclear power plant, downplayed the severity of the nuclear crisis and delayed in publishing radiation data. Also, the Japanese government provided radiation data in a nontransparent way. Importantly, such a lack of the common understanding of crisis conditions and how to resolve the crisis obstructed the formation of collaborative relationships between the Safecast team and the Japanese government.

In the literature, shared understanding is considered as a key factor to determine inter-organizational relationships (Ansell & Gash, 2008; Bentrup, 2001; K. Emerson et al., 2012). According to the literature, it is essential to reach a consensus on problems and how to address these problems to build collaborative inter-organizational relationships (Ansell & Gash, 2008; Bentrup, 2001).

> ***Hypothesis 2***. *When participatory online groups and formal organizations reach a shared understanding of crisis or disaster situations, participatory online groups and formal organizations are more likely to build collaborative inter-organizational relationships.*

Hypothesis 3*. When participatory online groups and formal organizations reach a shared understanding of how to address crises or disasters, participatory online groups and formal organizations are more likely to build collaborative inter-organizational relationships.*

Information technology. Information technology can influence the formation of collaborative organizational relationships between participatory online groups and formal organizations. Information technology consists of two sub-concepts: the adoption of technologies (both hardware and software) and technical management capacities. Participatory online groups and formal organizations adopted a variety of information and communication technologies (ICTs), including short message service (SMS), email, social networking sites (e.g., Facebook and Twitter), text or video chat applications (e.g., Skype), document collaboration tools (e.g., Google Docs), open-source crisis mapping platforms (e.g., Ushahidi), and collaborative mapping tools (e.g., OpenStreetMap). These ICTs were used for participatory online groups and formal organizations to communicate and collaborate with each other in response to crisis. In the Haiti case, over a dozen formal organizations and participatory online groups used open chat rooms to design and implement the SMS-based reporting system (i.e. Mission 4636) (Meier & Munro, 2010). By using these open chat rooms, participatory online groups and formal organizations quickly made decisions and built the reporting system within a few days. Indeed, these open chat rooms were the virtual headquarters of Mission 4636 during the earthquake response period. Also, participatory online groups, such as the Tufts support team and the OSM team, used open-source software and licenses for their voluntary collective action. Such an adoption of open-source software and licenses enabled formal organizations to

easily get access to data products created by participatory online groups and facilitated collaboration between participatory online groups and formal organizations for the Haiti earthquake response.

In addition to the adoption of technologies, I note the importance of technical management capacities, which are defined as information management skills and expertise for converting, updating, integrating, and distributing data from different sources. In the Haiti case, both participatory online groups and formal organizations had technical management capacities to collate and process disaster data from different sources and integrate the data with their own information systems and infrastructure. For participatory online groups, the OpenStreetMap volunteers had a geographic data management capacity to quickly process and geo-reference satellite imagery donated by for-profit satellite imagery companies such as GeoEye and DigitalGlobe. On the other hand, during the Haiti earthquake response period, formal organizations were also good at processing, converting, and integrating disaster data from participatory online groups. For example, international first responders like the U.S. Marine Corps had technical management capacities to retrieve and integrate disaster-related information (e.g., requests for rescue and aid) from the Ushahidi-Haiti platform (Nelson et al., 2010).

In contrast, in the Indonesia case, the Indonesian local government (particularly, emergency management agencies) did not adopted new media technologies such as the Internet and social networking sites, although a participatory online group called JALIN Merapi adopted a variety of information and communication technologies, including SMS, Twitter, Facebook, email, and the website, to communicate with the affected people and coordinate their volunteers (Nugroho & Syarief, 2012). Moreover, the

emergency management agencies did not have technical management capacities to integrate disaster-related information from multiple sources and to effectively operate the official disaster information system, although JALIN Merapi set up and managed the community-based, disaster information system by updating and integrating disaster data from the ground in near real-time (COMDEV, n.d.; Nugroho & Syarief, 2012). Thus, such differences in technology adoption and technical management capacities acted as a barrier to the development of collaborative relationships between JALIN Merapi and the emergency management agencies.

In the literature, the adoption of technologies (both hardware and software) and technical management capacities are considered as an important factor to determine inter-organizational relationships (Stoll et al., 2010; Wehn de Montalvo, 2003b). Particularly, these technical and information management factors are more important when the aim of inter-organizational relationships is the collection and sharing of data, such as geographic data, crisis data, or health data. In the data sharing context, integrating data from participatory online groups into formal organizations' database is not a trivial matter. It requires information technology and management skills and expertise (N. C. Roberts, 2011). In this regard, for formal organizations and participatory online groups to collaborate with each other, it is necessary for developing common standards of data management, similar or same data representation formats, and interoperable platforms and applications that enable both actors to collect, process and share data from diverse sources (Gao, Barbier, Goolsby, & Zeng, 2011; Wehn de Montalvo, 2003a). Thus, these technologies and information management capacities are important factors to determine

relationships and interactions between formal organizations and participatory online groups in crisis or disaster situations.

> ***Hypothesis 4****. Differences between participatory online groups and formal organizations in information technology adoption are negatively related to the likelihood of the formation of collaborative inter-organizational relationships between participatory online groups and formal organizations.*
>
> ***Hypothesis 5****. When participatory online groups and formal organizations have higher technical management capacities, participatory online groups and formal organizations are more likely to build collaborative inter-organizational relationships.*

The Formation of Inter-Organizational Relationships and Its Outcomes

The formation of inter-organizational relationships between participatory online groups and formal organizations created two key outcomes: inter-organizational alignment in emergency response and the effectiveness of emergency response.

Inter-organizational alignment. In large-scale crisis or disaster situations where numerous participatory online groups spontaneously emerge and a lot of formal response organizations are mobilized and deployed from both around the world and the affected countries, one of key problems related to emergency responses is a lack of timely information about the status of response tasks and activities (i.e. which organizations are doing what, where?) and the duplication of response tasks and activities. For example, in the immediate aftermath of a crisis or a disaster, participatory information groups and formal organizations often separately conduct their own crisis or disaster assessments

without sharing related information with each other, thus wasting time, human and financial resources. However, when participatory online groups and formal organizations formed collaborative relationships, inter-organizational alignment in response tasks and activities was achieved across the four cases. Inter-organizational alignment is defined as the coordination of a wide range of response tasks and activities (both onsite operations and offsite strategic decisions and supports) across participatory online groups and formal organizations that have collaborative relationships (Kathuria et al., 2007). It also means that response tasks and activities of participatory online groups and formal organizations complement and support one another (Kathuria et al., 2007).

In the Kenya case, the Ushahidi volunteers developed an online crisis reporting system and collected, processed, and visualized crisis data from multiple sources. Kenyan NGOs helped publicize the existence of the reporting system and verify reports from the ground. Also, these NGOs used the crisis data to effectively offer peacebuilding efforts and relief resources to the affected people. Thus, the response tasks and activities of the Ushahidi volunteers and Kenyan NGOs supplemented each other in a coordinated manner. In the Haiti case, inter-organizational alignment among a large network of participatory online groups and formal organizations was achieved. For-profit satellite imagery companies donated satellite imagery of post-earthquake Haiti to the OpenStreetMap (OSM) team. Based on the donated imagery, the OSM team collectively created digital base maps of post-earthquake Haiti and provided these maps to other participatory online groups and formal organizations. The Tufts support team collected, verified, and visualized actionable pieces of disaster information and directly sent this information to international first responders in the field. Also, in partnerships with

Haitian communications companies, the U.S. State Department and FrontlineSMS designed and set up the SMS-based reporting system called Mission 4636 by which the affected people on the ground submitted their requests for rescue and aid. Thousands of Mission 4636's volunteers processed, verified, translated and geocoded SMS reports. These reports were also used by international first responders to perform their search-and-rescue operations and allocate and deliver relief resources. As stated above, participatory online groups and formal organizations conducted a wide range of response tasks and activities that supplemented and supported one another.

In the Indonesia case, the volunteers of a community-based, participatory online group called JALIN Merapi collected, processed, and publicized information about volcanic activities, the affected people's needs and requests, and relief resources available. Several Indonesian NGOs provided administrative, technical, and financial supports to JALIN Merapi. These NGOs helped coordinate over 2,000 volunteers of JALIN Merapi and build an integrative disaster information system in which these volunteers processed and verified disaster information in real-time. JALIN Merapi and these NGOs developed and improved collaborative relationships between them and coordinated their response tasks and activities. In the Japan case, the Japanese OpenStreetMap community created digital base maps of post-earthquake Japan and collected, verified, and visualized disaster information in collaboration with Japanese students who studied abroad. Also, Safecast's volunteers developed a Geiger counter and measured and published radiation data. These participatory online groups conducted their diverse response tasks and activities in partnerships with many formal organizations, such as Keio University, International Medcom, Uncorked Studios, and the MacArthur

Foundation (Abe, 2014; Kera et al., 2013). These formal organizations provided a variety of technical and financial supports to participatory online groups. At that time, participatory online groups and formal organizations aligned their resources and efforts for the effective response to the earthquake and nuclear crisis.

Hypothesis 6*. The formation of collaborative relationships between participatory online groups and formal organizations improves inter-organizational alignment in emergency response.*

Effectiveness. Inter-organizational alignment (i.e. coordination of emergency response across participatory online groups and formal organizations) likely improves the effectiveness of emergency response. From a program evaluation perspective, the effectiveness of emergency response is the extent to which emergency response achieves its final goals and objectives. The key goals and objectives of emergency response are "to save lives, protect property and the environment, meet basic human needs, stabilize the incident, restore basic services and community functionality, and establish a safe and secure environment moving toward the transition to recovery" (DHS, 2013, p. i). Based on the four cases, I note that inter-organizational alignment contributes to saving lives and meeting the affected people's needs during the response period.

Saving lives. It is difficult to quantitatively assess how many people were saved as a result of inter-organizational coordination between participatory online groups and formal organizations. But it was clear across the cases that coordinated emergency response between participatory online groups and formal organizations saved numerous lives. Particularly, in the Haiti case, participatory online groups (the Tufts support team, Mission 4636, and OpenStreetMap) provided international first responders on the ground,

such as the U.S. Coast Guard and the U.S. Marine Corps, with digital base maps of post-earthquake Haiti and timely, verified information about requests for rescue. Based on the base maps and the information, international first responders were able to effectively coordinate their search-and-rescue missions. As a result, these first responders rescued a lot of lives. For example, "a seven-year-old girl and two women were pulled from the rubble of a collapsed supermarket by an American search-and-rescue team after they sent a text message calling for help" (Meier, 2010). Also, according to the U.S. Marine Corps (Meier, 2010),

"Based off some information that we received from [the] Ushahidi[-Haiti platform], we inserted the recon platoon this morning to check out a remote village that was listed in some of the blogs. We are now in the process of medevacing two local nationals who would not have received medical treatment in time for life or limb had we not found them."

Additionally, Craig Clark, a civilian analyst for the U.S. Marine Corps, summarized coordinated efforts between participatory online groups and their rescue-and-search teams as follows: "I say with confidence that there are 100s of these kinds of [success] stories" (Meier, 2011, p. 1245).

Meeting the affected people's needs. Coordinated efforts between participatory online groups and formal organizations were effective in meeting the affected people's needs. In the Indonesia case, JALIN Merapi's volunteers and an Indonesian NGO aligned their response tasks and activities in a coordinated manner and created an integrative disaster and relief information system. By using this information system, JALIN Merapi's volunteers collected and processed information about both the affected people's

requests for assistance and relief resources donated by the general public. The Indonesian NGO helped verify this information and offered technical supports for the information system. Such coordinated efforts made an important contribution to matching those in need to those who donated relief resources. In the Haiti case, formal organizations, such as the Red Cross and the World Food Program, used timely information that participatory online groups created about the affected people's requests for aid to effectively allocate and deliver diverse relief resources (drinking water, food, and medical supplies). For example, according to Patrick Meier, a key coordinator of the Tufts support team for the Ushahidi-Haiti platform, "the Red Cross took just 20 minutes to respond to a post about a need for fuel for a generator at a health clinic….[Also,] the World Food Program delivered food to an informal camp of 2500 people, having yet to receive food or water, in Diquini to a location that…[the Tufts support team] had identified for them" (Meier, 2010).

Hypothesis 7*. Inter-organizational alignment in emergency response improves the effectiveness of emergency response.*

Conclusion

In this chapter, I focused on one aspect of the event-driven lens developed in the first chapter of this dissertation. It is the formation of relationships between participatory online groups and formal organizations in crisis or disaster situations. More specifically, I aimed to explore key determinants and outcomes of forming relationships between participatory online groups and formal organizations. For that purpose, I employed the exploratory case study method and conducted four case studies including the 2007-2008

Kenya post-election violence, the 2010 Haiti earthquake, the 2010 Indonesia volcanic eruption, and the 2011 Japan earthquake and nuclear crisis. Based on the findings from these four case studies, I found out three key factors and their sub-factors to influence the formation of relationships between participatory online groups and formal organizations—including resource dependence, shared understanding (common problems and strategies), and information technology (adoption of technologies and technical management capacities). I also found out two outcomes of forming relationships between participatory online groups and formal organizations in crisis or disaster situations. These outcomes are inter-organizational alignment and the effectiveness of coordinated responding efforts. Finally, I developed seven hypotheses.

This research may have limitations. First, this research is based on secondary data. Although I collected data from multiple sources including academic journal articles, practical reports, news articles, and web documents, such secondary data may not provide sufficient, detailed descriptions and explanations regarding the formation of relationships between participatory online groups and formal organizations. Moreover, I did not fully consider a variety of political and social factors that may be associated with the formation of relationships between participatory online groups and formal organizations (e.g., social capital and trust in government).

Despite these limitations, this research is expected to contribute to the literature. Specifically, the findings of this research may contribute to bridging the disconnect between the emergency management literature that stresses formal emergency response and the crisis informatics literature that focuses on volunteer-based, participatory emergency response in the digital era, suggesting key factors to form relationships

between participatory online groups and formal organizations and the outcomes of the formation of such relationships. Furthermore, this research may contribute to the inter-organizational relations (IOR) theory, indicating how volunteer-based online communities and institutionalized formal organizations form loosely connected, inter-organizational relationships in crisis or disaster situations.

CHAPTER 3

TESTING HYPOTHESES ON RELATIONSHIPS BETWEEN PARTICIPATORY ONLINE GROUPS AND FORMAL ORGANIZATIONS

In the second chapter, I developed seven hypotheses on the determinants and outcomes of forming inter-organizational relationships between participatory online groups and formal organizations in crisis or disaster situations. Based on the results of four case studies, I found out three key determinants to form the inter-organizational relationships—including resource dependence, shared understanding, and information technology. I also identified two outcomes of forming the inter-organizational relationships (i.e. inter-organizational alignment and the effectiveness of emergency response). In this chapter, I aim to empirically test hypothesized relationships developed from four case studies in the second chapter. Specifically, for this purpose, this research employs the explanatory case study method, focusing on the 2015 Nepal earthquake.

Extended Conceptual Model: The Developmental Phases of Inter-Organizational Relationships

A conceptual model developed in the second chapter is based on the *formation* of inter-organizational relationships between participatory online groups and formal organizations during the emergency response period (i.e. whether inter-organizational relationships exist or not). However, I note that inter-organizational relationships may dynamically change over time (Imperial et al., 2016; Jap & Anderson, 2007). The literature indicates that there are the developmental phases (or processes) of inter-

organizational relationships: awareness and exploration; expansion and maturity; and decline and dissolution (Dwyer et al., 1987; Ring & Van de Ven, 1994). The first phase (awareness and exploration) is the search and trial phase. In that phase, potential collaboration partners are aware of each other and evaluate "obligations, benefits and burdens, and the possibility of cooperative relationships" (Dwyer et al., 1987, p. 16). In most cases, inter-organizational relationships "emerge incrementally and begin with small, informal deals that initially require little reliance on trust" (Ring & Van de Ven, 1994, p. 101). In that phase, inter-organizational relationships tend to be fragile and can be easily terminated.

In the second phase (expansion and maturity), collaboration partners achieve "the continual increase in benefits…[and] interdependence" (Dwyer et al., 1987, p. 18). Naturally, the levels of shared understanding and mutual trust likely improve. This phase is the most advanced developmental phase of inter-organizational relationships. But, in some cases, inter-organizational relationships reach the decline and dissolution phase. That is, there is always the possibility of withdrawal or disengagement due to violations of trust, changes in the legal and policy environment, or the presence of alternative collaboration partners (Dwyer et al., 1987; Ring & Van de Ven, 1994). Thus, in this chapter, based on the literature, I consider the developmental phases of inter-organizational relationships between participatory online groups and formal organizations, rather than considering only the formation of inter-organizational relationships.

The developmental phases of inter-organizational relationships are defined as (or measured by) the intensity of interaction between participatory online groups and formal

organizations in crisis or disaster situations. In other words, that participatory online groups and formal organizations reach a higher-level developmental phase of inter-organizational relationships means that there are rich, dynamic, and constant exchanges of information and resources between participatory online groups and formal organizations (Dwyer et al., 1987). Sometimes, in the literature, the developmental phases of inter-organizational relationships are defined as the level of institutionalization or formalization of inter-organizational relationships (e.g., a written contract and a formal agreement) (Ring & Van de Ven, 1994). However, I note that in most cases, participatory online groups and formal organizations collaborate with each other in an informal, voluntary manner. Thus, it would be inappropriate to define the developmental phases of inter-organizational relationships as the level of formalization.

Furthermore, I note that relationships between participatory online groups and formal organizations quickly evolve in an urgent crisis or disaster situation. It means that it would be possible for participatory online groups and formal organizations to reach a higher-level developmental phase of inter-organizational relationships during a relatively short period in crisis or disaster situations.

Figure 3.1 indicates the extended conceptual model of inter-organizational relationships between participatory online groups and formal organizations. Specifically, I examine how resource dependence, shared understanding, and information technology influence the level of inter-organizational relationship development (that is, the intensity of interaction) and ultimately how the level of the relationship development influences the outcomes of emergency response.

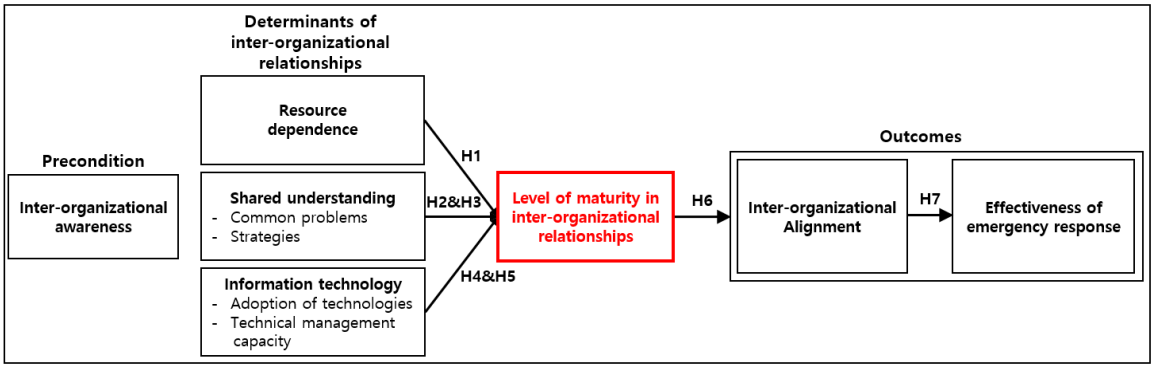

Figure 3.1. Extended conceptual model

Based on the conceptual model, this research tested the following hypotheses:

H1*: When participatory online groups and formal organizations are more dependent on each other in crisis or disaster situations, participatory online groups and formal organizations are likely to have a higher level of maturity in inter-organizational relationships.*

H2*: When participatory online groups and formal organizations reach a higher level of a shared understanding of crisis or disaster situations, participatory online groups and formal organizations are likely to have a higher level of maturity in inter-organizational relationships.*

H3*: When participatory online groups and formal organizations reach a higher level of a shared understanding of how to address crises or disasters, participatory online groups and formal organizations are likely to have a higher level of maturity in inter-organizational relationships.*

H4*: Differences between participatory online groups and formal organizations in information technology adoption are negatively related to the level of maturity in inter-organizational relationships.*

H5*: When participatory online groups and formal organizations have higher technical management capacities, participatory online groups and formal organizations are more likely to have a higher level of maturity in inter-organizational relationships.*

H6*: When participatory online groups and formal organizations have a higher level of maturity in inter-organizational relationships, inter-organizational alignment in emergency response likely increases.*

H7*: Inter-organizational alignment between participatory online groups and formal organizations in emergency response likely improves the effectiveness of emergency response.*

Research Methods: The Explanatory Case Study Method

This research employs the explanatory case study method. The explanatory case study method is an empirical inquiry that aims to test constructs (or variables) of interest within the real-life context (Yin, 2003). This research method allows the researcher to conduct in-depth analysis on how constructs (or variables) influence other constructs with multiple sources of evidence. This research focuses on the 2015 Nepal earthquake to investigate how resource dependence, shared understanding, and information technology shape the developmental phases of inter-organizational relationships and how the level of inter-organizational relationship development impacts inter-organizational coordination and the effectiveness of emergency response.

Case Selection

In this research, I employed theoretical sampling, which the researcher purposely selects a case or cases considered as suitable for illuminating relationships among

constructs (or variables) (Corbin & Strauss, 2008; Eisenhardt & Graebner, 2007). Specifically, I used the following case selection criteria: the magnitude of a crisis or a disaster, the level of public attention to a crisis or a disaster, the mobilization of formal organizations, the emergence and contributions of participatory online groups, and advances in technologies.

Based on the criteria, the 2015 Nepal earthquake case was selected for this study. The Nepal earthquake was one of the most catastrophic earthquakes regarding magnitude and fatality. On April 25, 2015, a 7.8 magnitude earthquake struck Nepal, followed by another 7.3 magnitude earthquake on May 12, 2015. These earthquakes caused approximately 9,000 deaths and injured over 100,000 people (UNOCHA, 2015a). Also, such magnitudes and fatalities of the earthquakes suddenly drew the attention of Nepalese people and the Nepalese government, the general public across the world, other governments, and international organizations to the catastrophic event. Naturally, approximately five hundred institutionalized formal organizations—including the United Nations, the Nepalese Government, Oxfam, and the Red Cross—participated in the earthquake response. Furthermore, many participatory online groups emerged from both across the globe and the affected regions and took voluntary, collective action to respond to the devastating earthquake by using information and communication technologies. Lastly, I note that various new technologies, such as artificial intelligence and drones, were used for the Nepal earthquake response.

Data Collection

One of key strengths that the case study method has is to use multiple sources of evidence (i.e. data triangulation) (Yin, 2003). In this study, data comes from diverse

sources including individual interviews, web documentation, mainstream media coverage, and activity logs and the content on an online platform.

Individual interviews. I conducted individual interviews with 15 people who participated in the Nepal earthquake response and have expertise on relationships and interactions between participatory online groups and formal organizations. 8 interviewees come from institutionalized formal organizations including the Canadian Disaster Assistance Response Team (DART), Humanity Road, MapAction, the U.N. Office for the Coordination of Humanitarian Affairs (UNOCHA), the U.N. Volunteers (UNV) Program, and the U.S. Agency for International Development (USAID). Other 7 interviewees are members of participatory online groups including the Kathmandu Living Labs (KLL), the Humanitarian OpenStreetMap Team (HOT), and the Standby Task Force (SBTF). These interviewees were selected because over the past 5 years, most of these interviewees have worked together to build collaborative initiatives between participatory online groups and formal organizations for emergency preparedness and response (e.g., the Digital Humanitarian Network[37] and Crisis Mappers Net[38]). Moreover, all the interviewees participated in the Nepal earthquake response (i.e. on-scene operations in the field or off-scene assistance), communicating and collaborating with one another.

In this study I conducted semi-structured interviews which have a preliminary framework of interview questions or themes, but allow for new questions or themes to

[37] http://digitalhumanitarians.com/

[38] http://crisismappers.net/

emerge during the interview (Kvale, 1996). I developed preliminary semi-structured interview questions based on the findings of the earlier four case studies and the literature (See Appendices I and II for specific interview questions). I used a live video chat application (Skype or Zoom[39]) to conduct individual interviews because the selected interviewees live in different countries, such as Germany, Nepal, the United Kingdom, the United States, and Switzerland. I conducted one video interview for each interviewee. Each video interview approximately took one hour. I also videotaped (or audiotaped) and transcribed the interviews to maintain the accuracy of the interview data. After the individual interviews, I conducted one or two follow-up interviews by using email and Google Forms and archived the follow-up interview data (See Appendices III and IV for specific follow-up interview questions).

Secondary data. I collected secondary data from multiple sources including documentation, mainstream media coverage, and activity logs and the content on an online platform. First, documentation includes blog posts, situation reports, after-action evaluations, and other administrative records (over 500 documents in total). Also, I collected media coverage such as newspapers and magazines during the 2015 Nepal earthquake response (approximately 50 news articles). Lastly, I collected activity logs and the content from an online platform (QuakeMap) used for the Nepal earthquake response.

Data Analysis

[39] https://zoom.us/

The hypothesis-testing process in this research is based on four general principles of the explanatory case study (Yin, 2003). The first principle is reliance on theoretical propositions or hypotheses. The explanatory case study aims to examine the causal relationships between constructs or variables of interest. In the explanatory case study, theoretical propositions or hypotheses guide the researcher "to focus attention on certain data [related to the propositions or hypotheses] and to ignore other data[,] [to select appropriate analytical methods,] and to define alternative explanations to be examined" (Yin, 2003, p. 112). Hence, I focused on constructs and the proposed relationships between constructs (i.e. hypotheses) developed from multiple case studies in the second chapter.

The second principle is taking rival explanations into account. That is, the researcher "tries to define and test rival explanations" in the explanatory case study (Yin, 2003, p. 112). In reality, human and organizational behavior and social phenomena occur in an extremely complex situations surrounded by various causes and effects. Thus, it is difficult to determine the causal relationships between constructs or variables of interest. Sometimes, although the researcher finds empirical evidence to support theoretical propositions (or hypotheses), there would be many moderators, mediators, or confounders that the researcher did not fully address. To deal with this issue, the researcher needs to take into consideration possible "other influences" (Yin, 2003). Typical examples of rival explanations include maturation, social trends, regression artifact, and selection bias (Bingham & Felbinger, 2002; Yin, 2003).

The third principle is the use of both qualitative and quantitative data (Yin, 2003). Although qualitative data is a primary source of evidence, the case of the Nepal

earthquake response offers a relatively large amount of quantitative data, particularly activity logs (e.g., how many reports were submitted from the ground? And how many reports were processed by participatory online groups and sent to first responders in the field to perform search-and-rescue operations?). Particularly, such quantitative data is useful to analyze the outcomes of emergency response activities. In this chapter, I conducted descriptive analysis of quantitative data. Results from the descriptive analysis of quantitative data was used to complement and support findings from qualitative data analysis. In other words, "smaller quantitative study helps evaluate and interpret results from a principally qualitative study" (Guest et al., 2012, p. 192).

The forth principle is focusing on both "whether" questions and "how" and "why" questions. This explanatory case study does not just aim to examine whether constructs are (positively or negatively) related to each other, searching for qualitative and/or quantitative evidence to support or reject hypotheses. But, this study also aims to investigate how and why constructs are related to each other in which contexts. Indeed, the case study is appropriate for answering "how" and "why" research questions, providing detailed, in-depth explanations on a phenomenon of interest (Yin, 2003).

Specific analytical approach. In this study, I use confirmatory or hypothesis-driven thematic analysis as a specific analytical approach (Guest et al., 2012; Saldaña, 2013). Unlike exploratory thematic analysis employed in the second chapter for hypothesis-building, confirmatory thematic analysis predetermines a specific coding scheme in which codes (or sub-codes) are directly developed from hypotheses (i.e. a deductive approach or top-down approach to data coding). Then, the researcher empirically assesses and confirms (or disconfirm) hypotheses, as coding and categorizing

actual data on the basis of the predetermined coding scheme. Thus, in this research, I first finalized the coding scheme for qualitative data analysis (See Table 3.1). After that, based on the coding scheme, I coded and categorized qualitative data from multiple sources (e.g., interviews, web documents, social media, mainstream media coverage, etc.) to examine whether hypotheses are confirmed or rejected and to assess how and why constructs are related (or unrelated) to each other. In this thematic analysis, I used a computer software program for qualitative analysis called MAXQDA.

Furthermore, to support and complement qualitative analysis findings, I conducted descriptive analysis of quantitative data. A separate table was created to provide evidence to support or reject each hypothesis (See Table 3.2).

Table 3.1

Deductive Data Coding Scheme

Domain	**Code**	**Description**
Determinants of inter-organizational relationships	Resource dependence	Participatory online groups and formal organizations rely on other parties to create and deliver responding tasks and activities (e.g., financial, human, and information resources)
	Shared understanding of common problems	A consensus between participatory online groups and formal organizations on crisis or disaster situations (i.e. the causes and impacts of crises or disasters and the current status and conditions of crisis or disasters)
	Shared understanding of strategies	A consensus between participatory online groups and formal organizations on how to resolve crisis or disaster situations
	Adoption of technologies	Information and communication technologies adopted by

		participatory online groups and formal organizations to collaborate and communicate with each other
	Technical management capacity	A capacity for converting, integrating, distributing crisis- or disaster-related information between participatory online groups and formal organizations
Level of maturity in inter-organizational relationships	Intensity of interaction	Rich, dynamic, and constant exchanges of information and resources between participatory online groups and formal organizations
Outcomes	Inter-organizational alignment	Coordination of a wide range of responding tasks and activities (both onsite operations and offsite strategic decision-making and supports) between participatory online groups and formal organizations
	Effectiveness of emergency response	Whether responding tasks and activities achieve final goals of emergency response, particularly saving lives and meeting human basic needs

Analysis and Results

Testing Hypothesis 1: Resource Dependence

In this research, I found mixed results on how resource dependence is associated with the development of inter-organizational relationships between participatory online groups and formal organizations in crisis or disaster situations. On one hand, resource dependence likely strengthens the development of collaborative relationships between participatory online groups and formal organizations. In the immediate aftermath of the Nepal earthquake, over 8,000 digital volunteer mappers of the Humanitarian OpenStreetMap Team (HOT) from both around the world and the affected areas collectively created and updated online base maps and offline mobile or printable maps

of post-earthquake Nepal within a few weeks. Because these maps were open source products, any individual or any organization was able to download and use these maps for free. Particularly, these post-earthquake maps were essential for formal organizations, such as international first responders on the ground, to perform their search-and-rescue operations and deliver relief resources.

Figure 3.2. Screenshot of an offline mobile map created by HOT[40]

A member of HOT stressed that "[m]any disasters response organizations rely on data generated by HOT volunteer mappers. This dependence often means we are in direct

[40] Figure 3.2 is a cropped image of the entire screenshot at http://wiki.openstreetmap.org/wiki/2015_Nepal_earthquake under Creative Commons Attribution-ShareAlike 2.0 Generic license.

discussions with humanitarian response organizations who request our data."[41] According to another member of HOT, "[t]here was a high level of interaction [between HOT and formal response organizations]. I would even say [that the relationship was] 'inter-dependent'…. [For example,] [t]he Canadian [Armed] Forces [deployed to Nepal] needed maps. [The Armed Forces'] [s]taff printed those maps right on site at Kathmandu Living Labs using OSM datasets."[42]

Another evidence that resource dependence may improve interactions between participatory online groups and formal organizations comes from collaboration between the Kathmandu Living Labs (KLL) and Humanity Road (HR). The Kathmandu Living Labs (KLL) is a Nepal-based, nonprofit organization that is "dedicated to the co-creation and implementation of mobile and internet-based technology solutions to enhance urban resilience and…civic innovation" (Kathmandu Living Labs, n.d.). Particularly, as a pioneer of the crowdsourced, global OpenStreetMap movement in Nepal, the KLL attempts to use and promote citizen-engaged, open-source, collaborative mapping to solve various social and environmental problems that Nepalese people face. The KLL made an important contribution to the Nepal earthquake response. In the immediate aftermath of the earthquake, the KLL launched a disaster reporting system called QuakeMap. Dozens of volunteers from the affected areas and many international online volunteers who worked remotely joined and collaborated with the KLL to operate the reporting system. The affected people could submit their requests for rescue and aid through the reporting system via email, SMS, and social media, or phone. The KLL

[41] Author's interview with a member of HOT, Participant 6

[42] Author's interview with a member of HOT, Participant 11

volunteers collected, verified, and mapped the reports from the ground. Thus, the KLL was transformed into a quite large group of volunteers during the Nepal earthquake response and served as a coordination hub for collating and processing disaster-related information on the ground.

Humanity Road, a U.S. nonprofit organization under category 501(c)(3), is a formal response organization specialized in emergency communications and online emergency response and is an official partner for civilian and military communications exercises (e.g., the U.S. Pacific Command). Particularly, a main responding task and activity of Humanity Road is to publish timely situation reports and other related information. In the immediate aftermath of the Nepal earthquake, Humanity Road aimed to produce and share situation reports and disaster-related information with other responding organizations. For this purpose, Humanity Road needed information about disaster conditions, the current status of disaster response efforts, and the affected people's requests for rescue and aid. On the other hand, during the Nepal earthquake response period, the KLL needed technical and operational support for the reporting system (QuakeMap) and human resources for overnight processing. In such conditions, the KLL and Humanity Road shared necessary resources with each other. The KLL provided real-time, verified disaster-related information from the ground to Humanity Road that worked remotely in the U.S., while Humanity Road offered "surge support for overnight processing…[,] support for incident process…[, and] operational advice and lessons learned from previous crisis mapping projects" (Humanity Road, 2015, p. 3). Indeed, such interdependence quickly created a high level of collaborative relationship. According to an emergency communications expert of Humanity Road,

> Mutual dependence was…relevant with Kathmandu Living Labs, for their staff when we were at the coordination, at the hand-off point. Daily when they would come on for the morning, for having their breakfast, their morning coffee, we would brief them over what happened in the afternoon or the evening…. [O]ften there were a lot of questions that needed to be answered for us, for our team to continue the following evening, so we had a mutual dependence to be able to communicate in a timely fashion in a way that we can understand each other…. [M]utual dependence [between Humanity Road and the KLL] … spurred on the development on the relationship because it opened up channels of communication.[43]

However, I note that there is critical evidence that resource dependence may not be a key determinant to develop interactions and relationships between participatory online groups and formal organizations. I found this evidence from relationships between the Standby Task Force (SBTF) and the U.N. Office for the Coordination of Humanitarian Affairs (UNOCHA). In the immediate aftermath of the Nepal earthquake, the Standby Task Force (SBTF), a global online group of volunteer crisis mappers, mobilized over 400 online volunteers from both across the globe and Nepal. Their responding tasks and activities were to collate, verify, and visualize disaster-related text and images from multiple sources (the news media and social media). Their tasks and activities created comprehensive '3W' (Who does What Where)[44] reports that included

[43] Author's interview with an emergency communications expert of Humanity Road, Participant 10

[44] 3W reports provide information about "who is responding, where and what they plan to do" to help formal and informal responders coordinate their tasks and activities (SBTF, 2015, p. 3).

information about over 500 formal organizations and volunteer groups that responded to the Nepal earthquake. Also, SBTF searched for and geo-located disaster-related data regarding the specific locations of the affected areas and the urgent needs of the affected people. All the data fed to approximately 30 formal organizations including the U.N. Office for the Coordination of Humanitarian Affairs (UNOCHA), the U.N. Development Program (UNDP), and the World Food Program (WFP).

UNOCHA as the part of the U.N. Secretariat is responsible for mobilizing and coordinating formal organizations across the globe to effectively prepare for, respond to, and recover from crises and disasters. Specifically, in crisis or disaster situations, UNOCHA conducts disaster assessments by collecting and analyzing related information from multiple sources to improve situational awareness on crises and disasters. UNOCHA also manages an Emergency Response Roster and "carries out its coordination function primarily through the Inter-Agency Standing Committee (IASC), which includes UN agencies, NGOs and other humanitarian organizations" (UNOCHA, 2015b, p. 5). Importantly, over the past five years, UNOCHA and SBTF have developed and maintained collaborative relationships (i.e. there has been a high level of dynamic communications and interactions between UNOCHA and SBTF since the 2010 Haiti earthquake). Indeed, UNOCHA and SBTF worked together to respond to several crises and disasters, such as the 2011 Libya crisis and the 2013 Typhoon Hainan. During the Nepal earthquake response, UNOCHA and SBTF actively communicated and collaborated with each other to collect and analyze disaster-related data.

However, despite a relatively high level of interaction between UNOCHA and SBTF (i.e. a high level of inter-organizational relationship development), both UNOCHA and SBTF reported that they were not reliant on each other.

According to a member of SBTF, "[w]e are totally dependent on our resources: Zero money, but heaps of information, connections and the ability to move between them….[SBTF works] with volunteers on the ground, ad hoc groups or civil society groups, and stuff like that. To be able to do what we do, we are not dependent on OCHA."[45] The interviewee also mentioned as follows:

> I'm not sure if they [(UNOCHA)] would ever say that they are dependent on the work that we do. They would never admit that. I don't think so. They would try to create the same kind of things as we do, situational awareness, 3W charts, who's doing what where. They would try to find this information and to create this information with the resources at hand. When there is an online community who can do this and who are experienced in doing this, that is very convenient. I'm actually uncertain if they would say that they are dependent on us.

Furthermore, an information management officer of UNOCHA was of the same opinion as follows:

> The exchange was quite dynamic or high intensity [between UNOCHA and SBTF] around the given projects on which we were collaborating. However, I am not sure if that reflects a dependency or more of a reflection on the nature of work (remote, digital collection of online info, etc). Having said that, none of the

[45] Author's interview with a member of SBTF, Participant 1

projects were "dependent" on the work that the participatory groups were doing for us. Their work was viewed as a "augmentation" of what we were getting through traditional approaches.[46]

Finally, these mixed findings do not support that resource dependence leads to the development of inter-organizational relationships between participatory online groups and formal organizations.

Testing Hypotheses 2 and 3: Shared Understanding

Shared understanding of common problems (H2). The findings from this case study research indicate that when participatory online groups and formal organizations reach a shared understanding of crisis or disaster situations (particularly, the severity of impacts that a crisis or a disaster has), such shared understanding likely leads to the development of inter-organizational relationships between participatory online groups and formal organizations. The participants of this study emphasized that participatory online groups and formal organizations had a consensus on the severity of the Nepal earthquake (i.e. a large-scale catastrophic disaster). According to a volunteer coordinator of the Kathmandu Living Labs, "I don't think we [(participatory online groups and formal organizations)] had a huge disjunct[ion] in sort of the severity of the crisis…. I think we had a somewhat shared understanding of what was going on, of what the situation was."[47] Also, an information management officer of UNOCHA reported that "there was a very good shared understanding of the common problems related to the

[46] Author's interview with an information management officer of UNOCHA, Participant 4

[47] Author's interview with a volunteer coordinator of the Kathmandu Living Labs, Participant 2

emergency."[48] Importantly, the information management officer stressed that "that sort of shared understanding…improves the level of the relation[ship] [between participatory online groups and formal organizations]."[49] Furthermore, a member of the Humanitarian OpenStreetMap Team was of the same opinion: "when we both agreed an event had a moderate to major impact, there was higher interaction [between participatory online groups and formal organizations]."[50] According to another information management officer of UNOCHA, "In Nepal it was very easy. Everybody was mobilizing in the same direction [due to a shared understanding of disaster conditions]….[T]he more difficult areas are [crisis situations] where there..[are] differences…[in] shared understanding particularly relate[d] to warring conflict zones….It's definitely those more ethical situations where there is limited understanding between formal organizations and online organizations."[51] These findings support that a shared understanding of crisis or disaster situations likely improves the interaction between participatory online groups and formal organizations.

Shared understanding of strategies (H3). Participatory online groups and formal organizations have different strategies for dealing with a crisis or a disaster on the basis of their own expertise, experience and resources. In most cases, participatory online groups' strategies are much less formalized and standardized (and flexible and agile) than those of formal organizations (Capelo et al., 2012). That participatory online groups and

[48] Author's interview with an information management officer of UNOCHA, Participant 4

[49] Author's interview with an information management officer of UNOCHA, Participant 4

[50] Author's interview with a member of HOT, Participant 6

[51] Author's interview with an information management officer of UNOCHA, Participant 3

formal organizations have a shared understanding of strategies (i.e. how to address a crisis or a disaster) indicates that both actors understand what each other's different strategies are, how useful and important each other's strategies are, and how each other's strategies can be incorporated to resolve the common problem (i.e. a crisis or a disaster).

In this case study research, I found out that when participatory online groups and formal organizations have a higher level of a shared understanding of strategies for resolving crises or disasters, participatory online groups and formal organizations likely have a higher level of the development of inter-organizational relationships (i.e. more dynamic interactions).

A volunteer coordinator of the Kathmandu Living Labs reported that during the Nepal earthquake response period, he recognized the existence of different strategies between their participatory online group and formal response organizations, but he tried to understand formal organizations' strategies and performed their voluntary emergency response, taking formal organizations' strategies into consideration.

> Because we [Nepalese volunteers at the Kathmandu Living Labs] had never been in a crisis before, there were certain things that we did not know about that were very important to these [formal response] organizations. So one thing's just simply how the [U.N.] Cluster system[52] is organized... Before I got there, there were all of these categories in there, and I just organized the volunteers to

[52] The U.N. clusters are a key element of the U.N. emergency management system to effectively coordinate a wider range of tasks and activities across the phases of emergency management including prevention, mitigation, preparedness, response, recovery, and reconstruction. There are 11 clusters in the U.N. clusters: sanitation, water, and hygiene; education; early recovery, emergency telecommunication; food security; protection; health; camp management and coordination; emergency shelter; nutrition; and logistics. Each cluster is coordinated by cluster leads (U.N. agencies and international humanitarian organizations). For example, UNICEF is the cluster lead of sanitation, water and hygiene (UNOCHA, n.d.).

> process information according to these categories…. I think the informal groups were focused on going as quickly as possible and they were more flexible, and the formal organizations had these standard procedures that they were going through that were important for what they were doing, but then took some more time than the informal organizations were really comfortable with [formal response organizations' emergency response strategies and procedures].[53]

A member of the Standby Task Force (SBTF) stressed that "[a shared] understanding [of strategies] is relatively well established between the formal responders and … [participatory online groups] like ours."[54] It is because "this joint understanding has been developed over many years, since [the] Haiti [earthquake]. For Standby Task Force part, on one side we have gained experience with how OCHA works, how the relief operations work with the different [U.N.] clusters, and how information is organized and grouped and all these things…. Also UNOCHA understands how Standby Task Force operates."[55] Regarding the Nepal earthquake response, the interviewee mentioned that "[d]ifferent strategies were visible during the Nepal earthquake response. High-profile, expensive international teams came with their rescue strategies, and local community groups, cheap, agile and with high local knowledge became visible and interacted in the online space. A shared understanding of the different strategies in play is essential for the intensity of the interaction."[56]

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[53] Author's interview with a volunteer coordinator of the Kathmandu Living Labs, Participant 2

[54] Author's interview with a member of the Standby Task Force, Participant 1

[55] Author's interview with a member of the Standby Task Force, Participant 1

[56] Author's interview with a member of the Standby Task Force, Participant 1

Furthermore, it is crucial for participatory online groups and formal organizations to have a shared understanding of not only what each other's emergency response strategies are, but also how useful and important these strategies are to each other. Such shared understanding is an important factor to develop relationships between participatory online groups and formal organizations. According to a volunteer mapper of the OpenStreetMap Team (HOT),

> I think as well as people like OCHA and the Red Crosses and MSF[57] and World Food Program and anybody who's in the OCHA logistics cluster, I think we all have a very good shared understanding of how important the data [created by the HOT volunteer mappers] is. I think that shared understanding is there. Like I said, that's leading to us further maturing, further developing our…relationships [with formal organizations] so that…they recognize how important what we do is.[58]

An information management officer of UNOCHA also agreed that a shared understanding of strategies is an important factor to determine the development of relationships between participatory online groups and formal organizations. Particularly, regarding a relationship with the Kathmandu Living Labs (KLL), she reported that in the immediate aftermath of the Nepal earthquake, UNOCHA and related stakeholders recognized KLL's emergency response strategies based on their expertise on a geographic information system (GIS) and "knew how to work with them, and how to

[57] Médecins Sans Frontières (or Doctors Without Borders) is "an international, independent, medical humanitarian organization that delivers emergency aid to people affected by armed conflict, epidemics, natural disasters and exclusion from healthcare" (MSF, n.d.).

[58] Author's interview with a member of the HOT, Participant 7

better support their work because…we [(i.e. UNOCHA and related stakeholders)] were all leveraging the same tool, we were all using the HOT tasking platform[59]….Kathmandu Living Labs is a brand new organization to us. We've never worked in Nepal before, however because of that shared knowledge and that shared understanding, …we were able to form partnerships relatively fast, and help them quickly".[60] Thus, these findings support that a shared understanding of strategies likely enhances the development of inter-organizational relationships between participatory online groups and formal organizations.

Testing Hypotheses 4 and 5: Information Technology

Information technology adoption (H4). In crisis or disaster situations, participatory online groups and formal organizations adopt a variety of information and communication technologies (ICTs) (i.e. hardware devices, online platforms, and software applications). ICTs refer to "a diverse set of technological tools…used to communicate and to create, disseminate, store, and manage information" (Blurton, 1999, p. 46). I note that during the Nepal earthquake response, participatory online groups and formal organizations adopted and used Skype, Google Docs, the Humanitarian Data Exchange (open data sharing platform), and geographic information system (GIS) mapping tools. The adoption of such applications and tools facilitated dynamic interactions between participatory online groups and formal organizations. Particularly, an information management officer of UNOCHA stressed that "there was not a major difference in technologies used or understood [during the Nepal earthquake response].

[59] HOT Tasking Manager (http://tasks.hotosm.org/) is an open source collaborative mapping tool.

[60] Author's interview with an information management officer, Participant 3

This made collaboration much easier for both sides [(i.e. participatory online groups and formal organizations)]".[61]

Most participants in this study emphasized the importance of Skype that allowed participatory online groups and formal organizations to effectively communicate and collaborate with each other in response to the Nepal earthquake. According to a GIS analyst of the U.S. Agency for International Development (USAID), "Skype groups for the aid were a very active form of communication technology that was used to coordinate between formal and informal members of the participants in the response. That was the primary one that I…used [during the Nepal earthquake response]."[62] A volunteer member of the Standby Task Force (SBTF) reported that "[d]uring [the] Nepal [earthquake response], it was still Skype that was the major communication tool. We were running, as I said, maybe twenty different chat rooms in Skype to collaborate with various groups of people."[63] Furthermore, the volunteer member stressed that "[r]esponders who are not used to online chats or webinars are losing the ability to gain …shared information and interaction with the [participatory] online community at all. We [(SBTF)] have noticed that those who are able to talk, ask questions or share information in such channels are getting into intense interactions with valuable partners [(participatory online groups and formal responders)][64].

[61] Author's interview with an information management officer of UNOCHA, Participant 4

[62] Author's interview with a GIS analyst of USAID, Participant 12

[63] Author's interview with a member of SBTF, Participant 1

[64] Author's interview with a member of SBTF, Participant 1

Open collaboration tools (particularly, Google Docs) are another important means to facilitate interactions between participatory online groups and formal organizations in crisis or disaster situations. Google Docs enabled participatory online groups and formal organizations to easily share disaster-related data in real-time. According to a social media expert of Humanity Road, "Google Docs is one of the single most impactful software that can create multi-functional, cross-functional teams into one unity quickly"[65] Also, according to a member of SBTF, "Google Docs and Google Sheets have become very central parts of what we do. Everybody knows how to enter a Google Sheet, and enter information into that format."[66]

Most importantly, participatory online groups and formal organizations sought to adopt communication and collaboration tools that they could leverage in crisis or disaster situations with low bandwidth and a power blackout.

> [W]e were interested in the minimum, like what are the minimum technologies that we can leverage in the field as to effectively share the information we need. These minimum technologies tend to be Skype; they tend to be Google sheets and Google documents. We have people conversing and both working on the same reports. For us it's really important to figure out like what is the base like what is the minimum thing we can use, especially some things as simple as Google documents and Google sheets enable offline editing. That's super important, when you lose power or when you lose internet access.[67]

[65] Author's interview with a social media expert of Humanity Road, Participant 10

[66] Author's interview with a member of SBTF, Participant 1

[67] Author's interview with an information management officer of UNOCHA, Participant 3

Furthermore, recent advances in information technology enabled more actors (individuals and organizations) to engage in the creation of crisis- or disaster-related data. But these actors often times created the data by using different data formats and standards. Moreover, there was a lack of awareness among these actors on the existence of the data created by other actors. Such different data formats and standards and lack of awareness hindered the sharing of data and the coordination of multiple actors' response efforts in many cases. To address these issues, UNOCHA launched an open platform for sharing data called the Humanitarian Data Exchange (HDX)[68] in July 2014 and requested participatory online groups and formal organizations to upload disaster-related data to the platform to facilitate data sharing in the immediate aftermath of the Nepal earthquake. As a consequence, many participatory online groups (SBTF, HOT, and Himalayan Disaster Relief Volunteer Group) and formal organizations (the World Food Program, OCHA Nepal, and the U.S. National Geospatial Intelligence Agency) quickly adopted the open data platform as a data sharing means and began to upload a wide range of data including casualties and damage, geospatial map data, the locations of earthquake-induced landslide, health infrastructure, and the locations of refugee camps, and the status of relief efforts. All the data was used for disaster assessments, the coordination of onsite response operations, and strategic decision-making to effectively address the Nepal earthquake. Thus, the adoption of the HDX led to the data sharing between participatory online groups and formal organizations. Particularly, regarding participatory online groups' adoption of the HDX, an information management officer of UNOCHA reported that

[68] https://data.humdata.org/

"[T]hey were really open towards integrating this new products and tools…. We're leveraging technology in the tech tools that we have available to us at that moment…. [I]t's really nice to have partners who are able to move so fast in their ability to adopt and maneuver and collect and try new things."[69]

In addition, I found out that when participatory online groups and formal organizations adopt the same GIS mapping tools and software, such technology adoption improved the interaction between participatory online groups and formal organizations. According to a member of the Humanitarian OpenStreetMap Team (HOT),

> HOT…produce[s] map data and provide[s] our technology platform like the Tasking Manager or the OpenStreetMap Export Tool, those things we provide free of charge to other organizations so the more an organization leverages those tools and that data, the relationship between us and that organization would become more mature just because they often have to come to us for questions, for support, and it means that we're communicating more and we're talking more [with that organization].[70]

Thus, these findings from the Nepal case study support that when participatory online groups and formal organizations adopt same information and communication technologies, such adoptions of technologies likely lead to more dynamic interactions between participatory online groups and formal organizations.

Technical management capacity (H5). A technical management capacity is defined as data management skills for converting, integrating, and distributing crisis- or

[69] Author's interview with an information management officer of UNOCHA, Participant 3

[70] Author's interview with a member of the HOT, Participant 6

disaster-related information in a timely manner. Due to a lack of data standards, on one hand, participatory online groups and formal organizations as data users are often times required to process data from other online groups and formal organizations by converting it from one format to another and then integrating the converted data into their own datasets. On the other hand, participatory online groups and formal organizations as data producers need to create and publish final data products that other online groups and formal organizations can easily convert and integrate for their own purposes. The participants of this study agreed that such technical capacity is a key factor to improve relationships between participatory online groups and formal organizations.

In this research, I found important evidence from the Humanitarian OpenStreetMap Team and the Kathmandu Living Labs. For the Humanitarian OpenStreetMap Team (HOT), when the Nepal earthquake occurred, digital satellite imagery providers—including Airbus Defense and Space[71], DigitalGlobe[72], Google Crisis Response[73], and Microsoft Bing[74]—donated the post-event satellite imagery of the affected regions to the HOT. After receiving the imagery, the HOT volunteers first began to process the imagery by removing duplicates and the clouds and dividing it into little squares, and then the post-event imagery was integrated into a collaborative mapping platform called HOT Tasking Manager[75] that crowdsourced mapping projects to

[71] https://airbusdefenceandspace.com/newsroom/news-and-features/kathmandu-viewed-by-pleiades-satellites-before-and-after-the-earthquake/

[72] https://twitter.com/DigitalGlobe/status/592690978210873347

[73] http://www.google.org/crisismap/2015-nepal-earthquake

[74] https://giovand.cartodb.com/viz/26477a94-eb6b-11e4-afd0-0e853d047bba/public_map

volunteer mappers across the globe. I note that the HOT volunteers (particularly, members of an imagery coordination group) had the capacity to process, convert, and integrate geospatial data (i.e. satellite imagery) from multiple sources during the Nepal earthquake response.

Furthermore, the HOT volunteers had a capacity to collectively produce and publish online and offline maps of various formats including an open-source OpenStreetMap format, a shapefile format for proprietary GIS software, and offline navigation formats for Android and iOS devices (HOT, 2015). Even the HOT offered printable maps of the affected areas in various sizes. According to a member of the HOT,

> Whatever GIS software they [(i.e. other participatory online groups or formal organizations)] are using, if they are proprietary solutions like Esri, ArcGIS, they can get data in ArcGIS shapefile formats. They can [get] data in formats that will work with OpenStreetMap editors, with free and open source GIS software and like UGIS, so we try to produce tools that let people get the information in a way that is useful to them. Everyone wants a different format, everyone needs something different, but we try to at least provide tools that allow them to get the data and use it in a way that is useful for their organization.[76]

The capacity of the HOT to produce a variety of online, offline, printable maps enabled formal organizations (particularly, first responders on the ground) to easily export and use these various maps for their emergency response purposes and led to

[75] http://tasks.hotosm.org/

[76] Author's interview with a member of the HOT, Participant 6

dynamic interactions and communications between the HOT and formal organizations during the Nepal earthquake response. A GIS analyst of USAID who used online maps of the HOT during the Nepal earthquake response reported:

> [F]or OpenStreetMap now it is pretty easy to get data off OpenStreetMap and convert it to…a shape file or something I could bring into ArcGIS to make a map…. I think technical fluency…. I think having integral capacity…very much helps to increase the ties between the [formal] organization and participatory online map [communities]…. The more technical capacity there is at an organization, I think the easier it is to form those relationships.[77]

Another evidence that a technical management capacity improves interactions between participatory online groups and formal organizations comes from the Kathmandu Living Labs (KLL). Soon after the Nepal earthquake occurred, the KLL volunteers in the field started collecting, verifying, geocoding, and visualizing reports from the ground regarding disaster conditions, the affected people's needs and requests for rescue and aid, and the status of relief efforts. Just like the HOT volunteers did, the KLL volunteers had a technical management capacity to convert, integrate, and distribute these reports in a timely manner. Specifically, the KLL volunteers initially planned to geocode the reports from the ground by using GPS coordinates. However, they recognized that formal organizations (particularly, the U.N. agencies and international aid organizations) were using a p-code system created by UNOCHA, UNHCR[78], and the

[77] Author's interview with a GIS analyst of USAID, Participant 12

[78] The U.N. Refugee Agency (http://www.unhcr.org/en-us)

International Center for Remote Sensing Education[79]. P-codes (or Place-codes) are "unique geographic (geo) identification codes, represented by combination of letters and/or numbers to identify a specific location or feature on a map" on the basis of the levels of administrative boundaries (UNOCHA, 2011, p. 5). After recognizing this fact, the KLL developers quickly created a way to filter the reports by the administrative boundaries of Nepal (i.e. districts and municipalities). Such filtering solution was helpful for formal response organizations to more easily and efficiently use and integrate disaster-related information processed by the KLL volunteers into their information management systems based on the p-codes.

Further, the KLL volunteers developed an export reports feature. By using this feature, formal response organizations could download a list of the reports in an Excel CSV format (comma-delimited text file). This feature allowed the Nepal Army (a key formal response organization during the Nepal earthquake response) to efficiently assess the status of requests for rescue or aid and coordinate their operations. According to a volunteer coordinator of the KLL, "I think a very important component was the export reports feature, we added that [to QuakeMap]. So that's how we got all of our reports over to the [Nepal] army…. What they did is they took full export on a periodic basis, then filtered it according to their own criteria."[80] In this regard, the KLL volunteers also developed the print reports feature for responders on the ground to easily print out a list of the reports. The volunteer coordinator stressed that "[by using] … the print reports

[79] A US-based not-for-profit corporation (http://www.icrsed.org/)

[80] Author's interview with a volunteer coordinator of the KLL, Participant 2

feature… they [(i.e. responders on the ground)] could very easily get a list of...contacts in a certain location. So they could go there, they'd have a list of who needed what, or who'd report that they needed something in a given…district and they'd have numbers to call. That was how we were trying to interact with both informal and formal responders."[81]

Lastly, the KLL offered the emergency alert system. If a report related to earthquake damages and relief needs was submitted to the KLL within a radius of 20 kilometers (approximately 12.4 miles) of a specific location that an alert subscriber selected, emergency alerts were sent to the subscriber via mobile phone or email. At that time, approximately 500 formal organizations or individuals affected by the earthquake subscribed to the alert system to receive timely disaster information[82]. Therefore, such technical management capacity of the KLL improved interactions with formal organizations by sharing disaster-related information with these organizations in real-time. Therefore, these findings from the Nepal earthquake response support that a technical management capacity is a key factor to improve the interaction between participatory online groups and formal organizations.

Testing Hypothesis 6: Inter-organizational Alignment (Coordination)

I hypothesized that the level of inter-organizational relationship development (i.e. intensity of interaction) between participatory online groups and formal organizations influences inter-organizational alignment in responding tasks and activities. Inter-organizational alignment is defined as the coordination of responding efforts between participatory online groups and formal organizations (Kathuria et al., 2007). The findings

[81] Author's interview with a volunteer coordinator of the KLL, Participant 2

[82] Author's interview with a volunteer coordinator of the KLL, Participant 2

from the Nepal case study provide empirical evidence that when participatory online groups and formal organizations have more dynamic interactions with each other (particularly, timely communications and the sharing of disaster-related data), a wide range of responding tasks and activities that participatory online groups and formal organizations perform are more efficiently coordinated by avoiding duplication of efforts.

Soon after the Nepal earthquake occurred, a quite large network of participatory online groups and formal organizations was formed and these online groups and formal organizations quickly developed their inter-organizational relationships, thereby improving the coordination of responding efforts. There were rich, dynamic communications between these online groups and formal organizations on Skype or online platforms. A variety of information and resources were mobilized and shared by these online groups and formal organizations. Specifically, the Qatar Computing Research Institute (QCRI), a nonprofit computing research institute based in Doha, Qatar, developed the Artificial Intelligence for Disaster Response (AIDR) that automatically identifies and collects life-saving and actionable content on Twitter (Meier, 2013). In the immediate aftermath of the Nepal earthquake, the QCRI allowed the Standby Task Force (SBTF) to get access to the AIDR for free. By using this artificial intelligence tool, the SBTF was able to quickly filter informative content on Twitter (e.g., "Pray for Nepal" messages)[83]. Moreover, the GDELT Project, which "monitors the world's news media…in print, broadcast, and web formats," gave the SBTF a aggregated feed from news media regarding the Nepal earthquake (The GDELT Project, n.d.).

[83] Author's interview with a member of SBTF, Participant 1

Based on such a large amount of disaster-related information provided by the QCRI and the GDELT Project, over 400 online volunteers of the SBTF performed their collective response to the Nepal earthquake. Specifically, these volunteers created comprehensive 3W reports (i.e. which organizations were doing what and where?) regarding the current status of responding efforts and such data fed to approximately 30 formal organizations that responded to the earthquake—including UNOCHA, the U.N. refugee agency (UNHCR), the World Food Program (WFP), Amnesty International, and Mercy Corps. The SBTF also created a Google Sheet collecting urgent needs of individuals affected by the earthquake and shared this Google Sheet with the Kathmandu Living Labs (KLL) on the ground. Importantly, the U.N. Volunteer (UNV) Program, which mobilizes online volunteers across the globe and matches the volunteers to nonprofit or public organizations that need the volunteers, helped the SBTF mobilize 14 "volunteers with knowledge of Nepal, the local languages and…GIS expertise."[84] These volunteers aided the SBTF in conducting social media analysis and geocoding disaster-related data on the digital maps (UNV, 2015).

Furthermore, many for-profit corporations—including Airbus Defense and Space, Microsoft Bing, Google Crisis Response, DigitalGlobe, and Mapbox—donated the satellite imagery of post-earthquake Nepal. Based on the imagery, over 8,000 online volunteer mappers of the Humanitarian OpenStreetMap Team (HOT) from both around the world and Nepal collectively created digital base maps, offline navigation maps, and paper maps of post-earthquake Nepal within a few weeks. During the Nepal earthquake

[84] Author's interview with an officer of the UNV Program, Participant 13

response, these maps were used by international formal responders (the American Red Cross, Canadian Disaster Assistance Response Team (DART), UNOCHA, and USAID), the Nepalese Army (a main responding organization of the Nepalese Government), and other participatory online groups (the SBTF and the KLL). In addition to creating post-disaster base maps, the HOT conducted the rapid identification of settlements in the mountainous areas, internally displaced people (IDP) camps, and landslide areas[85]. These tasks were essential for disaster assessment and the allocation and delivery of relief resources. Such information was shared with the Kathmandu Living Labs in a timely manner that worked with the Nepalese Army, Nepalese volunteer groups, and international responders on the ground.

Most importantly, the Kathmandu Living Labs (KLL) acted as a local coordination hub during the Nepal earthquake response. All the disaster-related information processed by other participatory online groups such as the SBTF and the HOT was integrated into the disaster data management system of the KLL (i.e. QuakeMap) that collated, verified, geocoded, and visualized the reports from the ground including the affected people's needs and requests, earthquake conditions, and the relief efforts of formal and informal responders. Such data was directly shared with both formal responders (particularly, the Nepalese Army and Canadian Disaster Assistance Response Team) that conducted search-and-rescue operations and delivered relief services and informal, volunteer-based responders (Himalayan Disaster Relief Volunteer Group) that emerged spontaneously in the immediate aftermath of the earthquake. By using real-time

[85] Author's interview with a member of the HOT, Participant 7

disaster information produced by the KLL, these formal and informal responders effectively coordinated a wide range of responding tasks and activities. However, according to a volunteer coordinator of the KLL, there were many other international first responders such as the U.N. Disaster Assessment and Coordination (UNDAC) and the U.S. Disaster Assistance Response Team (DART) that did not have interactions with the KLL during the Nepal earthquake response, although these formal responders might use the disaster data created by the KLL due to its openness.[86] In such cases, the KLL and these responders did not coordinate their responding tasks and activities because of a lack of the development of the inter-organizational relationships.

As stated above, there was a quite large network consisting of many participatory online groups and formal organizations during the Nepal earthquake response. These online groups and formal organizations dynamically communicated and interacted with one another and aided one another in assessing disaster situations and producing and delivering diverse responding services. As a consequence, the effective coordination of responding efforts was achieved in the network of participatory online groups and formal organizations.

Testing Hypothesis 7: The Effectiveness of Inter-Organizational Alignment

I hypothesized that inter-organizational alignment between participatory online groups and formal organizations in emergency response likely improves the effectiveness of emergency response. Particularly, I define (and measure) the effectiveness of coordinated emergency response between participatory online groups and formal

[86] Author's interview with a volunteer coordinator of the KLL, Participant 2

organizations as the extent to which the coordinated emergency response has an impact on saving lives and meeting human basic needs (e.g., water, foods, shelters, and emergency medical services).

The findings from this Nepal case study may not provide enough empirical evidence to support the hypothesis that inter-organizational alignment increases the effectiveness of emergency response. On one hand, a few participants of this study stressed that the coordinated efforts between participatory online groups and formal organizations had a positive impact on the effectiveness of emergency response during the Nepal earthquake response. A volunteer coordinator of the Kathmandu Living Labs reported that "within…first 72 hours people were able to just go to OpenStreetMap and get it…. I'm sure, … the DART team was using that [map] a lot…. The early responders, the ones that are rescuing people out of trapped buildings."[87] Moreover, a GIS specialist of the Canadian Disaster Assistance Response Team (DART) who participated in the Nepal earthquake response emphasized that "if they [(participatory online groups and formal responders)] are connected together and they work together. Then there is a better outcome".[88]

However, other participants of this study reported that indeed it is extremely difficult to evaluate the relationship between inter-organizational alignment and the effectiveness of coordinated emergency response. Specifically, to determine such relationship, it is needed to examine how information-related products created by participatory online groups such as a Google Sheet of real-time disaster reports and the

[87] Author's interview with a volunteer coordinator of the KLL, Participant 2

[88] Author's interview with a GIS specialist of Canadian DART, Participant 8

digital base maps of post-disaster areas are used by formal organizations to conduct their responding tasks and activities including search-and-rescue missions and the delivery of relief resources and ultimately how these information-related products contribute to saving the lives of disaster-affected people and meeting their basic needs. In this regard, a member of the Standby Task Force (SBTF) noted that there is "little systematic knowledge of the influence of our efforts apart from individual statements or anecdotes from the field."[89] According to another member of the SBTF,

> We provide the [disaster] data to the decision makers of the [formal] response organizations. They choose how to respond. We struggle to get feedback from these organizations to determine how our data was used or how much it influenced their response…. [W]e do not have the specific numbers that says, we helped this amount of people because we are not the ones who are directly helping them. What our purpose is…to provide situation awareness to the decision makers of those organizations that are traveling to the site and are going to be helping a certain amount of people.[90]

An information management officer of UNOCHA also agreed that there is a lack of evidence on the relationship between inter-organizational alignment and its effectiveness.

> Maybe it isn't easily measurable, like to say yes because you got me extra things on Twitter, we saved 10,000 more people. I cannot say that. If we say that we saved 10,000 people, maybe that's partly a result of the extra data, the extra

[89] Author's interview with a member of the SBTF, Participant 1

[90] Author's interview with a member of the SBTF, Participant 9

> effort that these [participatory online] groups provided or because they had more time, more effort, more data, better picture, we were better able to target our response and thus produce stuff…, save lives, these kinds of things…. It's difficult to then say yes with 100% certainty that [such extra efforts of participatory online groups] impacted the outcome of the emergency…. We believe so, but there's no sort of direct correlation that you can say, right.[91]

To find further evidence, I analyzed reports submitted from the ground to QuakeMap of the Kathmandu Living Labs (KLL). QuakeMap consisting of over 2,000 archived reports offers detailed information on disaster-affected people's specific needs (e.g., food, medical assistance, rescue, shelter, or transportation), the verification status of the reports, and responding efforts for meeting these needs. As stated earlier, the disaster-related information created by several participatory online groups across the globe was aggregated into QuakeMap and the aggregated information was shared with many formal organizations such as the Canadian DART, the Nepalese Army, the Nepalese government agencies and UNOCHA. Therefore, the content on QuakeMap is a good source to examine whether and how coordinated efforts between participatory online groups and formal organizations improved the effectiveness of emergency response.

Particularly, I focused on approximately 200 reports categorized by the KLL volunteers as 'action taken' which means that all needs of the affected people were fully met. Among these 200 reports, approximately 20 reports indicate that formal organizations offered relief resources to disaster-affected people:

[91] Author's interview with an information management officer of UNOCHA, Participant 4

Nepal government has reached the area and given sufficient number of tents.[92]

UNICEF provided a jar, water purifier and a tent to each household.[93]

The wounded were air-lifted by Nepal Army.[94]

Govt provided 200x30 kg of rice, 30 sacks of potato and other items.[95]

The Nepalese army is providing assistance in removing the [dead] bodies.[96]

[G]overnment has recently provided them an amount of 15000 for each family to buy zinc sheets and they are on the way to make temporary houses.[97]

Since QuakeMap was one of key sources of disaster-related information for the Nepalese Army, the Nepal government agencies, and some international formal responders in the aftermath of the Nepal earthquake, these formal organizations might use the information on QuakeMap (i.e. urgent requests for rescue and aid) to perform their response operations, thereby meeting the affected people's needs in a timely manner. However, I note that the content on QuakeMap does not provide specific information regarding whether and how the content was used by formal organizations. As the participants of this study mentioned above, it seems that the findings from this Nepal case study do not provide enough evidence that inter-organizational alignment likely improves the effectiveness of emergency response.

[92] http://quakemap.org/reports/view/1982

[93] http://quakemap.org/reports/view/1902

[94] http://quakemap.org/reports/view/1868

[95] http://quakemap.org/reports/view/1118

[96] http://quakemap.org/reports/view/218

[97] http://quakemap.org/reports/view/2309

Table 3.2

Results from Hypothesis Tests and Related Evidence

Hypothesis	Result	Evidence
H1: Resource dependence	Not supported	Evidence that supports the hypothesis - The relationship between the Humanitarian OpenStreetMap Team (HOT) and first responders (interview data from participants 6 and 11 and related secondary data) - The relationship between the Kathmandu Living Labs (KLL) and Humanity Road (HR) (interview data from participant 10 and related secondary data) Evidence that does not support the hypothesis - The relationship between the Standby Task Force (SBTF) and UNOCHA (interview data from participants 1 and 4)
H2: Shared understanding of common problems	Supported	- Interview data from participants 2, 3, 4, and 6
H3: Shared understanding of strategies	Supported	- The relationship between KLL and the U.N. cluster system (interview data from participant 2) - The relationship between SBTF and UNOCHA (interview data from participant 1 and related secondary data) - The relationship between HOT and formal organizations (interview data from participant 7) - The relationship between KLL and UNOCHA (interview data from participant 3)
H4: Adoption of technologies	Supported	- Skype (interview data from participants 1, 3, 12 and 14) - Google Docs (interview data from participants 1, 3, and 10) - Humanitarian Data Exchange (interview data from participant 3 and related secondary data) - GIS mapping tools (interview data from participant 6)
H5: Technical management capacity	Supported	- The capacity of HOT (interview data from participants 6 and 12 and related secondary data) - The capacity of KLL (interview data from participant 2 and related secondary data)

H6: Inter-organizational alignment	Supported	- Coordinated response efforts in a network of participatory online groups and formal organizations (interview data from participants 1, 2, 7 and 13 and related secondary data)
H7: Effectiveness of coordinated emergency response	Not supported	Evidence that supports the hypothesis - Interview data from participants 2 and 8 Insufficient evidence that supports the hypothesis - Interview data from participants 1, 4, and 9 - The content on QuakeMap

Conclusion

In this chapter I empirically tested seven hypotheses developed in the second chapter by using the 2015 Nepal earthquake case. Importantly, based on the inter-organizational relations (IOR) theory, I modified the hypotheses developed in the second chapter to consider the developmental phases of relationship between participatory online groups and formal organizations (formation, expansion and maturity, and decline and dissolution). To test these modified hypotheses, I employed the explanatory case study method. Specifically, I collected qualitative and quantitative data from individual interviews and multiple secondary sources. I used confirmatory or hypothesis-driven thematic analysis as a primary data analysis technique. As a result, I found empirical evidence that supports the hypotheses that shared understanding and information technology influence the level of inter-organizational relationship development, respectively. I also found out a positive relationship between the level of the relationship development and inter-organizational alignment from the Nepal earthquake case. However, for resource dependence as a determinant of relationships between participatory online groups and formal organizations, there were mixed results. In other words, there are inconsistencies in the Nepal case where some evidence supports the

hypothesis that resource dependence improves inter-organizational relationships, while other evidence does not support this hypothesis. As a result, this hypothesis was not supported in this study. Lastly, regarding the relationship between inter-organizational alignment and its outcomes (saving lives and meeting basic human needs), I was unable to find sufficient qualitative and quantitative evidence to support the relationship. Thus, this hypothesis was also not supported. In conclusion, the Nepal case study provides empirical evidence to support five hypotheses except two hypotheses regarding resource dependence and the effectiveness of coordinated emergency response.

I recognize the limitations of this study. This study relied primarily on qualitative data. Such qualitative data provided detailed, rich descriptions and explanations regarding the determinants and outcomes of the development of the relationship. Indeed, such descriptions and explanations are essential to deepen the understanding of a complex phenomenon related to the development of the relationship in crisis or disaster situations. However, qualitative research (particularly, the explanatory case study method employed for this study) would be unable to objectively verify whether and how the variables of interest are associated with each other as quantitative research would do. Another limitation pertains to generalizability. The findings from this study that focused on the Nepal earthquake case (i.e. a large-scale natural disaster in an undeveloped country in Asia) may not be generalizable to other crisis or disaster contexts (e.g., man-made crises such as terrorism in a developed country in Europe).

Despite such limitations, this study is expected to contribute to the literature (both emergency management and crisis informatics) by offering empirical findings regarding the determinants and outcomes of the development of the relationship between

participatory online groups and formal organizations. Such findings may be useful to deepen and extend the understanding of a mechanism in which resource dependence, shared understanding, and information technology determine the development of the relationship that influences inter-organizational alignment and the effectiveness of coordinated response efforts between participatory online groups and formal organizations.

CHAPTER 4

IMPLICATIONS AND FUTURE RESEARCH

In the dissertation, I focused on a new social phenomenon in the digital era. It is the emergence and contribution of participatory online groups in crisis or disaster situations. Indeed, advances in information and communication technologies enabled individuals from both across the globe and the affected areas to work together and make a meaningful contribution to the effective emergency response in recent crises or disasters. Such emergence and contribution of participatory online groups require both scholars and practitioners to have a new lens to understand emergency response in the networked age, because current emergency response systems are much more complex and dynamic than the existing emergency management literature and disaster policies have understood. Therefore, in the first chapter of this dissertation, I developed a new conceptual framework called an event-driven lens on the basis of a comprehensive literature review.

The event-driven lens integrates formal emergency response based on institutionalized formal organizations across the levels of government and the sectors and their established procedures and regulations and volunteer-based, participatory emergency response that amateurs and concerned publics perform by using information and communication technologies. Moreover, the event-driven lens takes into account the relationships between participatory online groups and formal organizations in crisis or disaster situations. The event-driven lens ultimately suggests five propositions that help scholars and practitioners explain and understand emergency response systems in the digital era.

In the second chapter of this dissertation, I focused on one aspect of the event-driven lens. It is the formation of relationships between participatory online groups and formal organizations. More specifically, I aimed to explore key determinants to influence the formation of relationships between participatory online groups and formal organizations. I also intended to investigated the outcomes of forming relationships between participatory online groups and formal organizations. For these purposes, I employed the exploratory case study method and conducted four case studies including the 2007-2008 Kenya post-election violence, the 2010 Haiti earthquake, the 2010 Indonesia volcanic eruption, and the 2011 Japan earthquake and nuclear crisis. These four case studies resulted in the development of seven hypotheses on the three key determinants to form relationships between participatory online groups and formal organizations (i.e. resource dependence, shared understanding, and information technology) and two outcomes of forming the relationships in crisis or disaster situations (inter-organizational alignment and the effectiveness of coordinated emergency response).

Then in the third chapter of this dissertation, I aimed to empirically tested seven hypotheses developed in the second chapter of this dissertation regarding the determinants and outcomes of the development of relationships between participatory online groups and formal organizations in crisis or disaster situations. To test these hypotheses, I employed the explanatory case study method, focusing on the Nepal earthquake case. Findings from this study support that the development of the relationship between participatory online groups and formal organizations is likely to be influenced by a shared understanding of crisis or disaster situations and of how to

respond to these situations, the adoption of information technology, and technical management capacities for converting, integrating, and distributing crisis or disaster data. Moreover, I found empirical evidence that supports that the development of the relationship likely improves inter-organizational alignment in various responding tasks and activities that participatory online groups and formal organizations perform.

This dissertation has several limitations. The limitations pertain to research methods. This dissertation employed the case study method that relies primarily on qualitative data analysis. Such case study method provides in-depth information of a single case or cross-case comparisons and analysis, thus allowing the researcher to describe and understand in rich detail a complex phenomenon of interest and to identify key factors related to the phenomenon. However, findings from the case study research "may not generalize to other people or other settings (i.e. findings may be unique to the relatively few people included in the research study)" because the case study method is based on a limited number of people or cases (Johnson & Onwuegbuzie, 2004, p. 20). More importantly, it is not easy to empirically test hypotheses to examine the relationship between variables of interest because qualitative data analysis results are not objectively verifiable. To address these issues, I conducted multiple case studies (five cases in total) and employed data triangulation (multiple sources of evidence) in this dissertation.

Despite these limitations, this dissertation can contribute to the literature. Particularly, I note that there is a disconnect between the emergency management literature and the crisis informatics literature. The emergency management literature focuses on (networks of) formal organizations in response to crisis, while the crisis informatics literature stresses the importance of informal actors (individuals across the

globe and the affected people) connected through information technology. The event-driven lens offers a plausible conceptual framework to integrate formal emergency response in the emergency management literature and volunteer-based, participatory emergency response in the crisis informatics literature. Moreover, five propositions drawn from the event-driven lens may help scholars focus on key concepts and develop and test hypotheses in their future research.

One of the most under-researched areas in the literature is relationships between participatory online groups and formal organizations in crisis or disaster situations. In other words, there are few studies on the determinants, processes, and outcomes of relationships between participatory online groups and formal organizations. As stated earlier, in the second and third chapters of this dissertation, I intended to develop and test the key determinants and outcomes of relationships between participatory online groups and formal organizations. Therefore, this research may make a theoretical contribution to the literature with evidence-based findings regarding the development of the relationship between participatory online groups and formal organizations.

Furthermore, the relationship between participatory online groups and formal organizations is one type of inter-organizational relationship. In fact, I considered inter-organizational relations (IOR) theory as a theoretical foundation to develop and test hypotheses on the relationship between participatory online groups and formal organizations in this dissertation. I note that the IOR theory stresses that building and developing inter-organizational relationships are time-consuming (Ansell & Gash, 2008). In other words, the IOR theory argues that inter-organizational relationships emerge and develop incrementally, and it takes a relatively long time for parties to reach the maturity

phase of inter-organizational relationships (Ring & Van de Ven, 1994). However, this research indicates that participatory online groups and formal organizations may form and develop inter-organizational relationships, defined as the intensity of interaction, during a relatively short period in an urgent crisis or disaster situation. In addition, the IOR theory often times focuses on the formalization and institutionalization of inter-organizational relationships (Azad & Wiggins, 1995; Oliver, 1990). However, this research indicates that in a loosely connected relationship between participatory online groups and formal organizations, both actors can work together and make a significant contribution to the effective emergency response. Information and communication technologies enabled such collaboration and coordination between participatory online groups and formal organizations in crisis or disaster situations. Therefore, this research may provide a new insight into new types of inter-organizational relationships in the digital era in the context of crises or disasters (i.e. a more dynamic, less formalized, and technology-driven relationship).

In addition to such potential theoretical contributions, this research can make a practical contribution. Particularly, the findings from this research (the event-driven lens and the results of hypothesis testing) can be useful for both participatory online groups and formal organizations to understand complex emergency response systems in the networked age and to build and manage partnerships and collaboration with each other to improve their capacities to address crises or disasters in a collective and coordinated manner.

Future Research Agenda

First of all, I plan to conduct quantitative research to examine how resource dependence, shared understanding, and information technology influence the development of the relationship between participatory online groups and formal organizations in a more rigorous manner. Specifically, I propose to collect Likert scale survey data from volunteer members of participatory online groups and those who work for formal organizations. Then I will conduct quantitative statistical analysis (regression analysis, ordered logit/probit models, panel analysis, etc.). Finally, I will compare and contrast between the findings of quantitative analysis and those of the case study research (i.e. the third chapter of this dissertation) to determine hypothesized relationships between the variables of interest.

Moreover, future research is needed to empirically assess the outcomes of coordinated emergency response between participatory online groups and formal organizations. Although there are many individual statements and anecdotes regarding the positive impacts of the coordination of responding efforts between participatory online groups and formal organizations, few studies were conducted to quantitatively evaluate the efficiency and effectiveness of such coordination. Thus, I plan to conduct impact studies and cost-benefit or cost-effectiveness analysis from the evaluation research perspective. Specifically, I am interested in whether and how crisis or disaster data created by participatory online groups increases the efficiency of emergency response (i.e. cost-saving) and ultimately impacts the final outcomes of emergency response (i.e. effectiveness regarding saving lives and meeting human basic needs).

Despite the potential contributions of participatory online groups, several challenges that need to be addressed remain. Specifically, some scholars and practitioners doubt the accuracy and credibility of the information gathered and analyzed by participatory online groups (Gao et al., 2011; Goolsby, 2010; B. R. Lindsay, 2011). Sometimes, unverified rumors and misinformation are submitted to crisis mapping platforms operated by participatory online groups. Recently, to deal with this issue, data verification and analysis tools were developed (e.g., SwiftRiver software[98]), but the effectiveness of these tools was not yet empirically examined. Moreover, crisis mapping platforms operated by participatory online groups may be vulnerable to privacy and security issues due to these platforms' openness and transparency (Lindsay, 2011; Nelson et al., 2010). In other words, anyone can easily get access to such crisis mapping platforms, thus the information published on these platforms can be used for malicious purposes. Therefore, I plan to investigate technical and managerial solutions for addressing these challenges (i.e. data inaccuracy, privacy, and security issues). This interdisciplinary research will require collaboration with scholars and practitioners in the fields of emergency management, computer science, information management, and crisis informatics.

Importantly, I note the absence of emergency information management systems integrating the information processed by participatory online groups and the information produced by formal emergency management agencies (Blanchard & Chapman, 2012; Gao et al. 2011). As a consequence, the duplication of efforts for data collection and

[98] https://wiki.ushahidi.com/display/WIKI/SwiftRiver

analysis is likely to occur in urgent crisis or disaster situations. Therefore, I plan to develop policy solutions and technical strategies for building integrative emergency information management systems where participatory online groups and formal organizations communicate and collaborate with each other in real-time (e.g., the development of information infrastructure and common communication standards).

Today participatory online groups and their crowdsourcing projects are being actively applied to increase community resilience in various crisis or disaster contexts (e.g., climate change, floods, hurricanes, etc.). These projects are highly related to collaborative governance and citizen engagement, because robust collaboration across the public, private, and nonprofit sectors may be a key factor to build resilient communities. Therefore, I plant to investigate how community-based participatory online groups can be leveraged to build cross-sectoral capacities for dealing with crises or disasters in the entire lifecycle of emergency management (i.e. mitigation, preparedness, response, and recovery).

Lastly, from an organizational theory and behavior perspective, participatory online groups are characterized by horizontal structures, decentralized decision-making, virtual communities, non-monetary motivations, shared leadership, and collaborative organizational learning. Currently, there is an opportunity to create intentional strategies to manage these kinds of new organization forms that emerge in the network age. I will study and develop effective leadership and management strategies for participatory online groups. Moreover, from a perspective of formal organizations (particularly, public emergency management agencies), I will investigate shared leadership and management

strategies for building and developing partnerships and collaboration between participatory online groups and formal organizations.

REFERENCES

Abe, Y. (2013). Why Safecast matters: A case study in collective risk assessment. In *STS Forum on the East Japan Disaster*. Berkeley, CA.

Abe, Y. (2014). Safecast or the production of collective intelligence on radiation risks after 3.11. *The Asia-Pacific Journal: Japan Focus*, *12*(7).

Aldrich, D. P. (2012). Post-crisis Japanese nuclear policy: From top-down directives to bottom-up activism. *Asia Pacific Issues*, *103*(January), 1–12.

Ansell, C., & Gash, A. (2008). Collaborative governance in theory and practice. *Journal of Public Administration Research and Theory*, *18*(4), 543–571.

Appleby, L. (2012). *Connecting the aast mile: The role of communications during the Great East Japan earthquake*. *Internews*. Washington, D.C.

Azad, B., & Wiggins, L. L. (1995). Dynamics of inter-organizational geographic data sharing: A conceptual framework for research. In H. J. Onsrud & G. Rushton (Eds.), *Sharing geographic information*. New Brunswick, NJ: Center for Urban Policy Research.

Babaud, S., & Ndung'u, J. (2012). *Early warning and conflict prevention by the EU: Learning lessons from the 2008 post-election violence in Kenya*. London, UK.

Barringer, B. R. (2000). Walking a tightrope: Creating value through interorganizational relationships. *Journal of Management*, *26*(3), 367–403.

Basit, T. (2003). Manual or electronic? The role of coding in qualitative data analysis. *Educational Research*, *45*(2), 143–154.

Bentrup, G. (2001). Evaluation of a collaborative model: A case study analysis of watershed planning in the intermountain west. *Environmental Management*, *27*(5), 739–748.

Bessant, J. (2005). Enabling continuous and discontinuous innovation: Learning from the private sector. *Public Money and Management*, *25*(1), 35–42.

Bingham, R. D., & Felbinger, C. L. (2002). *Evaluation in practice: A methodological approach* (2nd ed.). New York: Seven Bridges Press.

Birkland, T. A. (1997). *After disaster: Agenda setting, public policy, and focusing events*. Washington, D.C.: Georgetown University Press.

Birkland, T. A. (1998). Focusing events, mobilization, and agenda setting. *Journal of Public Policy*, *18*(1), 53–74.

Birowo, M. A. (2010). *Community radio and grassroots democracy: A case study of three villages in Yogyakarta region, Indonesia*. Curtin University.

Birowo, M. A. (2011). Community media and civic actions in response to volcanic hazards. In *Crisis information management: Communication and technologies* (pp. 139–153). Oxford, UK: Chandos Publishing.

Blanchard, H., & Chapman, K. (2012). *Volunteer technology communities: Open development*. Retrieved from http://www.gfdrr.org/sites/gfdrr/files/publication/Volunteer Technology Communities - Open Development_0.pdf

Blurton, C. (1999). New directions in education. In M. Tawfik, G. Bartagnon, & Y. Courrier (Eds.), *World communication and information report 1999-2000* (pp. 46–61). Paris: The United Nations Educational, Scientific and Cultural Organization (UNESCO).

Bonner, S. (2012). Safecast X Kickstarter Geiger Counter. Retrieved January 23, 2015, from https://www.kickstarter.com/projects/seanbonner/safecast-x-kickstarter-geiger-counter

Boulos, M. N. K., Resch, B., Crowley, D. N., Breslin, J. G., Sohn, G., Burtner, R., … Chuang, K.-Y. S. (2011). Crowdsourcing, citizen sensing and sensor web technologies for public and environmental health surveillance and crisis management: trends, OGC standards and application examples. *International Journal of Health Geographics*, *10*(1), 67.

Brass, D. J., Galaskiewicz, J., Greve, H. R., & Tsai, W. (2004). Taking stock of networks and organizations: A multilevel perspective. *The Academy of Management Journal*, *47*(6), 795–817.

Braun, V., & Clarke, V. (2012). Thematic analysis. In H. Cooper (Ed.), *APA handbook of research methods in psychology: Vol. 2. research designs*. The American Psychological Association.

Bryson, J. M., Crosby, B. C., & Stone, M. M. (2006). The Design and Implementation of Cross-Sector Collaborations: Propositions from the Literature. *Public Administration Review*, *66*(S1), 44–55.

Buck, D. A., Trainor, J. E., & Aguirre, B. E. (2006). A critical evaluation of the incident command system and NIMS. *Journal of Homeland Security and Emergency Management*, *3*(3), 1–27.

Capelo, L., Chang, N., & Verity, A. (2012). *Guidance for collaborating with volunteer and technical communities*.

Caquard, S. (2013). Cartography II: Collective cartographies in the social media era. *Progress in Human Geography*, *38*(1), 141–150.

Cole, D. (2000). *The incident command system: A 25-year evaluation by California practitioner*.

Comfort, L. K. (2007). Crisis management in hindsight: Cognition, communication, coordination, and control. *Public Administration Review*, *67*(SUPPL. 1), 189–197.

Comfort, L. K., Dunn, M., Johnson, D., Skertich, R., & Zagorecki, A. (2004). Coordination in complex systems: Increasing efficiency in disaster mitigation and response. *International Journal of Emergency Management*, *2*(1-2), 62–80.

Comfort, L. K., Oh, N., Ertan, G., & Scheinert, S. (2010). Designing adaptive systems for disaster mitigation and response: The role of structure. In L. K. Comfort, A. Boin, & C. C. Demchak (Eds.), *Designing Resilience: Preparing for Extreme Events* (p. 384). Pittsburgh, PA: University of Pittsburgh Press.

Comfort, L. K., Sungu, Y., Johnson, D., & Dunn, M. (2001). Complex systems in crisis: Anticipation and resilience in dynamic environments. *Journal of Contingencies & Crisis Management*, *9*(3), 144–158.

Communication for rural development in Asia and the Pacific. (n.d.). Community-based information network supporting emergency response. Retrieved July 14, 2015, from http://www.comdevasia.org/index.php?option=com_cont ent&view=article&id=46:supporting-emergency- response-and-aid-delivery-through-the-jalin-merapi- information-network&catid=27&Itemid=189

Corbane, C., Lemoine, G., & Kauffmann, M. (2012). Relationship between the spatial distribution of SMS messages reporting needs and building damage in 2010 Haiti disaster. *Natural Hazards and Earth System Science*, *12*(2), 255–265.

Corbin, J., & Strauss, A. (2008). *Basics of qualitative research: Techniques and procedures for developing grounded theory* (3rd ed.). Los Angeles, CA: Sage Publications, Inc.

Creswell, J. W. (2009). *Research design: Qualitative, qunatitative, and mixed methods approaches* (3rd ed.). Los Angeles, CA: SAGE Publications, Inc.

Cropanzano, R. (2005). Social exchange theory: An interdisciplinary review. *Journal of Management*, *31*(6), 874–900.

Crowley, J. (2013). Connecting grassroots and government for disaster response. *The Wilson Quarterly*, *3*, 70.

Crowley, J., & Chan, J. (2011). *Disaster relief 2.0: The future of information sharing in humanitarian emergencies*.

Derthick, M. (2007). Where federalism didn't fail. *Public Administration Review*, *67*(SUPPL. 1), 36–47.

DHS. (2008). *National incident management system*.

DHS. (2013). *National response framework*.

Drabek, T. E. (1985). Managing the emergency response. *Public Administration Review*, *45*(Special Issue), 85–92.

Drabek, T. E., & McEntire, D. A. (2003). Emergent phenomena and the sociology of disaster: Lessons, trends and opportunities from the research literature. *Disaster Prevention and Management*, *12*(2), 97–112.

Dwyer, F. R., Schurr, P. H., & Oh, S. (1987). Developing buyer-seller relationships. *The Journal of Marketing*, *51*(2), 11–27.

Eisenhardt, K. M. (1989). Building theories from case study research. *The Academy of Management Review*, *14*(4), 532–550.

Eisenhardt, K. M., & Graebner, M. E. (2007). Theory building from cases: Opportunities and challenges. *Academy of Management Journal*, *50*(1), 25–32.

Emerson, K., Nabatchi, T., & Balogh, S. (2012). An integrative framework for collaborative governance. *Journal of Public Administration Research and Theory*, *22*(1), 1–29.

Emerson, R. M. (1976). Social exchange theory. *Annual Review of Sociology*, *2*, 335–362.

Gao, H., Barbier, G., Goolsby, R., & Zeng, D. (2011). Harnessing the crowdsourcing power of social media for disaster relief. *IEEE Intelligent Systems*, *26*(3), 10–14.

George, A. L., & Bennett, A. (2005). *Case studies and theory development in the social sciences*. Cambridge, MA: The MIT Press.

George, S. (2008). *Key deployment report - March 2011*. Orlando, FL.

Gibson, W. J., & Brown, A. (2009). *Working with qualitative data*. Los Angeles, CA: SAGE Publications, Inc.

Giridharadas, A. (2010, March 14). Africa's gift to Silicon Valley. *The New York Times*. New York.

Goldstein, J. (2008). Blogs, SMS and the Kenyan election. Retrieved June 18, 2014, from http://inanafricanminute.blogspot.com/2008/01/blogs-sms-and-kenyan-election.html

Goldstein, J., & Rotich, J. (2008). *Digitally networked technology in Kenya's 2007–2008 post-election crisis*. *Berkman Center Research Publication*. Cambridge, MA.

Goodchild, M. F. (2007). Citizens as sensors: The world of volunteered geography. *GeoJournal*, *69*(4), 211–221.

Goolsby, R. (2010). Social media as crisis platform. *ACM Transactions on Intelligent Systems and Technology*, *1*(1), 1–11.

Guest, G., MacQueen, K. M., & Namey, E. E. (2012). *Applied thematic analysis*. Thousand Oaks, CA: SAGE Publications, Inc.

Gultom, D. I., & Joyce, Z. (2014). Crisis communication capacity for disaster resilience: Community participation of information providing and verifying in Indonesian volcanic eruption. In *12th Biennial Australian and New Zealand Third Sector Research Conference*. Christchurch, New Zealand.

Haddow, G. D., Bullock, J. A., & Coppola, D. P. (2008). *Introduction to emergency management* (3rd ed.). San Diego, CA: Butterworth-Heinemann.

Harrald, J. R. (2006). Agility and discipline: Critical success factors for disaster response. *The Annals of the American Academy of Political and Social Science*, *604*(1), 256–272.

Harvey, F., & Tulloch, D. L. (2006). Local government data sharing: Evaluating the foundations of spatial data infrastructures. *International Journal of Geographical Information Science*, *20*(7), 743–768.

Heinzelman, J., & Waters, C. (2010). *Crowdsourcing crisis information in disaster-affected Haiti*. Washington, D.C.

Helsloot, I., & Ruitenberg, A. (2004). Citizen response to disasters: a survey of literature and some practical implications. *Journal of Contingencies and Crisis Management*, *12*(3), 98–111.

Hemmi, A., & Graham, I. (2014). Hacker science versus closed science: Building environmental monitoring infrastructure. *Information, Communication & Society*, *17*(7), 830–842.

Hester, V., Shaw, A., & Biewald, L. (2010). Scalable crisis relief: Crowdsourced SMS translation and categorization with Mission 4636. In *the first Association for Computing Machinery Symposium on Computing for Development*. London, UK.

Hilgartner, S., & Bosk, C. L. (1988). The rise and fall of social problems: A public arenas model. *American Journal of Sociology*, *94*(1), 53–78.

Hillman, A. J., Withers, M. C., & Collins, B. J. (2009). Resource dependence theory: A review. *Journal of Management*, *35*(6), 1404–1427.

Hong, M. (2014). *Utilization of Crowdsourced Maps in Catastrophic Disasters*. San José State University.

HOT. (2015). 2015 Nepal earthquake. Retrieved June 30, 2016, from http://wiki.openstreetmap.org/wiki/2015_Nepal_earthquake#Imagery_and_Reference_Maps

Howe, J. (2009). *Crowdsourcing: Why the power of the crowd is driving the future of business*. New York: Three Rivers Press.

Hu, Q., & Kapucu, N. (2014). Information communication technology utilization for effective emergency management networks. *Public Management Review*, 1–26.

Humanity Road. (2015). *After action report Nepal Earthquakes*. Boydton, VA.

Huxham, C., & Vangen, S. (2005). *Managing to collaborate: The theory and practice of collaborative advantage*. New York, NY: Routledge.

Imperial, M. T., Johnston, E., Pruett-jones, M., Leong, K., & Thomsen, J. (2016). Sustaining the useful life of network governance: Life cycles and developmental challenges. *Frontiers in Ecology and the Environment*, *14*(3), 135–144.

Jaeger, P. T., Shneiderman, B., Fleischmann, K. R., Preece, J., Qu, Y., & Fei Wu, P. (2007). Community response grids: E-government, social networks, and effective emergency management. *Telecommunications Policy*, *31*(10-11), 592–604.

Jap, S. D., & Anderson, E. (2007). Testing a life-cycle theory of cooperative interorganizational relationships: Movement across stages and performance. *Management Science*, *53*(2), 260–275.

Johnson, R. B., & Onwuegbuzie, A. J. (2004). Mixed methods research : A research paradigm whose time has come. *Educational Researcher*, *33*(7), 14–26.

Kapucu, N. (2006a). Interagency communication networks during emergencies: Boundary spanners in multiagency coordination. *The American Review of Public Administration*, *36*(2), 207–225.

Kapucu, N. (2006b). Public-nonprofit partnerships for collective action in dynamic contexts of emergencies. *Public Administration*, *84*(1), 205–220.

Kapucu, N. (2009). Interorganizational coordination in complex environments of disasters: The evolution of intergovernmental disaster response systems. *Journal of Homeland Security and Emergency Management*, *6*(1).

Kapucu, N., Arslan, T., & Demiroz, F. (2010). Collaborative emergency management and national emergency management network. *Disaster Prevention and Management*, *19*(4), 452–468.

Kapucu, N., & Garayev, V. (2011). Collaborative decision-making in emergency and disaster management. *International Journal of Public Administration*, *34*(6), 366–375.

Kapucu, N., Garayev, V., & Wang, X. (2013). Sustaining Networks in Emergency Management. *Public Performance & Management Review*, *37*(1), 104–133.

Kapucu, N., & Ozerdem, A. (2013). *Managing emergencies and crises*. Burlington, MA: Jones & Bartlett Learning.

Kathmandu Living Labs. (n.d.). Who are we? Retrieved January 16, 2015, from http://kathmandulivinglabs.org/pages/details/about_us

Kathuria, R., Joshi, M. P., & Porth, S. J. (2007). Organizational alignment and performance: Past, present and future. *Management Decision*, *45*(3), 503–517.

Kera, D., Rod, J., & Petrova, R. (2013). Post-apocalyptic citizenship and humanitarian hardware. In *Nuclear Disaster at Fukushima Daiichi: Social, Political and Environmental Issues* (Hindmarsh,). New York: Routledge.

Kettl, D. F. (2003). Contingent coordination: Practical and theoretical puzzles for homeland security. *The American Review of Public Administration*, *33*(3), 253–277.

Kingdon, J. W. (1995). *Agendas, Alternatives, and Public Policies*. *Agendas, Alternatives, and Public Policies* (2nd ed.). New York: HarperCollins College Publishers.

Koppenjan, J., & Klijn, E.-H. (2004). *Managing uncertainties in networks: Public private controversies*. New York, NY: Routledge.

Kreps, G. A., & Bosworth, S. L. (1993). Disaster, organizing, and role enactment: A structural approach. *American Journal of Sociology*, *99*(2), 428–463.

Kvale, S. (1996). *InterViews: An introduction to qualitative research interviewing*. Thousand Oaks, CA: Sage Publications, Inc.

Leonard, D., & Howitt, A. (2005). A command system for all agencies? *Crisis Response Journal*, *1*(2), 40–42.

Lin, J. (2012). Ushahidi - Crowsourcing Democracy from Kenya to the World.

Lindsay, B. R. (2011). *Social media and disasters: Current uses, future options, and policy considerations*. Washington, D.C.

Lindsay, B. R. (2012). *Federal emergency management : A brief introduction*. Washington, D.C.

Liu, S. B., & Palen, L. (2010). The new cartographers: Crisis map mashups and the emergence of neogeographic practice. *Cartography and Geographic Information Science, 37*(1), 69–90. http://doi.org/10.1559/152304010790588098

Makinen, M., & Kuira, M. W. (2008). Social media and postelection crisis in Kenya. *The International Journal of Press/Politics, 13*(3), 328–335. http://doi.org/10.1177/1940161208319409

Marsden, J. (2013). Stigmergic self-organization and the improvisation of Ushahidi. *Cognitive Systems Research, 21*, 52–64.

Mei, E. T. W., Lavigne, F., Picquout, A., de Bélizal, E., Brunstein, D., Grancher, D., … Vidal, C. (2013). Lessons learned from the 2010 evacuations at Merapi volcano. *Journal of Volcanology and Geothermal Research*, *261*, 348–365.

Meier, P. (2009). Ushahidi: From crowdsourcing and crowdfeeding. Retrieved October 6, 2014, from http://irevolution.net/2009/03/27/ushahidi-from-croudsourcing-to-crowdfeeding/

Meier, P. (2010). Haiti: Taking stock of how we are doing. Retrieved June 20, 2014, from https://www.ushahidi.com/blog/2010/02/07/haiti-taking-stock-of-how-we-are-doing

Meier, P. (2011). New information technologies and their impact on the humanitarian sector. *International Review of the Red Cross*, *93*(884), 1239–1263.

Meier, P. (2013). AIDR: Artificial Intelligence for Disaster Response. Retrieved July 2, 2016, from https://irevolutions.org/2013/10/01/aidr-artificial-intelligence-for-disaster-response/

Meier, P. (2015). *Digital humanitarians: How big data is changing the face of humanitarian response*. New York: CRC Press.

Meier, P., & Munro, R. (2010). The unprecedented role of SMS in disaster response : Learning from Haiti. *The SAIS Review of International Affairs, 30*(2), 91–103.

Motozuka, T., & Kanki, K. (2013). A study on management of the self-installation temporary stronghold after natural disaster in Indonesia: A case study of POSKO management support by Jalin Merapi. In *The International Symposium on City Planning*. Sendai, Japan.

Moynihan, D. P. (2008). Combining structural forms in the search for policy tools : Incident Command Systems in U.S. crisis management. *Governance, 21*(2), 205–229.

MSF. (n.d.). About MSF. Retrieved June 28, 2016, from http://www.msf.org/en/about-msf

Munro, R. (2010). Crowdsourced translation for emergency response in Haiti: The global collaboration of local knowledge. In *Ninth Conference of the Association for Machine Translation in the Americas*. Boulder, CO.

Munro, R. (2013). Crowdsourcing and the crisis-affected community: Lessons learned and looking forward from Mission 4636. *Information Retrieval*, *16*(2), 210–266.

Nelson, A., Sigal, I., & Zambrano, D. (2010). *Media, information systems and communities: Lessons from Haiti*. Retrieved from http://www.alnap.org/resource/6268.aspx

Noveck, B. S. (2009). *Wiki government: How technology can make government better, democracy stronger, and citizens more powerful*. Washington, D.C.: Brookings Institution Press.

Nugroho, Y. (2011). *Citizens in @ction: Collaboration, participatory democracy and freedom of information*.

Nugroho, Y., & Syarief, S. S. (2012). *Beyond click-activism? New media and political processes in contemporary Indonesia*. Berlin, Germany: Friedrich-Ebert-Stiftung.

Okolloh, O. (2008). Update Jan 3 11:00 pm. Retrieved May 14, 2014, from http://www.kenyanpundit.com/2008/01/03/update-jan-3-445-1100-pm/

Okolloh, O. (2009). Ushahidi, or "testimony": Web 2.0 tools for crowdsourcing crisis information. *Participatory Learning and Action*, *59*(January), 65–70.

Oliver, C. (1990). Determinants of interorganizational relationships: Integration and future Directions. *Academy of Management Review*, *15*(2), 241–265.

Palen, L., Anderson, K. M., Mark, G., Martin, J., Sicker, D., Palmer, M., & Grunwald, D. (2010). A vision for technology-mediated support for public participation and assistance in mass emergencies and disasters. In *Proceedings of the 2010 ACM-BCS Visions of Computer Science Conference* (pp. 1–12). Edinburgh, United Kingdom: The British Informatics Society Ltd.

Pfeffer, J., & Salancik, G. R. (1978). *The external control of organizations: A resource dependence perspective*. New York: Harper & Row, Publishers.

Quarantelli, E. L. (2005). *Catastrophes are different from disasters: Some implications for crisis planning and managing drawn from Katrina*. Newark, DE.

Ridings, C. M., & Gefen, D. (2004). Virtual community attraction: Why people hang out online. *Journal of Computer-Mediated Communication*, *10*(1).

Ring, P. S., & Van de Ven, A. H. (1994). Developmental processes of cooperative interorganizational relationships. *The Academy of Management Review*, *19*(1), 90.

Roberts, J. A., Hann, I.-H., & Slaughter, S. A. (2006). Understanding the motivations, participation, and performance of open source software developers: A longitudinal study of the Apache projects. *Management Science*, *52*(7), 984–999.

Roberts, N. C. (2011). Beyond smokestacks and silos: Open-source, web-enabled coordination in organizations and networks. *Public Administration Review*, *71*(5).

Roche, S., Propeck-Zimmermann, E., & Mericskay, B. (2011). GeoWeb and crisis management: Issues and perspectives of volunteered geographic information. *GeoJournal*, *78*(1), 21–40.

Rodriguez, H. (2006). Rising to the challenges of a catastrophe: The emergent and prosocial behavior following Hurricane Katrina. *The Annals of the American Academy of Political and Social Science*, *604*(1), 82–101.

Ryan, G. W., & Bernard, H. R. (2003). Techniques to identify themes. *Field Methods*, *15*(1), 85–109.

Saldaña, J. (2013). *The coding manual for qualitative researchers* (2nd ed.). Los Angeles, CA: SAGE Publications, Inc.

Saputro, A. K. (2014). How information volunteers solve communicative issues during a disaster. Retrieved July 14, 2015, from http://johnpostill.com/2014/12/18/how-information-volunteers-solve-communicative-issues- during-a-disaster/

Schneider, S. K. (1992). Governmental response to disasters: The conflict between bureaucratic procedures and emergent Norms. *Public Administration Review*, *52*(2), 135.

Schroeder, A., Wamsley, G., & Ward, R. (2001). The evolution of emergency management in America: From a painful past to a promising but uncertain future. In A. Farazmand (Ed.), *Handbook of Crisis and Emergency Management*. New York: Marcel Dekker, Inc.

Shanley, L. A., Burns, R., Bastian, Z., & Robson, E. S. (2013). Tweeting up a storm: The promise and perils of crisis mapping. *Photogrammetric Engineering & Remote Sensing*, *79*(10), 865–879.

Shirky, C. (2008). *Here Comes Everybody: The Power of Organizing without Organizations*. New York: The Penguin Press.

Stallings, R. A., & Quarantelli, E. L. (1985). Groups Emergency Management. *Public Administration Review*, *45*(Special Issue: Emergencies Management: A Challenge for Pubblic Administration), 93–100.

Standby Task Force. (2015). *Nepal earthquake deployment -May 2015: After action review*.

Stoll, J., Edwards, W. K., & Mynatt, E. D. (2010). Interorganizational coordination and awareness in a nonprofit ecosystem. In *Proceedings of the 2010 ACM Conference on Computer Supported Cooperative Work*. Savannah, GA.

Surowiecki, J. (2005). *The Wisdom of Crowds*. New York: Anchor Books.

Sutherlin, G. (2013). A voice in the crowd: Broader implications for crowdsourcing translation during crisis. *Journal of Information Science*, *39*(3), 397–409.

Tanesia, A., & Habibi, Z. (2011). *JALIN Merapi community information system in response to Mount Merapi's 2010 eruption*. Montréal, Canada. Retrieved from http://www.amarc.org/documents/Caribbean_Conference/CR_ResponseJALIN_MerapiEruption_EN.pdf

Tapscott, D., & Williams, A. D. (2006). *Wikinomics: How Mass Collaboration Changes Everything*. New York: The Penguin Group.

Tavaana. (n.d.). Ushahidi: From crisis mapping Kenya to mapping the globe. Retrieved May 26, 2014, from https://tavaana.org/en/content/ushahidi-crisis-mapping-kenya-mapping-globe

The GDELT Project. (n.d.). About. Retrieved July 2, 2016, from http://gdeltproject.org/about.html

Thellufsen, C., Rajabifard, A., Enemark, S., & Williamson, I. (2009). Awareness as a foundation for developing effective spatial data infrastructures. *Land Use Policy*, *26*(2), 254–261.

Thomson, A. M., & Perry, J. L. (2006). Collaboration processes : Inside the black box. *Public Administration Review*, *66*(Special Issue: Collaborative Public Management), 20–32.

UNOCHA. (n.d.). Cluster coordination. Retrieved June 28, 2016, from http://www.unocha.org/what-we-do/coordination-tools/cluster-coordination

UNOCHA. (2011). *Field guide for the use of geo-codes*.

UNOCHA. (2015a). *Flash Appeal Revision: Nepal Earthquake*.

UNOCHA. (2015b). *This is OCHA*. Geneva, Switzerland.

UNV. (2015). Online volunteers help prepare the ground for Nepal emergency relief. Retrieved July 2, 2016, from https://www.onlinevolunteering.org/en/org/resources/newsletter_june_2015.html

Waugh, W. L. (2000). *Living with hazards dealing with disasters: An introduction to emergency management*. Armonk, NY: M.E. Sharpe.

Waugh, W. L. (2006). The political costs of failure in the Katrina and Rita disasters. *The Annals of the American Academy of Political and Social Science*, *604*(1), 10–25.

Waugh, W. L. (2007). EMAC, Katrina, and the governors of Louisiana and Mississippi. *Public Administration Review*, *67*(SUPPL. 1), 107–113.

Wehn de Montalvo, U. (2003a). In search of rigorous models for policy oriented research: A behavioural approach to spatial data sharing. *URISA Journal*, *15*(1), 19–28.

Wehn de Montalvo, U. (2003b). *Mapping the determinants of spatial data sharing*. Aldershot, UK: Ashgate Publishing, Ltd.

White, J. I., Palen, L., & Anderson, K. M. (2014). Digital mobilization in disaster response: The work and self-organization of on-line pet advocates in response to Hurricane Sandy. In *The 17th ACM Conference on Computer Supported Cooperation Work and Social Computing*. Baltimore, MD.

Willig, C. (2008). *Introducing qualitative research in psychology* (2nd ed.). Maidenhead, England: McGraw-Hill Professional Publishing.

Willig, C. (2012). Perspectives on the epistemological bases for qualitative research. In H. Cooper (Ed.), *APA handbook of research methods in psychology: Vol. 1. foundations, planning, measures, and psychometics*. The American Psychological Association.

Yin, R. K. (2003). *Case Study Research: Design and Methods, 3rd Edition* (3rd ed.). Thousand Oaks, CA: SAGE Publications, Inc.

Yuan, W., Guan, D., Huh, E., & Lee, S. (2013). Harness human sensor networks for situational awareness in disaster reliefs : A survey. *IETE Technical Review*, *30*(3).

Zook, M., Graham, M., Shelton, T., & Gorman, S. (2010). Volunteered geographic information and crowdsourcing disaster relief: A case study of the Haitian earthquake. *World Medical & Health Policy*, *2*(2), 6–32.

Zuckerman, E. (2008a). Citizen media and the 2007 Kenyan election crisis. Retrieved May 27, 2014, from http://www.ethanzuckerman.com/blog/2008/06/20/kenya-citizen-media-in-a-time-of-crisis/

Zuckerman, E. (2008b). Digital activists find ways to help Kenya. Retrieved from http://www.ethanzuckerman.com/blog/2008/01/09/digital-activists-find-ways-to-help-kenya/

APPENDIX A

INTERVIEW QUESTIONS

FOR PEOPLE WHO WORK FOR FORMAL ORGANIZATIONS

1. Tell me about your background briefly (e.g., education and occupation).

2. Tell me about your organization′s tasks and activities during the Nepal earthquake response. What were your roles during the Nepal earthquake response?

3. Tell me about the names of participatory online groups which your organization cooperated with during the Nepal earthquake response.

3.1. How did your organization cooperate with them during the Nepal earthquake response?

4. Relationships between your organization and participatory online groups would have different stages, including formation, maturation, or decline. Tell me about the level of maturity in relationships between your organization and participatory online groups that you mentioned above.

5. Tell me about mutual dependence between your organization and participatory online groups during the Nepal earthquake response. For example, I would say your organization had a local office or contacts and shared this local knowledge and resources with participatory online groups. On the other hand, participatory online groups created real-time crisis information and shared this information with your organization.

5.1. Tell me about how this kind of mutual dependence influenced the level of maturity in relationships between your organization and participatory online groups. Did mutual dependence lead to more mature relationships and why during the Nepal earthquake response?

6. Tell me about shared understanding between your organization and participatory online groups regarding disaster conditions and how to respond to disasters. That is, did

your organization and participatory online groups reach consensus on disaster conditions and how to respond to disasters during the Nepal earthquake response and how?

6.1. Tell me about how this kind of shared understanding influenced the level of maturity in relationships between your organization and participatory online groups during the Nepal earthquake response.

7. Tell me about your organization′s information technology and management skills. How did your organization use information technology and management skills to cooperate with participatory online groups during the Nepal earthquake response?

7.1. Tell me about how your organization′s information technology and management skills influenced the level of maturity in relationships between your organization and participatory online groups.

8. Tell me about how the level of maturity in relationships between your organization and participatory online groups influenced the outcomes of the Nepal earthquake response. That is, did more mature relationships create better response outcomes and why? Response outcomes would include saving more lives and meeting basic needs more effectively.

APPENDIX B

INTERVIEW QUESTIONS

FOR A MEMBER OF PARTICIPATORY ONLINE GROUPS

1. Tell me about your background briefly (e.g., education and occupation).

2. Tell me about your participatory online group′s tasks and activities during the Nepal earthquake response. What were your roles during the Nepal earthquake response?

3. Tell me about the names of formal organizations which your participatory online groups cooperated with during the Nepal earthquake response. How did your participatory online group cooperate with them during the Nepal earthquake response?

4. Relationships between your participatory online group and formal organizations would have different stages, including formation, maturation, or decline. Tell me about the level of maturity in relationships between your online group and formal organizations that you mentioned above.

5. Tell me about mutual dependence between your online group and formal organizations during the Nepal earthquake response. For example, I would say a formal organization had a local office or contacts and shared this local knowledge and resources with your online groups. On the other hand, your participatory online groups created real-time crisis information and shared this information with formal organizations.

5.1. Tell me about how this kind of mutual dependence influenced the level of maturity in relationships between your online group and formal organizations. Did mutual dependence lead to more mature relationships and why during the Nepal earthquake response?

6. Tell me about shared understanding between your participatory online group and formal organizations regarding disaster conditions and how to respond to disasters. That

is, did your online group and formal organizations reach consensus on disaster conditions and how to respond to disasters during the Nepal earthquake response and how?

6.1. Tell me about how this kind of shared understanding influenced the level of maturity in relationships between your participatory online group and formal organizations during the Nepal earthquake response.

7. Tell me about your participatory online group′s information technology and management skills. How did your participatory online groups use information technology and management skills to cooperate with formal organizations during the Nepal earthquake response?

7.1. Tell me about how your online group′s information technology and management skills influenced the level of maturity in relationships between your participatory online groups and formal organizations.

8. Tell me about how the level of maturity in relationships between your participatory online group and formal organizations influenced the outcomes of the Nepal earthquake response. That is, did more mature relationships create better response outcomes and why? Response outcomes would include saving more lives and meeting the affected people′s needs more effectively.

APPENDIX C

FOLLOW-UP INTERVIEW QUESTIONS

FOR PEOPLE WHO WORK FOR FORMAL ORGANIZATIONS

1. How did resource dependence influence the intensity of interaction ** between your organization and participatory online groups during the Nepal earthquake response? (** A high level of interaction intensity means that there are dynamic communications and exchanges of information and resources) (For example, if your organization is reliant on participatory online groups′ real-time disaster information, your organization may have dynamic interactions and communications with participatory online groups to obtain the information.)

2. How did shared understanding of common problems (i.e. disaster conditions and status) influence the intensity of interaction between your organization and participatory online groups during the Nepal earthquake response? (For example, if your organization and participatory online groups have a higher level of consensus on disaster conditions and status, your organization and participatory online groups may have more dynamic communications and interactions to collectively respond to a devastating disaster.)

3. How did shared understanding of strategies (i.e. how to resolve common problems) influence the intensity of interaction between your organization and participatory online groups during the Nepal earthquake response? (For example, if your organization and participatory online groups have a higher level of consensus on how to deal with disaster conditions, your organization and participatory online groups may have more dynamic communications and interactions to collectively respond to a devastating disaster.)

4. How did difference between your organization and participatory online groups in information technology adoption (e.g., Skype, Google Docs, Ushahidi platform, GIS

software etc.) influence the intensity of interaction between your organization and participatory online groups during the Nepal earthquake response? (For example, if your organization adopted Skype, but a participatory online groups did not use Skype, such difference in technology adoption would decrease communications and interactions between your organization and participatory online groups.)

5. How did your organization′s technical management capacities (i.e. capacities for converting, integrating, and distributing disaster-related information) influence the intensity of interaction between your organization and participatory online groups during the Nepal earthquake response? (For example, if your organization has a higher level of technical management capacity, your organization may have more dynamic interactions with participatory online groups to transmit and integrate disaster-related data from your organization and participatory online groups.)

6. How did the intensity of interaction between your organization and participatory online groups influence inter-organizational alignment in emergency response (i.e. coordination of a wide range of responding tasks and activities, such as crisis mapping, situation reports, 3W, onsite operations, and offsite strategic decision making and supports) during the Nepal earthquake response? (For example, if your organization and participatory online groups have rich, dynamic interactions and communications with each other, your organization and participatory online groups may coordinate diverse responding tasks and activities more effectively.)

7. How did inter-organizational alignment (coordination) between your organization and participatory online groups influence the effectiveness of emergency response,

particularly regarding saving lives and meeting basic human needs during the Nepal earthquake response?

APPENDIX D

FOLLOW-UP INTERVIEW QUESTIONS

FOR A MEMBER OF PARTICIPATORY ONLINE GROUPS

1. How did resource dependence influence the intensity of interaction ** between your participatory online group and formal response organizations during the Nepal earthquake response? (** A high level of interaction intensity means that there are dynamic communications and exchanges of information and resources) (For example, if your participatory online group is reliant on formal response organizations′ disaster-related information or other resources, your participatory online group may have dynamic interactions and communications with formal response organizations to obtain the information or resources.)

2. How did shared understanding of common problems (i.e. disaster conditions and status) influence the intensity of interaction between your participatory online group and formal response organizations during the Nepal earthquake response? (For example, if your participatory online group and formal response organizations have a higher level of consensus on disaster conditions and status, your participatory online group and formal response organizations may have more dynamic communications and interactions to collectively respond to a devastating disaster.)

3. How did shared understanding of strategies (i.e. how to resolve common problems) influence the intensity of interaction between your participatory online group and formal response organizations during the Nepal earthquake response? (For example, if your participatory online group and formal response organizations have a higher level of consensus on how to deal with disaster conditions, your participatory online group and formal response organizations may have more dynamic communications and interactions to collectively respond to a devastating disaster.)

4. How did difference between your participatory online group and formal response organizations in information technology adoption (e.g., Skype, Google Docs, Ushahidi platform, GIS software etc.) influence the intensity of interaction between your participatory online group and formal response organizations during the Nepal earthquake response? (For example, if your participatory online group adopted Skype, but formal response organizations did not use Skype, such difference in technology adoption would decrease communications and interactions between your participatory online group and formal response organizations.)

5. How did your participatory online group′s technical management capacities (i.e. capacities for converting, integrating, and distributing disaster-related information) influence the intensity of interaction between your participatory online group and formal response organizations during the Nepal earthquake response? (For example, if your participatory online group has a higher level of technical management capacity, your participatory online group may have more dynamic interactions with formal response organizations to transmit and integrate disaster-related data from your participatory online group and formal response organizations.)

6. How did the intensity of interaction between your participatory online group and formal response organizations influence inter-organizational alignment in emergency response (i.e. coordination of a wide range of responding tasks and activities, such as crisis mapping, situation reports, 3W, onsite operations, and offsite strategic decision making and supports) during the Nepal earthquake response? (For example, if your participatory online group and formal response organizations have rich, dynamic

interactions and communications with each other, your participatory online group and formal response organizations may coordinate diverse responding tasks and activities more effectively.)

7. How did inter-organizational alignment (coordination) between your participatory online group and formal response organizations influence the effectiveness of emergency response, particularly regarding saving lives and meeting basic human needs during the Nepal earthquake response.