

An Event-Driven Lens for Bridging Formal Organizations and Informal Online Participation: How Policy Informatics Enables Just-in-Time Responses to Crises

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Abstract Policy informatics not only gives new approaches to analyzing policy challenges, but also provides guidance for understanding new forms of organizing in the digital era. This chapter aims to investigate how technology accelerates the creation of just-in-time efforts while also lowering the barriers for joining such efforts to an increasingly diverse set of formal and informal actors who can make a meaningful contribution in the context of emergency management. In this chapter, we suggest a novel and extended lens called an ‘event-driven’ lens for integrating formal and informal responses by reviewing the literature on emergency management, crowdsourcing, open innovation, policy informatics, and digital humanitarianism. The novel lens is called an event-driven lens because crises 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 informal actors across the globe and from the affected communities to collectively respond to disasters or crises. Traditionally, emergency preparedness and response are in large part the role and responsibility of formal organizations like emergency management agencies and police and fire departments. Due to concurrent advances in a variety of technologies (information, communication, and artificial intelligence), informal groups of publics from both across the globe and the affected regions now regularly emerge and can play a significant role in the response through crowdsourcing vital information and assisting with the allocation of needed resources and services.

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Abbreviations

AIDR	Artificial Intelligence for Disaster Response
DHS	The U.S. Department of Homeland Security
EMAC	Emergency Management Assistance Compact
ICS	Incident Command System
OSM	OpenStreetMap
SBTF	Standby Task Force
SMS	Short Message Service
UAV	Unmanned Aerial Vehicle

Introduction

Policy informatics not only gives new approaches to analyzing policy challenges, but also provides guidance for understanding new forms of organizing in the digital era. In particular, technology accelerates the creation of just-in-time 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 man-made crises (terrorism and ethnic violence) are 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 like emergency management agencies and police and fire departments under related laws and regulations. The U.S. Federal Emergency Management Agency (FEMA) is responsible for developing emergency management policies and 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. Today, 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 prepare for and respond to every possible type of catastrophe. Thus, when a catastrophe occurs, multiple public agencies across local, state, and federal governments are mobilized and deployed to deal with the disaster. Also, formal nonprofit organizations like the American Red Cross and the Salvation Army and for-profit organizations collaborate with public agencies to offer rescue and relief services to disaster-affected people.

Importantly, because of concurrent advances in information, communication, and computational technologies, communities now regularly emerge where amateurs or concerned publics can play a meaningful role in the response through crowdsourcing vital information and assisting with the allocation of needed resources or services. In recent catastrophic disasters or crises such as the 2010 Haiti earthquake, the 2011 Japan earthquake, tsunami, and nuclear disaster, and the 2015 Nepal earthquake, informal, emergent groups of individuals across the globe

and from the affected areas made significant contributions to the effective response. As a novel phenomenon in the digital era, informal actors were able to provide a vital component of the emergency response. In some cases they filled information gaps on disaster conditions and the affected people's needs, voluntarily mobilized, delivered, and allocated relief resources, and helped coordinate formal organizations' tasks and activities in complex, urgent disaster situations. These informal groups are often a kind of virtual community consisting of digital volunteers who are loosely connected through information and communication technologies.

Specifically, these informal groups created a reporting system through which the affected people submitted their requests for rescue or relief and the information of disaster conditions by using various technologies. These informal actors also gathered, verified, and visualized a large amount of disaster 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. The information processed by these informal actors increased situational awareness of the current state of disasters, the affected peoples' needs and requests, and which organizations were working with what and where to meet the unmet needs of the affected people. By providing real-time, verified, and reliable disaster information, these informal actors enabled the affected communities (local residents affected by disasters and local community-based nonprofit organizations) to quickly mobilize aid resources and help the communities, formal emergency management agencies and first responders to make timely and effective decisions about rescue missions and relief services. In addition, numerous organizations from the public, private, and nonprofit sectors could efficiently coordinate their various tasks and activities in response to disasters. These informal actors' efforts are becoming now an anticipated and legitimate part of the overall response to catastrophes (Meier 2015).

The Importance of Considering Both Formal and Informal Emergency Responses

Institutionalized formal organizations and their emergency responses are relatively effective in dealing with small-scale or routine emergencies, but formal emergency responses are likely severely delayed and challenged when addressing large-scale, catastrophic disasters and crises. According to Leonard and Howitt (2005), a formal emergency management organization "functions best when it is directed at a well-defined, reasonable consistent or clear prioritized set of purposes" (cited in Buck et al. 2006, p. 5). However, the emergency response systems of formal organizations sometimes operate "poorly for large disasters which often involve a. multiple hazards occurring in close temporal and spatial succession, b. with multiple agent-generated demands, with c. multiple responding agencies, d. attempting to satisfy often conflicting goals that cannot be anticipated and reconciled" (Buck et al. 2006, p. 5). 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 disaster situations (Crowley and Chan 2011; Yuan et al. 2013). Formal response actors' difficulty or failure is caused primarily by a lack or absence of information on the current state of disasters (e.g., fatalities, injuries, damages, and the needs of those affected) and on real-time response efforts (i.e. who is working on what, where). Existing emergency management systems often do not have open communication channels and related formal protocols that aggregate or prioritize local intelligence from outside sources and share freely the intelligence with the affected people and informal actors (Yuan et al. 2013). Hence, there are 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 deployed to help address a disaster or a crisis, and the affected people on the ground (Kapucu 2006). 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).

Importantly, with advances in information and communication technologies, the role and contributions of informal groups of publics have become more useful in response to recent disasters or crises. Hence, one needs "modern" emergency response systems integrating both formal organizations and informal groups. That is, if the strengths of both formal and informal actors are incorporated, the capacity to deal with disasters or crises would be tremendously increased. Moreover, theoretically and conceptually, a more integrative lens needs to be developed to help explain and understand various responses to catastrophic disasters by taking into account not only formal actors with legal responsibilities, but also informal actors who actively involve emergency response. Thus, this chapter suggests an "event-driven" lens for bridging formal organizations and informal groups of individuals in response to crises. For this purpose, we conducted a comprehensive literature review on emergency management, disaster policy, policy informatics, crowdsourcing, and open innovation.

An Event-Driven Lens for Integrating Formal and Informal Emergency Responses

Recent catastrophic events led to the emergence of informal, online groups of publics that collaborated with formal organizations or worked independently (outside of formal organizations) to respond to the events. That is, one can witness that the actual disaster response systems in the networked age are much more complex and

dynamic than the existing emergency management literature and disaster policies based on formal organizations have understood, because a wide range of formal and informal actors work together or independently in response to the catastrophic events. Thus, it is necessary to build a novel and extended lens for integrating both formal and informal responses in the networked age. The novel lens is called an event-driven lens, because crises 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 informal actors across the globe and from the affected communities to collectively respond to disasters or crises. Specifically, the event-driven lens takes into account: (1) formal emergency response (i.e. how do formal organizations respond to catastrophic disasters or crises, following predetermined policies, procedures, and related laws? And what are the challenges and limitations of formal organizations in large-scale disasters or crises?); (2) informal emergency response (i.e. what do informal actors perform to voluntarily respond to disasters? And what are their contributions to the effective emergency response?); and (3) how formal actors and informal actors interact with each other in catastrophic disaster or crises (i.e. what are the types of the relationships between formal and informal actors?)

Formal Emergency Response

Formal emergency response is an official system consisting of institutionalized organizations at all levels of government and across 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. In the formal emergency response system, institutionalized organizations conduct a wide range of activities and tasks to respond to a disaster or a crisis (Haddow et al. 2008). Such activities and tasks include search and rescue missions, emergency medical services, and relief services (foods, water, and temporary shelters).

Formal Organizations

A key feature of formal emergency response is the 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 (e.g., the Federal Emergency Management Agency, the U.S. Forest Service, the U.S. Coast Guard, and the U.S. Army Corps of Engineering), first responders (e.g., police and fire departments and emergency medical services), institutionalized nonprofit organizations (e.g., the American Red Cross, the Salvation Army, World Vision, and National Voluntary Organizations Active in Disaster), and private corporations (e.g., private utility companies).

Laws, Policies, Procedures, Plans, and Agreements

Prior to the occurrence of a disaster or a crisis, a wide range of established laws, disaster policies, standard operating procedures, emergency preparedness plans, and mutual aid agreements already exist for an effective formal emergency response. For example, these formal rules, plans and policies include the Robert T. Stafford Disaster Relief and Emergency Assistance Act,¹ the National Incident Management System (NIMS),² the National Response Framework (NRF),³ and the Emergency Management Assistance Compact (EMAC)⁴ in the United States (Kapucu and Garayev 2011; Lindsay 2012; DHS 2008, 2013; Waugh 2007). These formal rules, plans and policies describe the key principles and concepts of emergency management, the specific roles and responsibilities of each formal organization involved, and detailed procedures on how resources and personnel are mobilized, deployed and reimbursed.

Inter-Organizational Coordination Mechanisms

Soon after a disaster or a crisis occurs, formal organizations and their latent networks are activated, following predetermined policies, procedures, and agreements. That is, the formal emergency response system becomes a large network(s) of formal organizations across the public, nonprofit, and for-profit sectors. The size of the network of formal organizations involved is mostly determined by the magnitude of a disaster or a crisis and its immediate impacts, including fatalities, injuries, collapsed buildings, and displaced people (McGuire and Silvia 2010; Waugh 2006). There are the two types of inter-organizational coordination mechanisms in a network(s) of formal organizations: the Incident Command System (ICS) and collaborative decision making processes. The ICS that emphasizes unified command and control 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) in California, the ICS has spread across the United States (Buck et al. 2006; Cole 2000; Harrald 2006). The ICS 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 actors.

¹<https://www.fema.gov/robert-t-stafford-disaster-relief-and-emergency-assistance-act-public-law-93-288-amended>.

²<http://www.fema.gov/national-incident-management-system>.

³<http://www.fema.gov/national-response-framework>.

⁴<http://www.emacweb.org/>.

Unlike the on-scene operations based on unified command and control, 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 (Kapucu and Garayev 2011; DHS 2013; Waugh 2007). Such off-scene inter-organizational structures and procedures are “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). These off-scene arrangements aim to provide timely supports and assistance to first responders on the ground, mostly following predefined standard operating procedures and protocols. A typical example of these 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 and Garayev 2011; Waugh 2007). According to the literature, cooperative inter-organizational coordination is likely influenced not only by established formal rules (i.e. the ICS and collaborative arrangements), but also a variety of the characteristics of inter-organizational relationships including prior history of collaboration, trust, and intergovernmental political dynamics (Haddow et al. 2008; Harrald 2006; Kapucu et al. 2013; Quarantelli 2005; Waugh 2006).

Products and Services

Formal organizations’ responding activities create a wide range of products and services. These products and services in response to a disaster or a crisis include hazard warnings and public information on emergency services, transportation services for evacuating the affected people or animals, mass care services (food, water, and temporary shelters), family reunification support services, search and rescue missions, public health and emergency medical services, on-scene security and protection through law enforcement, and situational assessment (DHS 2013). These products and services are the outputs of formal organizations’ responding activities.

Informal Emergency Response

For the past four decades, disaster sociologists have researched informal, emergent groups of individuals and their behavior in response to a disaster or a crisis. Most prior studies have focused on emergent collective behavior at the local community level before, during and after a disaster or a crisis (e.g., Drabek and McEntire 2003; Drabek 1985; Helsloot and Ruitenberg 2004; Kreps and Bosworth 1993; Rodriguez 2006; Stallings and Quarantelli 1985). The disaster sociology literature has provided useful knowledge on collective behavior and organizational structures of informal, emergent groups of individuals. However, most prior studies in disaster sociology

have investigated relatively small groups of the affected people who helped each other in extreme events. Hence, the existing disaster sociology literature has paid little attention to large-scale collaboration enabled through information, communication, and computational technologies in disaster or crisis situations.

In the fields of crisis informatics, digital humanitarianism, emergency communications, and computer science, many scholars and practitioners recently began to note the contributions and potentials of informal, citizen-driven, volunteer-based groups in a variety of disaster or crisis situations including natural disasters like earthquakes, hurricanes, volcanic eruptions, and tsunamis and manmade disasters like riots, terrorism, and ethnic conflicts (Crowley 2013; Palen et al. 2010; White et al. 2014; Zook et al. 2010). Informal groups of publics are characterized as loosely connected, decentralized, and emergent groups of individuals across the globe and from the affected areas in response to a disaster or a crisis. These informal groups are often crowdsourced communities that perform collective responses by using information and communication technologies and automated data mining tools. Specifically, in recent disaster situations, these informal groups of ordinary people like students, software developers, and bloggers were interconnected through information and communication technologies. These informal groups mostly gathered, processed, and visualized timely, accurate, and reliable disaster information through crowdsourced human computation and artificial intelligence. Also, these informal groups self-organized and coordinated the mobilization and allocation of various relief resources (food, water, temporary shelters, and transportation) through simple web platforms and social networking sites, including Airbnb,⁵ Uber,⁶ crowdfunding websites like Indiegogo⁷ and GoFundMe,⁸ Facebook, Twitter, Google Docs, Reddit,⁹ and other online platforms.

For instance, in the immediate aftermath of the 2010 Haiti earthquake, students from Tufts University, the Haitian diaspora, and disaster-affected people on the ground remotely collaborated with each other to collate actionable pieces of disaster-related information from mainstream media and social media (Meier 2011, 2015). The disaster-related information consisted mostly of disaster conditions and the affected people's requests for rescue and aid. Such disaster-related information was verified, processed and updated by a large group of informal actors from about 50 countries including Canada, Colombia, Haiti, Switzerland, and the United States

⁵<https://www.airbnb.com/>; Airbnb was used to provide post-disaster accommodations for the affected people in the 2015 Nepal earthquake and the 2015 Paris Terrorist attacks.

⁶<https://www.uber.com/>; In the aftermath of the 2015 Nepal earthquake, Uber was used for picking up donations for the affected people in India.

⁷<https://www.indiegogo.com/>; In the aftermath of the 2015 Nepal earthquake, a group of Nepalese young volunteers and a nonprofit organization used indiegogo to crowdfund their voluntary responding activities.

⁸<https://www.gofundme.com/>; During and after the 2015 Nepal earthquake, an informal group of publics called One Stop Portal initiated a crowdfunding campaign through gofundme.

⁹<https://www.reddit.com/>; In the aftermath of the 2013 Boston Marathon bombing, an informal group of volunteers used reddit to deliver foods (pizzas in particular) to first responders and the affected people.

(Meier and Munro 2010). Also, urgent requests for rescue were directly sent to international first responders in the field. That is, these informal groups of publics helped international and local community-based responding organizations effectively coordinate their missions and tasks on the ground.

The informal emergency response of amateurs and concerned publics is a system consisting of a large group of informal actors including individuals across the globe and the affected people, technologies, and decentralized, open, adaptable organizational structures.

Informal Actors

Numerous individuals like students, software developers, reporters, and GIS professionals around the world and from the affected areas participate in and contribute to their own collective responses. These people have diverse backgrounds regarding age, gender, race and ethnicity, nationality, skill, education, and socioeconomic status (Howe 2009; Meier and Munro 2010). Informal actors can be categorized into a small group of key contributors and a large group of micro-contributors (Howe 2009; Shirky 2008; Tapscott and Williams 2006). In disaster or crisis situations, key contributors often create online platforms as communication channels and collect and process large amounts of disaster-related information from mainstream media and social media. These key contributors serve as builders, processors, and facilitators of informal, emergent groups of publics. In addition, large groups of micro-contributors are likely mobilized by key contributors' open calls for volunteering. Micro-contributors perform small, discrete tasks as much as they can do (e.g., collecting and verifying actionable pieces of disaster-related information and offering couches and beds to those who are stranded). Both key contributors and micro-contributors are essential for an effective informal emergency response.

Information, Communication, and Computational Technologies

Informal groups of individuals in response to a disaster or a crisis mostly rely on information and communication technologies and advanced computing. These technologies are used to mobilize their members across the globe and from the affected regions, to communicate with each other in real-time, and to take collective action by aggregating a variety of intelligence, skills, and resources from the ground and their mobilized members across the globe. In most cases, these informal groups of individuals do not have physical spaces for their collective action. Online chat rooms like Skype and social networking sites like Facebook Groups or Google Groups are their virtual headquarters.

These informal groups of publics utilize multiple technologies for the collection, mining, verification, and visualization of disaster-related data. Specifically, disaster-related data (both text- and image-based data) is collected from multiple sources including reports from the ground (via short message service (SMS), email, and

online forms like Google Forms), social networking sites (Facebook, Flickr, Instagram, Twitter, and YouTube), mainstream media (news articles), and satellite imagery donated by for-profit satellite imagery providers.

Moreover, Unmanned Aerial Vehicles (UAVs), commonly called drones, are beginning to be used. The aerial imagery of disaster-affected areas is essential for assessing disaster conditions (collapsed buildings and roads) and creating post-disaster maps. Aerial images captured by drones have several advantages compared to commercial satellite images. “First off, cloud cover is regularly a big challenge for commercial satellites.... UAVs fly below the clouds. This is especially critical following typhoons and hurricanes since clouds may linger for days after the devastation.... In addition, it generally takes 48–72 h to task a satellite over an area of interest. In contrast, a locally deployed UAV can capture imagery within hours and even minutes” (Meier 2015, p. 84). When Typhoon Haiyan struck the Philippines and caused over 6000 fatalities in 2013, an informal group of publics for voluntary online mapping called the Humanitarian OpenStreetMap Team¹⁰ used UAV imagery to “quickly identify destroyed buildings and trace up-to-date roadmaps of the hardest hit areas, thus providing humanitarian organizations with critical information on which roads could still be used to provide urgent aid” (Meier 2015).

Notably, informal groups of individuals utilize both advanced computational technologies (i.e. machine learning) for data mining and crowdsourced human computation for data verification and analysis. A large amount of disaster-related information (texts and images) is often posted on social media in the immediate aftermath of disasters or crises. For example, over 250,000 disaster-related contents were posted on Twitter right after Typhoon Haiyan in 2013 (Meier 2015). However, such information is not likely to be useful to emergency management agencies and first responders due to information overload (Boulos et al. 2011; Edmunds and Morris 2000). It is because public agencies and departments usually do not have enough human and technical resources to quickly process such a large amount of disaster data. In fact, informal groups of publics have the same issue as formal organizations do. However, to deal with disaster information overload, informal online communities sometimes use an open-source, automated data-mining tool called Artificial Intelligence for Disaster Response (AIDR) developed and donated by a Qatar-based nonprofit computing research institute.¹¹ The AIDR uses both machine learning and human intelligence. The general architecture of the AIDR consists of collector, trainer, and tagger (Imran et al. 2014). The collector compiles messages from Twitters. It enables users to filter tweets posted during a disaster or a crisis by using keywords and hashtags (e.g., #Nepalquake and #Fukushima). Next, the messages filtered through the collector are passed to the tagger. The tagger performs the classification of each tweet by user-defined topics or categories such as collapsed buildings, casualties, and urgent needs (Imran et al. 2014).

Messages from Twitter are often too complex for machines to accurately classify them (Castillo 2015). To address this issue, the trainer “allows one or more users to

¹⁰A global community of online volunteer mappers for humanitarian disaster response.

¹¹<http://qcri.com/>.

train the AIDR platform to automatically tag tweets” (Meier 2013). The collection owner creates a trainer page for tweets of interest by identifying categories of interest such as damages or rumors and manually labeling tweets by the identified categories. This training task can be performed by the collection owner him or herself or be crowdsourced to the public (i.e. online volunteers). If the collection owner wants the crowd to help classify the tweets, he or she can invite volunteers by sharing a link to the training page. As humans (i.e. the collection owner or a group of volunteers) manually label a small set of the tweets, the AIDR learns how to classify the tweets. Once enough tweets are labeled by humans (at least 20 tweets), the tagger automatically begin to apply the human-labeled classifier to incoming tweets by assigning one of the user-defined categories to each tweet (Imran et al. 2014). Then the tagger displays the automatically classified tweets on an online map or another visualization platform.

In the immediate aftermath of Typhoon Haiyan in 2013, an online volunteer community for crisis mapping called the Standby Task Force (SBTF) utilized the AIDR. The SBTF first collected tweets by using keywords and hashtags related to Typhoon Haiyan. Then the SBTF uploaded the collected tweets to a micro-tasking platform called the Tweet Clicker (i.e. a kind of the trainer for the AIDR). By using this platform, online volunteers of the SBTF manually labeled the tweets by the identified categories. Such human intervention provided training examples for the AIDR to learn how to classify the tweets. Ultimately, the AIDR enabled the SBTF to reduce over 250,000 tweets to approximately 55,000 disaster-related tweets that formal organizations could use for their response activities.

Lastly, informal groups of individuals sometimes utilize several data verification tools. For instance, Swift River, which was developed by Ushahidi, a nonprofit, open-source software company, organizes and filters incoming reports from the ground and social media. “Specific report sources are tracked through unique IDs (phone numbers or e-mail addresses) and thus can be ranked according to their record of veracity (Heinzelman and Waters 2010, p. 12).

Informal Organizational Characteristics and Structures

These informal groups are a new form of organization in the networked age (Capelo et al. 2012; Roberts 2011; White et al. 2014). From a systems theory viewpoint, these informal groups are mostly open systems. It means that anyone can participate in and contribute to these informal groups. Moreover, these informal groups have decentralized and horizontal organizational structures (Capelo et al. 2012; White et al. 2014). Such organizational structures enable the informal groups of people to quickly and constantly change their organizational structures and collective action processes to respond to unexpected challenges and problems in an agile, adaptive manner. Furthermore, the members of these informal groups likely share a sense of community and willingly provide mutual aid for learning and problem-solving.

These informal groups are often a kind of virtual community. In other words, a lot of individuals across the globe and the affected people are loosely connected and

work together through a variety of information and communication technologies (e.g. short message service (SMS), email, social media, mobile applications, etc.). In many cases, these groups' collective action is coordinated through online crowdsourcing platforms. A large amount of labor is broken into small pieces and is distributed to a large group of individuals around the world and the affected people on the ground.

Resources and Services

Informal groups of people create a variety of products and services to help respond to a disaster or a crisis. In most cases, these informal groups of individuals around the world collectively create the following products and services: online or offline post-disaster base maps of the affected areas; timely, accurate disaster-related information on the current state of a disaster or a crisis, relief resources available, and the affected people's needs and requests; and real-time humanitarian '3W' information regarding **Which** formal organizations are doing **What**, **Where** to meet the affected people's unmet needs; and the self-organized mobilization and delivery of a variety of aid resources by matching those who donate resources to those in need.

Interactions and Relationships Between Formal and Informal Actors

In some disaster or crisis situations, informal groups of individuals actively collaborate with formal organizations such as public emergency management agencies and nonprofit organizations. But in other situations, formal and informal actors perform their own responding activities independently. Interactions and relationships between formal organizations and informal groups can be categorized into four types according to whether formal and informal actors are aware of each other and whether there is alignment in formal and informal emergency responses (Kathuria et al. 2007; Thellufsen et al. 2009) (See Fig. 1).

In the first type of relationship, formal and informal actors recognize each other's existence, resources, and responding activities and these actors complement each other's efforts in a coordinated manner. In such a situation, the efficiency and effectiveness of overall emergency response systems are likely to be maximized. When formal and informal actors develop complementary and synergic relationships, these actors tend to achieve just-in-time performance. Roe and Schulman categorize crisis management in the context of high reliability organizations (particularly, electricity infrastructure) on the basis of instability¹² and options variety¹³ (Roe and

¹²"Instability is the extent to which [a high reliability organization]...faces rapid, uncontrollable changes or unpredictable conditions that threaten the grid and service reliability of electricity supply, i.e., that threaten the task of balancing load and generation" (Schulman et al. 2004, p. 19).

¹³"Options variety is the amount of...[a high reliability organization] resources...to respond to events" (Schulman et al. 2004, p. 19).

		Awareness	
		+	-
Alignment	+	<p>Type 1 (Complementary and synergic)</p> <ul style="list-style-type: none"> - 2010 Haiti earthquake: The Tufts team, Mission 4636, OpenStreetMap, and international first responders 	<p>Type 2 (Additive)</p> <ul style="list-style-type: none"> - 2011 Japan earthquake: Action-oriented local groups and the Japanese local government - 2012 Hurricane Sandy: Online pet advocates and related formal agencies
	-	<p>Type 3 (Ignoring and uncooperative)</p> <ul style="list-style-type: none"> - 2011 Japan earthquake: The Safecast team and the Japanese government 	<p>Type 4 (Inconsistent and confusing)</p> <ul style="list-style-type: none"> - Within the first 24 to 72 hours of catastrophic disasters or crises

Fig. 1 Relationships between formal organizations and informal online groups

Schulman 2008; Schulman et al. 2004). When both options variety and system instability are high, just-in-time performance is likely to be dominant. “This performance condition demands ‘real-time’ flexibility, that is, the ability to utilise and develop different options and strategies quickly” through rich, dynamic communications between related stakeholders (Schulman et al. 2004, p. 20).

The 2010 Haiti earthquake is an exemplary case of complementary and synergic relationships between formal and informal actors. Soon after a devastating earthquake struck Haiti in 2010, informal groups of individuals emerged globally on a large scale. Students from Tufts University in the United States collected, verified, and visualized actionable pieces of disaster information from social media and mainstream media by using Google Docs and Ushahidi (free and open-source software for crisis mapping) in near real-time (Heinzelman and Waters 2010). A global volunteer community for creating a free editable map called OpenStreetMap (OSM)¹⁴ collectively created an online map of post-disaster Haiti (Crowley and Chan 2011; Roche et al. 2011). Over two thousand volunteers from both across the globe and the affected regions participated and contributed to a SMS-based reporting system called the Mission 4636 project that allowed the affected people on the ground to submit their disaster conditions and requests for rescue or aid. In this project, such numerous volunteers translated reports from and to Haitian Creole, French, and English and verified these reports (Munro 2013). Three informal groups of volunteers (Tufts students, the OSM community, and the Mission 4636 volunteers) were connected to one another through information and communication tech-

¹⁴<https://www.openstreetmap.org/>.

nologies such as online chat rooms and collaborative crisis-mapping platforms and shared their disaster and geographic information.

Moreover, all information created by informal groups of volunteers was shared with formal emergency management agencies (e.g., the U.N. Office for Coordination of Humanitarian Affairs and the International Federation of Red Cross and Red Crescent Societies) and international first responders (e.g., the U.S. Marine Corps and the U.S. Coast Guard) on the ground in real-time. Particularly, the international first responders used the information to coordinate their search-and-rescue missions and the allocation and delivery of relief resources. After these first responders completed their response operations, they gave the informal groups of volunteers an update on the current status of response operations. Therefore, there were dynamic collaboration and communications between formal and informal actors during the Haiti earthquake response period.

In the second type of relationship, formal and informal actors are not aware of each other, but there is ‘unintentional’ alignment in response efforts between formal and informal actors. In such conditions, both actors’ responding efforts are simply additive, but not able to be coordinated in a synergistic manner due to a lack of inter-organizational awareness. Particularly, such relationships between formal and informal actors may appear in catastrophic disaster situations. According to Quarantelli (2005), a catastrophe is systemically different from a disaster. In a catastrophic event compared to a disaster, “[m]ost or all of the community built structure is heavily impacted.... Local [emergency management] officials are unable to undertake their usual work role.... Most, if not all, of the everyday community functions are sharply and concurrently interrupted.” Such catastrophe likely leads to the emergence of numerous informal actors in situations where formal organizations do not have sufficient resources and capacities for dealing with the catastrophe. For example, in the aftermath of the 2011 Japan earthquake, a lot of action-oriented local groups of people voluntarily emerged and self-organized the mobilization and delivery of aid resources within their communities by using simple webpages (Slater et al. 2012). Moreover, during and after the 2012 Hurricane Sandy, loosely organized online pet advocates launched a lost-and-found-pets page on Facebook. By using this page, the online pet advocates aimed to reunite lost pets with their owners. For this purpose, these advocates shared visual information about lost or found pets on Facebook, circulated paper flyers in the areas where the affected people could not get access to the Internet, and self-organized pet transports (White et al. 2014). Importantly, these local groups are often disconnected from formal emergency management organizations (Slater et al. 2012). In other words, formal and informal actors may have different aims and target groups and provide different relief services independently.

In the third type of relationship, formal and informal actors recognize each other’s existence and responding activities, but both actors do not interact and collaborate with each other. Rather, they criticize and ignore their counterparts’ responding activities. This situation likely occurs when a disaster or a crisis becomes a politically sensitive problem or issue. For example, in the immediate aftermath of the 2011 Japan earthquake and nuclear crisis, over one hundred volunteers from both

across the globe called Safecast worked together to develop a low-cost Geiger counter (i.e. bGeige Nano) and measure and publish radiation data on their webpage.¹⁵ Thus, any individual or organization could download and use the data for free. The Safecast team also crowdsourced the collection of radiation data to the public (Hemmi and Graham 2014). Anyone who had a Geiger counter could measure radiation levels and upload the data to the webpage. On the other side, the Japanese government (particularly, the Ministry of Education, Culture, Sports, Science and Technology) monitored and published radiation data online. Although the Japanese government and the Safecast team were aware of each other's efforts, these formal and informal actors did not collaborate with each other. Particularly, the Safecast team did not want to work with the Japanese government to be independent of a political debate on the nuclear crisis.

Lastly, in the fourth type of relationship, formal and informal actors do not recognize each other's existence and response efforts. Also, both actors' response efforts are inconsistent and confusing due to false, outdated, competing information on disaster conditions, the affected people's needs, and relief resources. This type of the relationships likely appears in the immediate aftermath of catastrophic disasters or crises such as the 2010 Haiti earthquake and the 2015 Nepal earthquake. In such catastrophic situations, many formal organizations are likely mobilized across the levels of government and the sectors. Moreover, numerous informal groups often emerge to deal with such catastrophes. For example, during and after the 2015 Nepal earthquake, over 500 formal and informal actors were involved in response to the catastrophic natural disaster. Thus, within the first 24–72 h of catastrophes, formal and informal actors are unlikely to recognize which formal organizations and informal groups are doing what and where. Such a lack of situational awareness often leads to inefficient and ineffective coordination of various responding activities between formal and informal actors.

Conclusion and Implications

Traditionally, emergency response is in large part the role and responsibility of public organizations like emergency management departments and agencies and police and fire departments and their collaborative partners such as nonprofit and for-profit organizations. This chapter focused on not only formal organizations from the public, nonprofit, and for-profit sectors, but also informal groups of publics that emerged spontaneously to respond to recent disasters and crises. The emergence and contributions of these informal actors are a novel phenomenon in the digital age because advances in information, communication, and computational technologies enable mass collaboration among numerous informal actors around the world and from the affected regions in overcoming space and time limits (Tapscott and Williams 2006).

¹⁵<http://blog.safecast.org/>.

Despite potential contributions of informal actors, we emphasize that informal actors do not replace formal actors, but supplement formal actors to increase the capacities of the overall emergency response systems for addressing disasters or crises. We note informal actors may have several limitations: data inaccuracy; privacy and security issues; and volunteers' burn out. One of the key criticisms of informal actors is the collection and circulation of inaccurate information. For example, soon after the 2013 Boston Marathon bombing, the general public participated in amateur investigations (Tapia et al. 2014). They launched online forums on [reddit.com](https://www.reddit.com/)¹⁶ and [4chan.org](http://www.4chan.org/)¹⁷ to collectively identify suspects. These amateur detectives posted related images and videos to the online forums and conducted voluntary investigations. Unfortunately, the amateur detectives not only produced incorrect information about suspects, but such incorrect information was also circulated rapidly on the Internet, thus leading to serious privacy issues. Moreover, informal emergency response is mostly dependent on the contributions of online volunteers. However, these "volunteers are a fragile and finite resource, frequently subject to burnout" (Korset 2013, p. 138).

Most importantly, we argued that one needs a new and extended lens for integrating formal and informal emergency responses called an event-driven lens. The event-driven lens first takes into account formal emergency response characterized by institutionalized organizations, formal rules and procedures, and hierarchical organizational structures. The event-driven lens also considers informal emergency response based on the voluntary contributions of publics, decentralized, open, adaptive organizational structures, and technologies. Moreover, the event-driven lens concentrates on the interactions and relationships between formal and informal actors in response to a disaster or a crisis. It is argued that the event-driven lens is more useful for understanding and explaining complex and dynamic emergency response systems in the networked age than an existing framework based primarily on formal organizations and their roles and responsibilities.

Lastly, from a practical point of view, we argue that formal organizations need to develop technical and management capacities for collaborating with informal groups of individuals. These informal groups mostly create disaster-related information by collecting, processing, and visualizing content from social media and mainstream media in near real-time. Formal organizations are required to build technical capacities for integrating the information created by informal actors into official emergency information management systems to improve situational awareness and to effectively coordinate on-scene operations and off-scene supports. Moreover, informal groups of individuals are a new form of organization characterized by openness, decentralized organizational structures, and the use of technologies. To collaborate with these informal groups, formal organizations need to not only understand such organizational characteristics of informal groups, but also build and facilitate dynamic communications and robust partnerships with informal groups.

¹⁶<https://www.reddit.com/>.

¹⁷<http://www.4chan.org/>.