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Volunteered Geographic Information and Crowdsourcing Disaster Relief: A Case Study of the Haitian Earthquake

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Abstract

This paper outlines the ways in which information technologies (ITs) were used in the Haiti relief effort, especially with respect to web-based mapping services. Although there were numerous ways in which this took place, this paper focuses on four in particular: CrisisCamp Haiti, OpenStreetMap, Ushahidi, and GeoCommons. This analysis demonstrates that ITs were a key means through which individuals could make a tangible difference in the work of relief and aid agencies without actually being physically present in Haiti. While not without problems, this effort nevertheless represents a remarkable example of the power and crowdsourced online mapping and the potential for new avenues of interaction between physically distant places that vary tremendously.

Keywords: Haiti, OpenStreetMap, Ushahidi, GeoCommons, volunteered geographic information, crowdsourcing

Author Notes: Conflicts of interest: Sean Gorman is employed by FortiusOne Inc. which built the GeoCommons community. He also helped with supporting CrisisCommons, participates in the OpenStreetMap project, and has participated in Ushahidi implementations in Afghanistan and Haiti. Most of the figures in this article are screenshots of publicly available websites and do not require permissions. In all cases the sources are acknowledged.

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Introduction

"Is that road up there passable? . . . Does it really exist?" (Wohltman 2010)

When the magnitude 7.0 earthquake struck Haiti on January 12, 2010, there was an immediate need for maps. Emergency responders had to know where the people most in need were located and how to get assistance and relief to them. Large parts of Haiti and its capital, Port-au-Prince, lacked adequate coverage in the standard web mapping services (e.g., Bing Maps and Google Maps) that people in most of the developed world have grown accustomed to using. As one of the world's poorest countries, Haiti had simply not provided the kind of demand for online mapping that drove its expansion elsewhere. Post-earthquake, the demand for spatial information and online maps increased tremendously and, given the urgency of relief operations, the ability to crowdsource the data collection process became particularly important.

This paper outlines some of the ways in which information technologies (ITs) were used in the Haiti relief effort, especially with respect to web-based mapping services. It demonstrates that ITs were a key means through which individuals could make a tangible difference in the work of relief and aid agencies without actually being physically present in Haiti. While not without problems, this effort nevertheless represents a remarkable example of the power of crowdsourced online mapping and the potential for new avenues of interaction between physically distant places.

The first section of this paper briefly reviews the history of IT, mapping, and disaster response with a particular focus on the role of volunteered data acquisition and distribution. The second part of the paper reviews some of the key ICT infrastructures employed during the Haitian earthquake crisis. Finally, the paper discusses potential lessons from the experience of crowdsourcing and disaster relief. While these lessons are preliminary and best viewed as a starting point rather than a final format, the earthquake in Chile on February 27, 2010, reiterates the importance and relevance of these efforts.

Mapping Disasters

"It is sobering to be reminded that one of the basic instincts of human nature—mutual cooperation for no cost—is thriving on a global scale." (Keegan 2010)

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Natural and anthropogenic disasters have occurred throughout history, and the trappings of the twenty-first century (e.g., global climate change, population growth, spread of infectious disease) seem to indicate that they will surely continue. Responses to disasters, however, have changed both in people's sense of connection to distance places and in their ability to contribute to relief efforts. Both these changes are strongly tied to ITs, which have long allowed for the broadcasting of news about disasters in a one-to-many fashion, but are now beginning to allow people to respond directly to these disasters by way of a many-to-many model.

IT and Disaster Response

For the most part, research on disaster response has assumed that states or other quasi-governmental entities (e.g., the United Nations) would be the primary actors in disaster relief, with NGOs playing a secondary role. Therefore it comes as no surprise that the role of IT was primarily viewed as a means to enhance the command, control, and dissemination of information (Alexander 1991; Comfort 1993; Gruntfest and Weber 1998; Quarantelli 1997). Much of the early research focused primarily on the positive side of IT in disaster recovery (Alexander 1991), although later research also recognized the complications within command structures resulting from non-proximate technology use (Stephenson and Anderson 1997). Questions were also raised as to whether disaster response plans incorporating IT only mirror non-IT disaster response plans, and whether these plans are even put into practice in the event of a disaster (Fischer 1998). But in almost all cases there was little thought given to the role of individuals or ad hoc networks emerging in response to the crisis.

Despite this tendency, some research has also focused on the variety of ways that telecommunications (including personal and individual exchanges) are a vital part of disaster response and can help mitigate losses and personal trauma (Townsend and Moss 2005). In addition to the importance at the individual level of the continuity of communication, others have examined how these ITs can empower activists and citizens on the ground during crises to work for the public good (Fischer 1999; Rodrigue 2001). Moreover, the past three decades have seen an ideological shift away from the state and emphasizing the importance of the market or private forces (e.g., neoliberalism) in regulating society (Harvey 2005). If nothing else, the quasi-ubiquitous web of personal communication can lead to serious rethinking of how the state (at a range of scales) should provide early warning and response to disasters (Rodriguez et al. 2007).

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The Rise of Web 2.0 and Mapping

Concurrent with this shift of emphasis from the role of IT in state-led disaster response is the growing significance of what is often referred to as Web 2.0. Also referred to as peer production, cloud collaboration, or cloud sourcing, the phenomenon refers to the ability of people from around the world to collaborate on projects that are often highly ambitious in both their scale and scope (Graham 2010a). It also marks the "…increased ability for individual users and loosely affiliated networks to construct and shape cyberspace and their daily lives" (Crutcher and Zook 2009: 524).

By 2006, it was recognized that the peer production of information had become so transformational that *Time* magazine voted "you" (that is, creators of user-generated content) as their person of the year, with the editor arguing that Web 2.0 represents nothing short of a revolution because it is no longer "the few, the powerful and the famous who shape our collective destiny as a species" (Grossman 2006). One prime example of Web 2.0–style mapping is the OpenStreetMap (OSM) project, which leverages Global Positioning System (GPS) trails and digitized street patterns from aerial imagery to create a free street map for the entire world. Although developed countries enjoy better coverage than poor countries, the OSM project proved to be an important source of Web 2.0 mapping during the Haitian crisis.

What drives millions of people around the world to contribute their labor for free? Research has shown that the gift economy is often driven both by participants' desires to gain cultural capital by sharing and creating information and by a widespread desire to help other people (for example, in the case of medical bloggers) (Karimi and Poo 2009; Kollock 1999; Preece and Shneiderman 2009). The desire of participants to gain technical knowledge and see their contributions as a rewarding educational experience has also been identified as an important factor behind contributions to crowdsourced projects and virtual communities (Holohan and Garg 2005; Lakhani and von Hippel 2003).

The peer production of information has reshaped a variety of practices, but arguably none as profoundly as the production of geographic information where many users have moved from being passive recipients of geographic information to being producers themselves (Budhathoki et al. 2008). A core motivation behind the production of volunteered geographic information (VGI) is likely the inaccessibility and cost of accurate sources of geographic information (Haklay and Weber 2008). The capacity of people from around the world to create geographic information has further been assisted by the drop in the price of GPS units and the wide availability of computers (Graham 2010b; Haklay and Weber 2008). Finally, the desire simply to fill in the blank spaces on the map and reveal the previously hidden should not be underestimated as a factor behind participation (Goodchild 2007; Perkins and Dodge 2008; Sui 2008).

Web 2.0 and Disaster Mapping

With the aforementioned development of OpenStreetMap and a variety of other web-based mapping services (such as Google Maps), the ability for volunteers to assist in disaster response situations via mapping and other spatial analysis has grown significantly. Given the immediate need for reliable maps in volatile disaster response situations, the model of peer produced mapping provides a number of new avenues for producing and accessing spatial data, apart from the traditional models of top-down geographic information system (GIS) provision. This new constellation of social and technological forces provides a number of benefits, yet also faces shortcomings.

Perhaps the greatest benefit to this form of distributed mapping is that a greater number of maps can be produced in a shorter period of time, allowing scarce technical resources to be diverted elsewhere. This is especially the case for labor, as volunteer, crowdsourced mapping allows aid agencies to focus their limited resources on other needs that cannot be so easily met via distributed, volunteer workers.

A second important benefit of Web 2.0 and disaster mapping is the ability to leverage ITs to allow individuals to report on local and specific conditions. These uses come in a wide range of forms, including name-based databases that allow reports on or searches for individuals such as Google's Haitian Earthquake Person Finder (http://haiticrisis.appspot.com/). Other examples include the Scipionus map following the Hurricane Katrina disaster, which allowed users to tie comments about local conditions, e.g., "there was three feet of water here," to specific locations (Singel 2005); and the dynamic map of conditions during the 2007 San Diego wild fires (based on individual reports) maintained by the KPBS radio station. While the sources for these maps were not crosschecked or confirmed by third parties, they provided additional data at levels of granularity and timeliness that could not be matched by other means.

Reliance on crowdsourced labor has led, however, to a return to concerns regarding the accuracy and validity of data that is not being centrally managed (Brandel 2002; Burgener 2004). Will the maps be as good as the traditional means of mapping in disaster situations or will they contain flaws that would have been prevented by professional cartographers? While this remains a point of debate, a key benefit of peer-produced

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knowledge is the idea that "given enough eyeballs, all bugs are shallow" (Raymond 1999). In other words, with enough people working together, any errors by one individual can be easily corrected by another. Indeed, this crosschecking by many can be used as an argument for the superiority of peer-produced mapping over more traditional means. It has even been argued that "Internet users are faster to report earthquakes than are the seismological procedures currently in place" (Bossu et al. 2008).

Clearly the issue of quality does not lend itself to a one-size-fits-all solution. The extent to which the tensions between expert and amateur knowledge exist and are reconciled varies across both space and time. Some situations require data of the highest quality, likely only to be produced by an expert with the right set of tools and personal skills. In disaster situations, however, geographic information need only be good *enough* to assist recovery workers using the maps, meaning that crowdsourced information is likely to be just as helpful as that produced by more centralized means. Indeed, it can be even more useful if peer production allows for new information to be incorporated and distributed in near real time.

In addition to the division between expert and amateur knowledge production, there remains a significant gap between the liberatory potential of these technologies and their realization in practice. Although web-based mapping enables broader participation in disaster response, persistent inequality in both individual skills and access to proper tools has meant that only a relatively small and homogenous group has assisted in crowdsourced mapping (Crutcher and Zook 2009). This calls into question the oft-made claims to a Web 2.0–enabled democratic revitalization (cf. Beer and Burrows 2007).

Changes in the way that maps are accessed have also influenced their use in disaster response. With only 25.9% of the world's population having access to the Internet, but 67% having access to mobile phones (International Telecommunications Union 2009), mobile devices present a much greater possibility for access by those working in disaster response situations in developing countries. The ability of mobile devices to both create and upload new spatial data, as well as access data created by others, helps to ameliorate the limited access to full-service PCs and high-speed broadband connections.

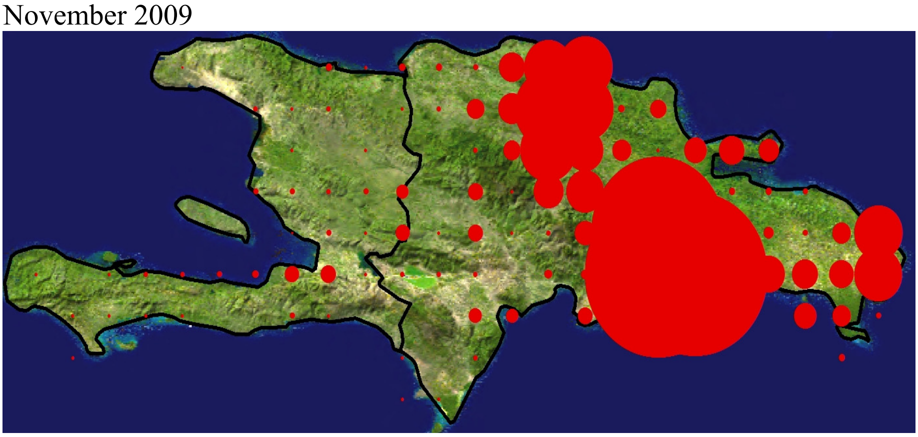
IT applications in disaster response also allow for reciprocity between those providing information and those seeking it. Not only can experts provide assistance from non-proximate locations, but so too can locals actively seek out this help in order to gain access to otherwise inaccessible information. This is the case not only for immediate response to disasters, but also for gaining a more complete picture of potential secondary effects (Flora 2007).

Volunteered Mapping and the Haitian Crisis

"The Haiti Quake is the first disaster in which open-source, online platforms are being heavily utilized."—Patrick Meier, director of crisis mapping at Ushahidi (Forrest 2010)

Two crucial questions that needed to be answered immediately after the earthquake hit on January 12 were: Who needs help? And where? (BBC 2010). Relief efforts had to get supplies and resources to the parts of the country most desperately in need, but it was difficult to know where to deploy resources because there was no systematic plan or data in place to help make such decisions. For decades, Haiti has been a country challenged by strife, political upheaval, and lagging economic growth, and its baseline of information infrastructure was poor. Particularly challenging to relief efforts was the fact that comprehensive databases of assets, infrastructure, population, and location were minimal. As a result, the underpinnings for an operational picture of the country before the earthquake were largely absent. Even some of the most fundamental informational needs, like detailed roadmaps and locations of critical assets, were not available.

Figure 1: Number of User-Generated Placemarks Indexed by Google Maps, November 2009



Source: Author's analysis; the size of the symbol indicates the total number of user-generated placemarks. Map generated for this paper.

A compelling example of the relative lack of geo-coded information in Haiti is illustrated in Figure 1, which shows the number of user-generated placemarks (Graham and Zook 2010) on the island of Hispaniola. As can be seen, the Dominican Republic (to the east) has a much more densely populated collection of user-generated data than does Haiti (on the western portion of the island), indicating the vast disparity in available user-generated information.

Immediate Responses to the Challenges

Figure 2: Before and After Satellite Images in Haiti

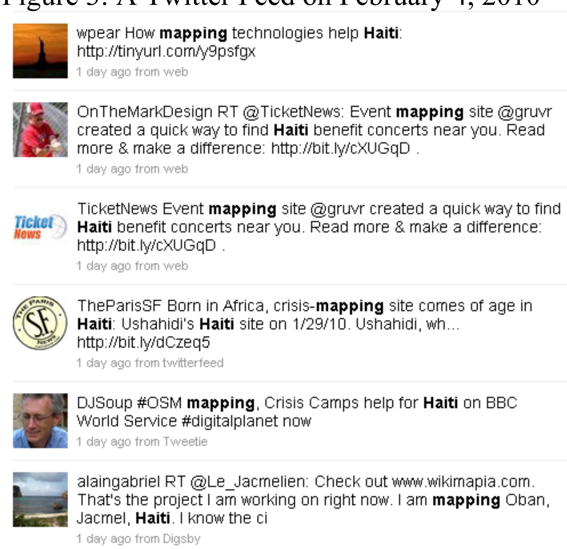
Source: Google (2010). Screenshot of Google website, allowed use.

Due to the dearth of available high-quality geo-information, Google, DigitalGlobe, and GeoEye worked together to get high-quality satellite imagery of post-earthquake Haiti collected, processed, and made freely available within 24 hours of the disaster (see Figure 2). This move undoubtedly helped with the coordination of emergency relief and aid services in Haiti.

Still, the lack of information complicated rescue and recovery efforts in the first days after the quake. Typical informational databases are built up over many years through GISs requiring a cadre of trained professionals to operate and maintain. However, in the Haitian crisis, much of this critical geographic information needed to build up from scratch and much of the data that was available needed to be updated based on landscape change resulting from the disaster. The years typically required to create such detailed databases now had to be accomplished in a matter of days. Even further complicating the situation was the need to identify those in need, in a country with already poor information infrastructure that had been severely damaged in the quake.

In response to this need, a rather unexpected solution appeared: volunteer community efforts matching simple web-based tools with nonprofessional data contributors. People and organizations around the world realized that they didn't have to be physically present in Haiti to provide meaningful assistance to those who were. Information about opportunities to contribute spread quickly through a variety of online outlets, including blogs, emails, tweets, and status updates (see Figure 3).

Figure 3: A Twitter Feed on February 4, 2010



Source: Twitter. Screenshot of Twitter website, allowed use.

As this example highlights, a structure and social network was in place to mobilize the tech community to support disaster relief efforts when the earthquake struck in January 2010. Projects and services such as CrisisCamp Haiti, OpenStreetMap, Ushahidi, and GeoCommons already had communities of contributors, tools, and data that could provide immediate ad hoc geographic information and situational awareness for Haiti. More importantly, their network of users and data collection tools could quickly build the needed data infrastructure for Haiti, creating an operational picture of their new reality.

CrisisCamp Haiti

CrisisCommons was formed in 2009 as a federation of citizens, NGOs, government stakeholders, and private enterprise, with the goal of better coordinating volunteer technology support during disasters. The group drew strongly from the technology community worldwide and its meetings became known as CrisisCamps. The response to the Haitian earthquake was the first widespread deployment of CrisisCommons' collective capabilities. Just four days after the earthquake struck Haiti, volunteers in Silicon Valley and Los Angeles, California, Washington, DC, New York City, and Boulder, Colorado, came together in CrisisCamps in order to begin collaborating on a variety of technology. Within another week, CrisisCamps had spread to 20 cities across the world, although the vast majority were located in the United States. Using a variety of social media tools, these groups collaborated on numerous projects meant to make the recovery effort in Haiti easier through the application of technologies.

It was clear from the start that any online mapping tools for Haiti had to account for the fact that Haitians had largely been disconnected from their already minimal connection to the Internet. This meant that delivery of the appropriate technologies required the bundling of various web components in order for their application in Haiti to work. CrisisCommons and the World Bank initiated an effort to provide vast amounts of data and tools, created by volunteers, directly to the Haitian government. The goal was to provide simple data collection and mapping tools with a solid set of baseline data that could be built upon, such as World Bank aerial imagery, OpenStreetMap road data, validated medical facility information, demographics, and other core operational information. These tools included an offline Haiti map browser that could run with just a hard drive or USB stick. The portable hard drives also included Delta State University's MGRS Atlases for printing map books and map images that can be viewed using Garmin handheld GPS units.

Some tools, such as We Have We Need and HaitiVoiceNeeds, were conceived of and developed by CrisisCamp volunteers specifically for application in Haiti. Although they represent just a small number of the projects worked on by the many CrisisCamps, both tools are designed to make communication between distant individuals and groups more efficient. Whether that communication is in the form of an offer or request for supplies, or a translated voice message to be sent to aid agencies, these tools have attempted to bridge the gap between those on the ground in Haiti and those who are far away, but eager to help. Although these tools have significant potential to assist aid workers, the amount of content on these sites remains relatively minimal, suggesting a limited adoption. Whether this lack of adoption is due to a lack of awareness about their benefits or an issue with the tool itself remains to be studied; however, it is clearly an issue with respect to preparation for potential disasters in the future.

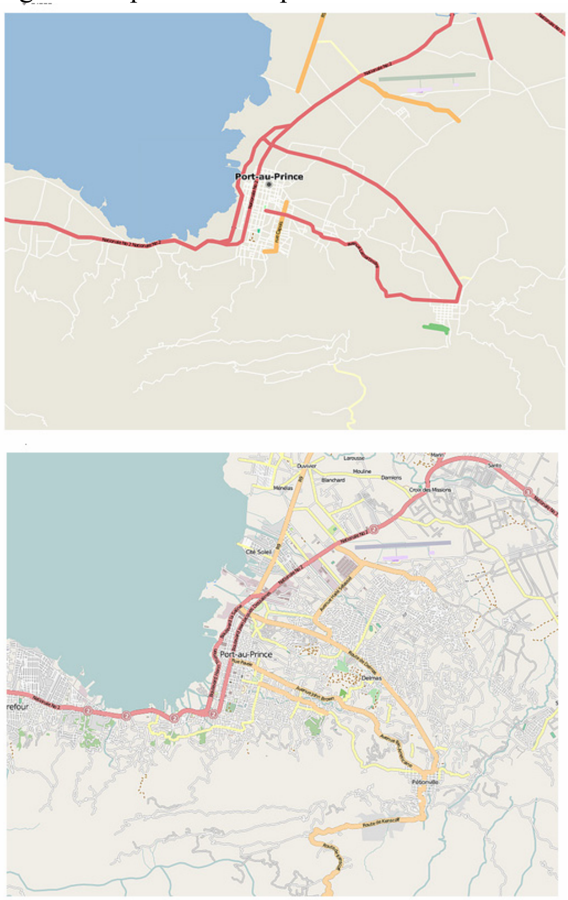
In addition to their original technological contributions, CrisisCamps also worked to provide assistance using preexisting open-source infrastructures. Spanning multiple tools, such as Akvo and Sahana, the concentrated efforts by CrisisCamp volunteers to contribute were perhaps most visible with respect to the development of OpenStreetMap information in Haiti's urban areas. These linkages to other ongoing projects are, in many ways, mirrored by CrisisCommons' connections with the aid agencies that it seeks to support. A post on the CrisisCommons blog summarizes their work:

> *Working closely with the United Nations, the World Bank, and other groups providing aid*, Crisis Camps everywhere have used the internet to create a powerful community with a positive purpose. Using every sort of collaborative and social media tool (open source projects, shared workspaces, Wikis, blogs, Skype, chat, twitter, facebook, etc.) *this group has pioneered a new kind of aid organization*, working hard to provide tools and information vital [to] the mission of helping Haiti recover. (CrisisCommons 2010, emphasis added)

Here the juxtaposition of a new, pioneering organization with that of the UN, World Bank, and any number of other traditional, hierarchical aid organizations is telling of the interdependencies between the two. Because of the distance and nature of assistance (technical and logistics), CrisisCommons relies upon the complementary work of on-the-ground aid agencies helping with the physical reconstruction of affected areas. At the same time, however, these relationships are much more complex, as aid agencies are growing more dependent on the skills of crowdsourced volunteers, whether they participate independently or through CrisisCamps.

OpenStreetMap

Figure 4: OpenStreetMap Before and After the Earthquake



Source: Maron (2010). Screenshot of Brainoff website, allowed use.

OpenStreetMap (OSM) volunteers from around the world downloaded satellite images (some already freely available and some donated by Yahoo and Google) in order to trace and record the outlines of streets, buildings, and other places of interest. These traces were uploaded into the OSM database and complemented by the work of on-the-ground volunteers in Haiti who, using portable GPS devices, were able to upload additional information (Keegan 2010). In the few weeks after the disaster, there had been nearly 10,000 edits to the Port-au-Prince region and its immediate surroundings within OpenStreetMap by hundreds of people located worldwide (Keegan 2010).

One important issue that came to light during the efforts to improve user-generated map coverage of Haiti was the duplication of efforts and barriers to combining data sets generated within different software packages. This issue is best illustrated via the lack of compatibility between OpenStreetMap and another leading means for crowdsourced street maps, Google's Map Maker. Map Maker is a tool that, like OpenStreetMap, allows users to draw roads and map out areas poorly served by publicly available maps. Following the earthquake people utilized both services and started to trace out roads, hospitals, and other sites of interest. Unfortunately, due to licensing issues (OpenStreetMap issues all map data using a Creative Commons license, but Google retains the intellectual property of all information created using Map Maker), data is not portable between the two systems and efforts were undoubtedly duplicated. More importantly, this incompatibility resulted in maps with varying degrees of coverage, depending upon the location within Haiti. Figure 5 demonstrates that different parts of the country had varying levels of coverage in OpenStreetMap (blue shading) and Map Maker (yellow shading) (Haklay 2010).

While the varying levels of information are not debilitating, this example illustrates the challenges that integrating crowdsourced data can pose. Not only should one be concerned about quality and ground-truthing, but issues of intellectual property and regulation can complicate such collaborative efforts. Despite these concerns, OpenStreetMap and Map Maker *did* continue to provide rescue efforts with street map coverage extremely quickly. These spatial data were ultimately crucial for first responders, aid workers, and even U.S. military humanitarian efforts on the ground.

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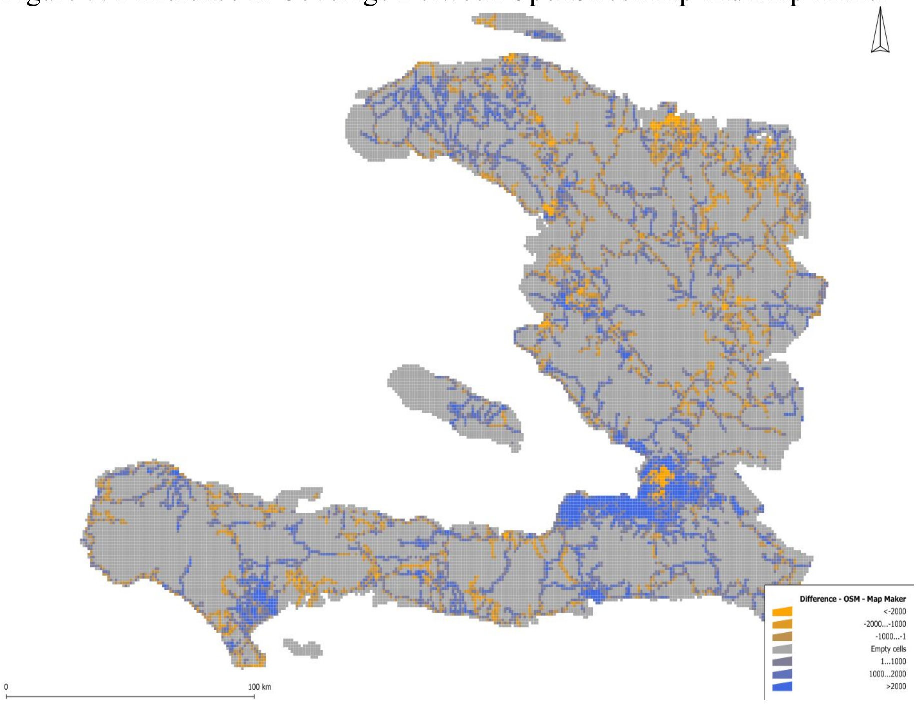
Figure 5: Difference in Coverage Between OpenStreetMap and Map Maker



Source: Haklay (2010). Screenshot of Haklay website, allowed use.

Ushahidi

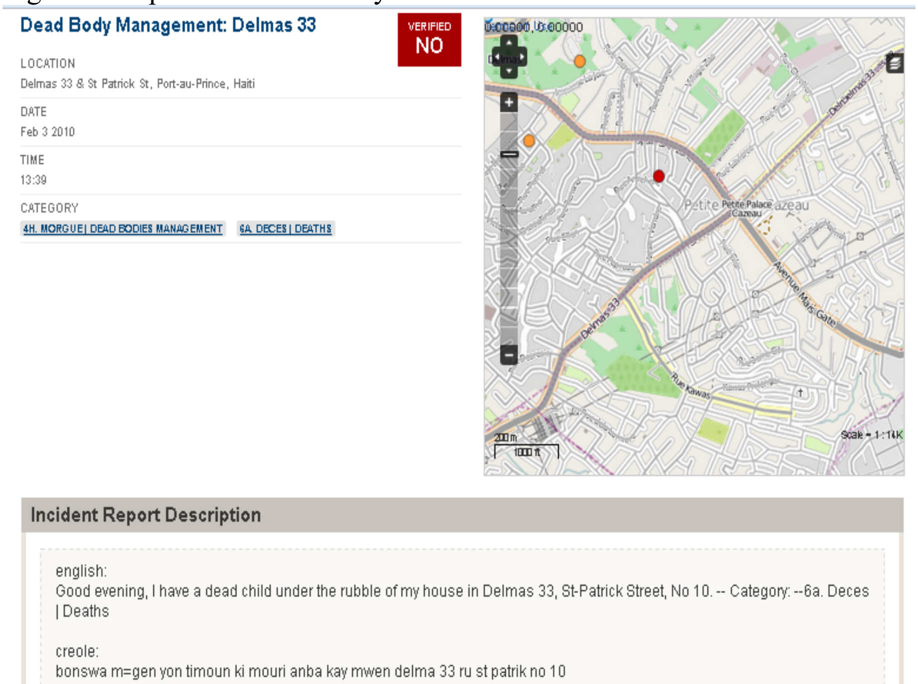
A very different model of crowdsourcing was employed by the Ushahidi project. A platform with its roots in the Kenyan post-election crisis of 2008, Ushahidi users submit reports through SMS, MMS, or an online interface. Text-based reports are then geo-tagged to a particular location within an interactive map. Because of this, connections between on-the-ground events and the particular locations at which they occur are more easily discerned.

Much of this effort was set into motion by a somewhat cryptic message on Twitter posted on January 13 from Washington, DC. The message read:

> Reaching out to @FrontlineSMS users in #Haiti with hopes of establishing local SMS gateway for http://haiti.ushahidi.com

The message, written by Josh Nesbit, was an attempt to set up an emergency mobile short code for Haiti that would allow people to report various incidents via SMS. Volunteers translated messages from Creole, geo-tagged, and then placed them onto a map so that aid agencies could determine how best to employ their limited resources (see Figure 6 for an example) (BBC 2010). The U.S. State Department further assisted with the geo-location of some messages so that more reliable information could be routed to the Red Cross and U.S. Coast Guard (Knowles 2010).

Figure 6: Report of a Dead Body on Ushahidi.com



Source: Ushahidi. Screenshot of Ushahidi website, allowed use.

It should be pointed out that the Ushahidi framework also allowed web-based and email submissions. Volunteers for Ushahidi likewise monitored all posts using the #Haiti hashtag on Twitter, and then entered the various calls for help and assistance into their publically searchable database. However, it was the ability for large amounts of local, on-the-ground knowledge to be submitted via cheap mobile devices and then systematized and shared online that distinguished Ushahidi from other projects that rely solely on the Internet as a means of user input and distribution. By allowing submissions through SMS, the system had a broad reach among the general population (only 11% of Haitians have access to the

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Internet compared to about a third that have access to mobile phones) (Internet World Stats 2009; Sutter 2010).

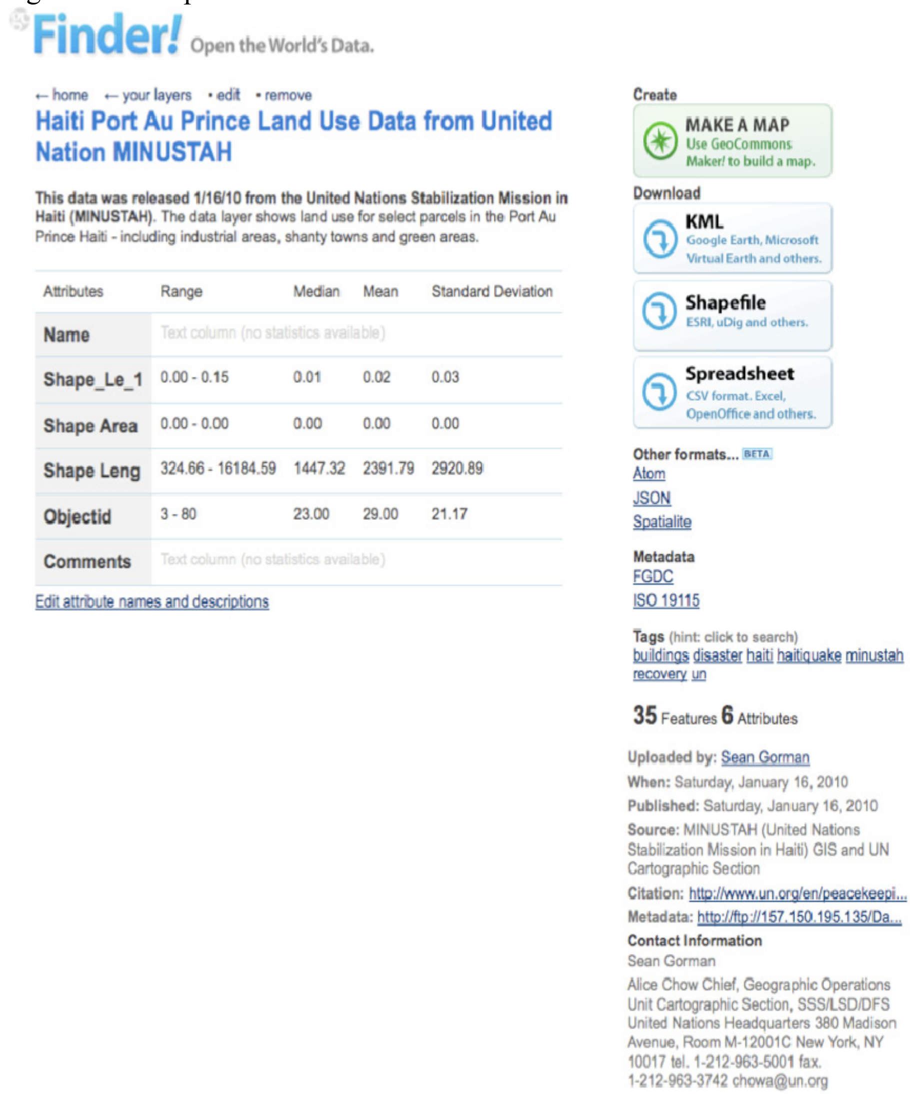
The Ushahidi project was reportedly able to make a significant impact on the relief efforts. By geo-locating urgent messages like “I’m buried under the rubble, but I'm still alive,” and simply publishing relatively less immediately actionable messages such as “our community has run out of water,” the project could direct people to locations in which relief actions were needed. Key to the usefulness of Ushahidi was the ability to connect short statements about problems and needs with geographic coordinates. These coordinates were then used by relief workers to find individuals and communities in need. One U.S. Marine Corps officer involved in the relief effort went so far as to state that “I cannot overemphasize to you what the work of the Ushahidi/Haiti has provided. It is saving lives every day” (Ramirez 2010).

GeoCommons

One of the challenges in the surge of VGI was ensuring that information was discoverable, interoperable, and could be repurposed across the wide variety of stakeholders involved in relief efforts. The GeoCommons project helped to achieve these objectives in the relief efforts, providing both an online and offline platform for data aggregation, dissemination, mapping, and analysis. Prior to the disaster there were less than two dozen Haiti-specific data sets and feeds in the GeoCommons project repository. Within weeks there were over 350 data sets and feeds from a multitude of sources. Data came not only from volunteers, but also from official agencies. Crowdsourcing is not limited to amateurs, and the GeoCommons project illustrated how institutions can crowdsource their internal data to facilitate better data sharing and collaboration. It is because of this that the term “volunteered geographic information” fails to fully describe the changes occurring in the creation and provision of geographic information. Crowdsourcing is about more than volunteers and amateurs. It is about creating fluidity in data sharing and collaboration by breaking down barriers in access to technology and participation through the web, open standards, and simplified interfaces. This impacts both individuals and organizations—both professionals and amateurs.

In Haiti, the GeoCommons tools not only enabled data aggregation and dissemination, but they also provided a resource for collecting metadata. Contributors could annotate the pedigree, currency, and veracity of data. An example metadata page is provided in Figure 7.

Figure 7: Example GeoCommons Metadata

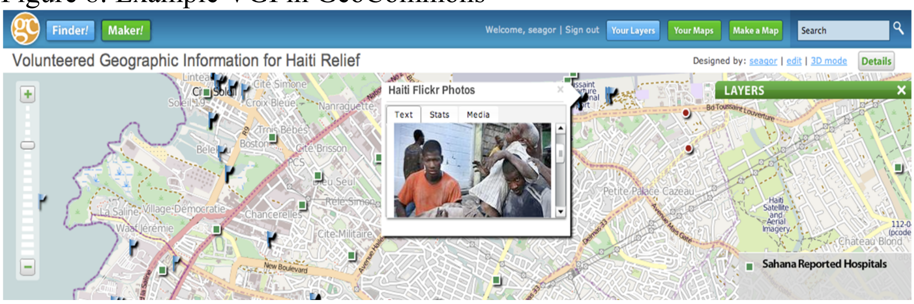


Source: GeoCommons. Screenshot of GeoCommons website, allowed use.

This allowed data provenance to be established for the wide variety of disparate information being collected from official and unofficial sources. The tool also facilitated the repurposing of data to a variety of workflows on the ground and across the web. Data could be extracted for GIS professionals through shapefiles, Google users downloaded KML, spreadsheet users downloaded .csv, and web developers pulled content out in Atom, JSON, and Spatialite. This allowed data to be usable in a variety of venues and prevented the stove piping of critical information.

In addition, users created maps combining a variety of data sources into a single view for collaboration. This allowed maps and analysis to be personalized by users on the ground to address the specific problems they needed to address without depending on outside and scarce technical support. Figure 8 illustrates an aggregation of some of the most used sources of VGI during the early Haiti relief efforts.

Figure 8: Example VGI in GeoCommons



Source: GeoCommons. Screenshot of GeoCommons website, allowed use.

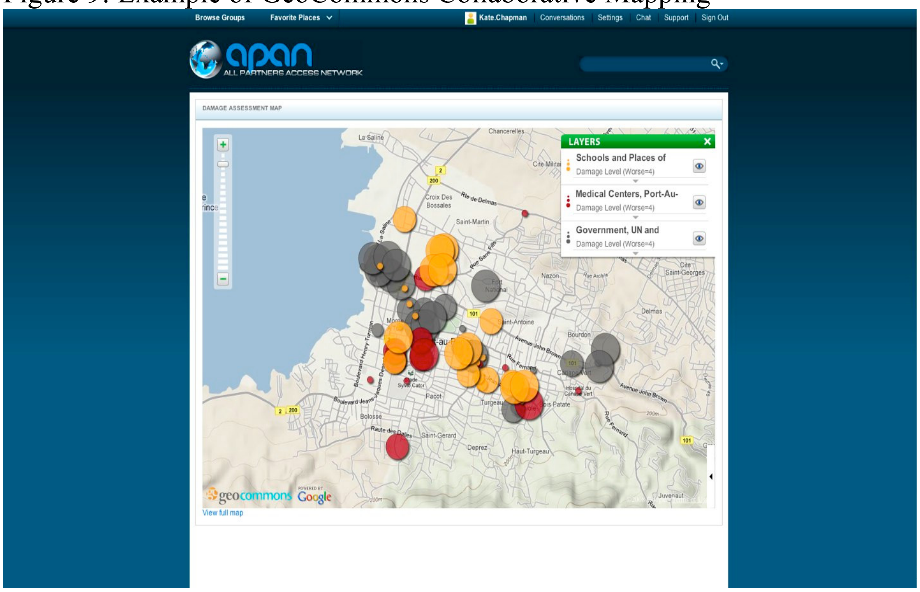
Historically, both data creation and mapping in the face of disaster required the skills of trained professionals. After the Haitian earthquake, relatively untrained volunteers, NGOs, and citizens were all able to create data critical to the recovery and maps that contextualized this data. There has been concern in both academia and industry about the accuracy and validity of VGI that could cause issues with accuracy and validity, possibly making it unreliable in emergency situations (Goodchild 2007). The situation and response within Haiti provide a counterexample. VGI played a critical role in emergency response in Haiti. OpenStreetMap data was heavily used by multiple agencies and NGOs on the ground. The importance of the data is seen in feedback from emergency response workers deployed in Haiti:

> I am currently in Port Au Prince with the Fairfax County Urban Search & Rescue Team (USA-1) out of Fairfax, VA, USA. I wish there was a way that I can express to you properly how important your OSM files were to us. . . . I am spreading the word about this work to all rescue and humanitarian teams on the ground here in Haiti. Please be

> assured that we are using your data—I just wish we knew about this earlier. (OpenStreetMap Wiki 2010)

Data was used by on-the-ground emergency response workers as well as coordinating agencies. For instance, the United States Southern Command used VGI in their role coordinating disaster response for the Department of Defense. Figure 9 shows GeoCommons data and maps where VGI and official source data were fused to serve as a common operating picture for the United States Department of Defense Southern Command through their All Partners Access Network, which served as the collaboration point for U.S. government agencies responding to the crisis.

Figure 9: Example of GeoCommons Collaborative Mapping



Source: GeoCommons. Screenshot of GeoCommons website, allowed use.

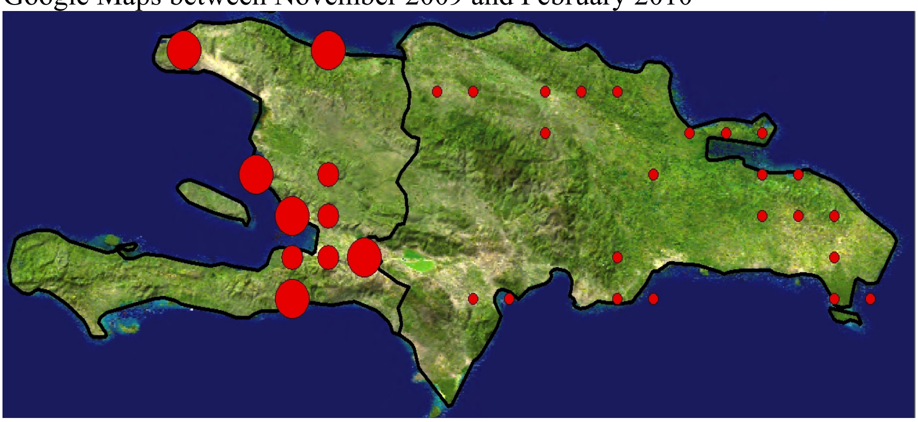
VGI and crowdsourced disaster response played an integral role in Haiti relief efforts. It is a role, though, that complements the traditional sources of geospatial information. The largest impacts seen in Haiti were the fusion of the two sources. This combination has incredible value—providing baselines, context, and temporal adaptability to create a malleable abstract that can be molded to solve a myriad of disparate challenges.

Lessons Learned from the Haitian Earthquake Crisis

This review of efforts during the response to the Haitian earthquake highlights how people from around the world can come together (via structures like CrisisCommons) to provide assistance in times of disaster.

The first observation is that the crisis clearly resulted in a much greater availability of geo-coded data about Haiti. One can see this in the quality of aerial imagery (Figure 2), the availability of user-generated street network data (Figure 4), and the increase in data sets available via outlets like GeoCommons. A particularly striking look at the growth of crowdsourced information is provided in Figure 10, which shows the relative growth of user-generated placemarks in both Haiti and the Dominican Republic. In the brief interval between these two snapshots in time, Haiti experienced considerably more growth than the Dominican Republic, almost certainly related to the earthquake and subsequent disaster response.

Figure 10: Change in the Number of User-Generated Placemarks Indexed by Google Maps between November 2009 and February 2010



Source: Author's analysis; the size of the symbol indicates the percentage change in user-generated placemarks. Map generated for this paper

This increased availability of data was a function of volunteered labor using a variety of web applications. While this can produce duplication of efforts (e.g., the same streets digitized several times), this is greatly tempered by the speed at which these data sets can be produced through this decentralized structure. Moreover, duplication is not necessarily a bad thing as it can provide multiple avenues to access information. It can, however, make interpretation of a situation more complicated as multiple sources can provide conflicting versions of the built and natural environments. Furthermore, as the issues between OpenStreetMap and Google Map Maker illustrate, nontechnical issues such as licensing can greatly complicate the combining of data sets.

These issues highlight the key role of aggregation of crowdsourced data within disaster response. Otherwise data cannot be leveraged or combined with other data sets to provide the maximum benefit for relief efforts. While typically this kind of aggregation has been provided by a government or similar organization, the Haitian crisis shows that more user-driven means of aggregation have also become viable strategies. Both Ushahidi and GeoCommons worked to aggregate data coming from multiple sources (including individual SMS messages) so that rescue teams could focus time and energy on their response rather than sorting through data.

This aggregation function (particularly the use of text messaging as an input) also highlights the importance of providing multiple channels by which data can be shared. As IT is a vulnerable and, in many cases, sparse infrastructure, disasters can destroy the capabilities (particularly Internet connections) within the affected region. Ushahidi's use of SMS highlights the benefits that come from a multi-platform approach. However, simply because a platform or service is made available does not guarantee that it will be used extensively.[1] Such a statement should not be seen as an argument *against* the creation and deployment of such services, but rather an emphasis on the need to experiment widely and adapt efforts based on response and use.

Even inhabitants of a disaster zone who have access to IT (a very small percentage in the case of Haiti) may not be tied to the networks in which technology (such as Ushahidi's SMS reporting system) is made known. Accessing those most in need is a perennial challenge within economic and crisis programming, and crowdsourcing is not immune from this issue. Disasters may hit indiscriminately, but well-trod paths of economic and social standing help shape one's experience in the post-disaster world, including one's participation and access, or lack thereof, to a range of IT-driven resources (Crutcher and Zook 2009).

For example, Figure 11 shows the distribution of user-generated placemarks that make reference to the term earthquake in the Port-au-Prince region. Like other cities around the world, Port-au-Prince exhibits a pattern of clusters and empty spaces within the city (Zook 2010). However, the exact same search using a range of Haitian Creole words such as "tranblemanntè" (earthquake) or the terms for water, home, die, and hospital

[1] The We Have We Need service is an example of one service that failed to gain much traction.

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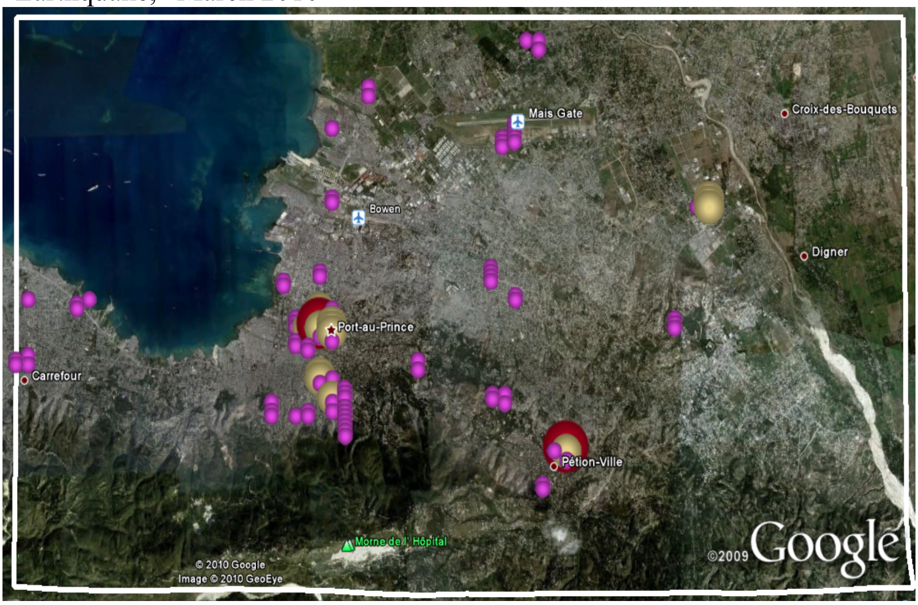
revealed no user-generated placemarks while searches on the English words revealed similar patterns of points to Figure 9.

Figure 11: Number of User-Generated Placemarks Containing the Term "Earthquake," March 2010



Source: Author's analysis. Map generated for this paper.

It is therefore crucial to always recognize that user-generated content will provide only selective representations of any issue. While these representations may be highly useful to aid workers, it should not be forgotten that there will always be people and communities that are left off the map. Medical and health workers should therefore always be aware of the geographical inequalities in any crowdsourced data in order to ensure that the technologically disconnected are not denied crucial services that they may need.

Despite popular claims to the contrary, distance is not dead and the collective effort towards web-based mapping from individuals from around the world cannot change the material reality on the ground, no matter how much we wish they could. At the most basic level, the success of any disaster response depends on extremely physical factors, e.g., digging people out of the rubble, bringing in food, water, and shelter.

However, this review has also shown that crowdsourcing information and mapping services can greatly enhance the logistical systems upon which relief efforts are ultimately grounded. After all, conditions on the ground are often chaotic with multiple and conflicting inputs about priorities. The ability to aggregate, evaluate, and plan via logistical back support is a fundamental part of any response. And as the case of Haiti has shown, crowdsourcing can play a key role in these logistics.

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