

Chapter 15

Putting 200 Million People “on the Map”: Evolving Methods and Tools



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15.1 Introduction

Accurate maps play a critical role in understanding human communities, particularly for populations at risk. Maps help individuals to understand their surroundings, locate features of interest, plan routes and journeys, and conduct broader scale processes such as urban planning and disaster response. In crisis situations specifically, basemaps and geospatial data act as key tools for first responders and NGOs to visualize damage assessments; assess infrastructure, hazards, and demographics; plan local and larger scale emergency response activities; and share information among relevant actors. A lack of maps and geographic data can prevent lifesaving resources from meeting those in need. For this reason, mapping is a core component of the Red Cross' disaster response efforts.

Much of the Global North has been mapped with incredible detail. With an Internet connection or a smartphone, individuals can instantly access detailed address information, building footprints, transit information, and locations for health facilities, public services, and businesses. This is still not the reality for billions of people in vulnerable areas, however. Popular services such as Google Maps lack information for much of the Global South; many communities exist as simply a place name and perhaps a collection of roads. Other communities are absent entirely. Even when a community is mapped at a detailed level, information published without an open license (e.g., many web-maps and PDF maps) offers limited value to humanitarian actors. A user often cannot download the information, combine it with other datasets, and create and share products from it. Thus, the user is essentially viewing a picture of data rather than accessing the data directly. The same is true for mapping products created by government agencies and other traditional mapping authorities, who have

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© The Author(s) 2018
S. Hostettler et al. (eds.), *Technologies for Development*,
https://doi.org/10.1007/978-3-319-91068-0_15

traditionally operated on a retail model of distribution and often do not release their data for free and open use (Goodchild and Glennon 2010).

OpenStreetMap (OSM) has greatly improved this situation for humanitarians. Often described as “the Wikipedia of maps” (Heinzelman and Waters 2010), OSM is a free online map and geospatial database whose data can be viewed, edited, downloaded, and used by anyone with an Internet connection. While there are several other geographically focused examples of what academics refer to as Web 2.0 (Vossen and Hagemann 2007), crowdsourcing (Howe 2008), or volunteered geographic information (Goodchild 2007), OSM is the most prominent platform, with a community of over two million registered users (OSM Contributors 2016). Data quality and quantity vary by region, but previous studies of locations such as the UK (Haklay 2010), Ireland (Ciepluch et al. 2010), France (Girres and Touya 2010), and Iran (Forghani and Delavar 2014) confirmed that the data are generally of high quality.

OSM plays an important role for many humanitarian organizations as their primary source for base map data and primary platform for new data creation. At the time of the 2010 Haiti earthquake, for example, only rudimentary maps were widely available. Within hours of the earthquake, over 600 OSM users around the world began rapidly tracing satellite imagery to create a detailed map of the country, which disaster response and relief agencies used as an important tool in relief and recovery efforts—both in the immediate aftermath and in the years to come (Soden and Palen 2014; Zook et al. 2010). A non-profit organization called the Humanitarian OpenStreetMap Team (HOT) was formed as a result. HOT coordinates the creation and distribution of mapping resources to assist humanitarians responding to crises and disasters around the world (Neis and Zielstra 2014). The group played a key role in organizing similar mapping efforts after the 2013 Typhoon Haiyan in the Philippines (Palen et al. 2015), the 2014 West African Ebola outbreak (Cassano 2014), the 2015 Nepal earthquake (Sneed 2015), and countless other small-scale disasters and for communities at risk.

In addition to post-disaster mapping, OSM has also acted as a platform for mapping disaster-prone communities in vulnerable areas. Map Kibera led to the grassroots mapping of Kenya’s biggest slum community (Hagen 2011). HOT launched a large-scale community-based effort to map Jakarta and other parts of earthquake-prone Indonesia (Soden and Palen 2014). A World Bank Open Cities project prompted detailed mapping of the central Kathmandu Valley, which led to the creation of a local non-profit, Kathmandu Living Labs (Ibid.). These efforts have been highly successful in building communities of skilled, engaged OSM contributors who generated valuable data, which played a key role to responders following floods in Indonesia and the 2015 Nepal earthquake.

Despite these successes, the communities home to billions of people remain “off the map”. Because of the digital divide and differences in levels of development, geographic information “is usually least available where it is most needed” (Sui et al. 2013: 5). For the humanitarian community, further efforts are needed to preemptively generate baseline data before major crises occur. Recognizing this need, the American Red Cross, in partnership with the Humanitarian OpenStreetMap Team (HOT), the British Red Cross, and Médecins Sans Frontières UK, launched an innovative project

called Missing Maps, which aims to put 200 million vulnerable people on the map by 2021—adding the communities in which they live to OSM, where the data are openly available for use and revision. This represents a targeted effort to conduct widespread pre-disaster mapping without limiting the focus to a particular geography.

This paper (1) describes the Missing Maps project’s remote and field mapping methods, (2) outlines the technical tools developed for the project, (3) highlights how humanitarian and development organizations can adapt these tools and methods to other initiatives, and (4) explores current challenges and research questions surrounding mapping initiatives focused on the Global South. In doing so, this paper provides an overview of current trends in crowdsourced mapping and emerging data collection methods, with the aim to share tools and experiences with others in the humanitarian community.

15.2 Remote and Field Mapping Methods

As of November 2017, three years after the project’s launch, Missing Maps volunteers collectively mapped an estimated 60 million people. The majority of this progress involved remote mapping efforts. The American Red Cross and its partners host and support mapping parties (“mapathons”) in cities around the world, often working with university groups or even private corporations who are interested in bringing people together and training them how to trace buildings and roads from satellite imagery in order to map a vulnerable area.

This engagement strategy is modeled after mapping parties and “crisis camps” held by HOT, Kathmandu Living Labs (KLL), the World Bank, and other organizations (see Soden and Palen 2014). Missing Maps is unique, however, in its unprecedented number of events and its geographic reach. Figure 15.1 shows the locations and density of Missing Maps mapathons as well as the location of every building mapped by Missing Maps volunteers from the project’s launch in November 2014 until the time this article was written, in November 2017. Partners have hosted a total of 623 public mapathons across all six continents, resulting in nearly 40,000 attendees mapping over 15 million buildings and 13 million kilometers of roads in OSM. Outside of mapping parties, volunteers also remotely contribute to mapping tasks. Missing Maps continues to build momentum, with 17 organizations now part of the partnership.

Remote tracing efforts very quickly result in basemap data for the area of interest. Over a matter of days, a community can go from a blank spot on the map to a detailed collection of buildings and roads. This gives humanitarian agencies necessary data to plan and organize their community development and disaster preparedness/response activities.

Remote mapping rapidly produces data but faces certain limits. Building and road outlines provide a baseline of physical infrastructure information for humanitarians, but additional information is necessary to make the map more complete and useful. It is impossible to tell from satellite imagery where hospitals, schools, water and



Fig. 15.1 Missing maps mapathons and target mapping areas, as of November 2017

sanitation facilities, community landmarks, and physical hazards are located. Moreover, local community engagement is important in order to promote sustainability and a sense of ownership over the map data. Therefore, the American Red Cross began to increasingly focus on the local engagement and field-based activities.

The American Red Cross had led Missing Maps field training in countries such as Bangladesh, Belize, Colombia, Ecuador, Guinea, Jamaica, Liberia, Rwanda, Sierra Leone, South Africa, Tanzania, and Zimbabwe. For each field visit, remote volunteers map the area of interest, then a team of staff visit the local area to work with local Red Cross volunteers in order to explain about the mapping project, train the volunteers in necessary processes and technology, and organize the fieldwork. The team consults local officials and Red Cross staff and volunteers to solicit their input on data collection priorities, which often include water points, waste disposal sites, and building or road conditions. Staff mentor the volunteers to help them edit and upload the resulting data. After the project, they leave equipment behind with the local Red Cross in order to enable future mapping efforts. Because areas of interest are selected based on current project locations and needs, the data add immediate value to resilience projects, community assessments, and other ongoing activities.

Short field projects provide a valuable opportunity to engage local communities and add contextual data to the map. However, engagement based on bursts of international travel poses challenges in terms of sustainability. It can be very difficult for organizations to foster long-term engagement and support local mappers without an embedded presence in the community. Past experience suggests that, even when local volunteers received extensive training and staff left equipment behind for the volunteers' use, limited mapping activities continued independently after the site visits concluded. This prompted the team to consider additional strategies to increase community engagement and sustainability.

As one response to these challenges, the American Red Cross launched a more embedded approach in West Africa, where it launched a mapping hub in Guéckédou,

Guinea—the epicenter of the 2014 Ebola outbreak. The hub operated in 2015–2016 as a physical office location with equipment, four technical staff, administrative support, and training facilities. It acted as a base for specific mapping projects and to host community meetings, conduct outreach events, and offer training modules designed to boost basic computer skills and build up a large community of volunteers with skills in various mapping and data-gathering technologies. As volunteers become more experienced, they played a larger role in leading these activities.

The hub initially supported the rapid mapping of all communities (totaling 7000) within 15 km of the international borders shared between Liberia, Guinea, and Sierra Leone—focusing on water, sanitation, health, and public amenities in each community. Volunteers on motorbikes carried out the fieldwork, equipped with a smartphone app (OpenMapKit) and other technical tools. Resulting data were published on OSM and the Humanitarian Data Exchange, and were shared with decision makers, humanitarian workers, and community stakeholders to ensure they are well aware of water, sanitation, health, and community resources before and during the next regional crisis—helping them to make data-driven programming decisions and potentially preventing or slowing the spread of infectious disease during future disease outbreaks.

Although the West Africa project has ended and the hub has closed, equipment was donated to nascent OSM groups who continue to conduct mapping and fieldwork; in Guinea, for example, the local mapping community conducted 10 mapathons to support local mapping as well as disaster response activations for Hurricane Irma, malaria prevention in Zambia, and a recent earthquake in Mexico. Over 300 community members have joined OSM Guinea and a further 400 have joined OSM Liberia, suggesting that the investment into mapping has spurred a lasting interest in community-based, participatory mapping.

Moving forward, the American Red Cross and its partners continue to pursue opportunities for sustained engagement, and will continue to evaluate their methods in order to respond to challenges and promote best practices.

15.3 Technical Tools

For remote mapping, Missing Maps trains volunteers in OSM using an in-browser editing interface (iD Editor), which most mapathon participants have easily learned within a few minutes of instruction. The team also produces training videos and resources for mapping that provides a reference and examples for volunteers.¹ As volunteers gain experience, we encourage the use of the Java OSM editor (JOSM), which is a faster and more robust editing interface but can also be more difficult for beginners to learn.

Beyond these existing tools, the American Red Cross introduced new efforts to gamify remote mapping and keep trained volunteers engaged between disasters.

¹Examples are embedded into mapping tasks, available at <http://www.tasks.hotosm.org>.

The team developed an online tracking tool and API that compiles stats and metrics for each Missing Maps volunteer, which feeds into user profile webpages with badges for different achievements and “levels” the mapper has reached.² In addition, the tracking tool may help the Missing Maps team to identify dedicated and experienced remote volunteers who may be interested in hosting their own mapping events in their communities in the future.

A combination of high- and low-tech tools facilitate field mapping. The team’s primary tool is OpenMapKit,³ an Android app the American Red Cross developed that enables a user to pre-download the OSM map of an area, shows the user’s location, and enables him/her to simply tap on a building or feature in order to add information about it. When an object is tapped, a brief set of questions will appear, asking the user what sort of object this is (e.g., school, residential building, health facility) and for any other relevant information. These fields are determined based on community priorities and created at the outset of the mapping project, using OpenDataKit forms. Volunteers upload their mapping results from the mobile devices, and the data are added to OSM, where staff review the additions for quality control. Teams can easily map thousands of buildings in a week using this method.

When the use of mobile phones presents security concerns, or other factors necessitate an alternative method, the American Red Cross uses paper-based mapping tools (such as Field Papers, a tool which enables users to print map pages for an area, annotate the pages by hand, and then scan/edit/upload the annotated information to OpenStreetMap). These tools are freely available and easy to use.

In addition, the American Red Cross developed new tools to facilitate OSM editing in areas with unreliable connectivity. Humanitarians, in general, have become increasingly reliant on cloud-based tools for use in increasingly remote areas. For mapping projects specifically, users previously needed an Internet connection to use OpenMapKit in order to download map areas at the beginning of a project, and then to upload data into OSM at the end of each day. Field Papers also requires an Internet connection to prepare map atlases. Reliable Internet access on a daily basis is not realistic for many areas in which the Red Cross and other humanitarians work.

With this in mind, the American Red Cross created a new tool: Portable OSM (POSM). POSM combines an offline OSM API, Field Papers, OpenMapKit, a captive portal, and many new enhancements to the OSM workflow. POSM runs on very inexpensive hardware (costing roughly \$300 USD) and free, openly available software. With POSM, users are able to download all necessary files for an area of interest, easily configure the portable server, work offline in the field (using OpenMapKit, OpenDataKit, iD Editor, JOSM, and OpenDroneMap), and then return to a connected environment and sync all changes back to OpenStreetMap. With this new technology, users can conduct mapping or mobile data collection fieldwork for upwards of a month at a time without connecting to the Internet. User-friendly documentation is available at the POSM website⁴ and full source code is available online.

² Available at <http://missingmaps.org/users>.

³ Available at <http://www.openmapkit.org>.

⁴ Available at <http://www.posm.io>.

15.4 Applications and Potential Development Impacts

Missing Maps’ intent is to enable local communities and humanitarian organizations to collect useful geospatial information. Accordingly, the field mapping methods described above use low-cost devices (basic smartphones), rely on applications that are easy to learn, and use free and open-source software. All of the technical tools mentioned in the previous section are freely available for public use. This includes tools developed by others (iD editor,⁵ JOSM,⁶ OpenDataKit,⁷ Field Papers⁸) and those developed by the American Red Cross (OpenMapKit, POSM). Various training materials exist for the former, and instructional materials were to be created for the latter. Source code can also be found on the American Red Cross’ GitHub⁹ page. In addition, Missing Maps partner organizations have published materials to support individuals interested in hosting a mapathon,¹⁰ and the team regularly provides support to individuals who contact them with questions.

Missing Maps’ field mapping methods and tools can be leveraged by the humanitarian/development community for a variety of situations. For example, an organization could use OpenMapKit specifically to create a basemap of the area in which it is working, to monitor the state of water points and sanitation facilities, to assess damaged buildings and roads after a natural disaster, to create a database of school locations and addresses, etc. POSM can be used by small mapping teams to map large areas with variable connectivity; it can bridge connected and disconnected environments and provide an offline backup for intermittent Internet connectivity.

15.5 Challenges and Research Directions

By engaging remote mappers and local volunteers to map 60 million people in three years, the Missing Maps project and its partner organizations have made significant contributions to tools and methods for mapping vulnerable communities. Based on its experiences, the American Red Cross has highlighted certain challenges and areas for future growth.

For remote mapping, an important challenge is developing new ways to keep volunteers engaged between disasters. High numbers of volunteers express interest in remote tracing after a major disaster. However, remotely training a large pool of extremely diverse volunteers requires time, proper tools, and coordination. A disaster setting is not the ideal time to start the process. Instead, it is imperative to have a large body of well-coordinated volunteers that are ready to assist when a disaster occurs.

⁵ Available at <http://www.openstreetmap.org/edit?editor=id>.

⁶ For more information: <http://wiki.openstreetmap.org/wiki/JOSM>.

⁷ For more information: <https://opendatakit.org>.

⁸ For more information: <http://fieldpapers.org>.

⁹ <https://github.com/AmericanRedCross>.

¹⁰ For more information: <http://www.missingmaps.org/mapathons>.

The American Red Cross is actively developing digital tools and ways to gamify remote mapping, but the humanitarian community could benefit from additional insight and tools for engaging remote volunteers. Additionally, ensuring data quality becomes especially important when adding large numbers of new mappers into the OSM community. The American Red Cross has emphasized the importance of data validation and held events for more experienced mappers in order to check and correct OSM data. More work remains in this area.

Machine learning algorithms offer another area for future research and exploration. For larger mapping needs where crowdsourcing is less feasible or timely, organizations recently began to experiment with machine learning methods and outputs. For example, Facebook, Columbia University, and the World Bank pioneered a method to identify buildings from high-resolution,¹¹ commercially available satellite imagery (Tiecke 2016). The partners trained the model to adapt it to local conditions in 18 different countries, ground truthed the results against household survey data and existing crowdsourced OSM building data, and applied most recent government census population data to outputs. The result is openly accessible, nationwide datasets that contain estimates of human population down to the 30-m scale. Data are available for 18 countries at the time of publication (Facebook Connectivity Lab and CIESIN 2016) and agencies like the Red Cross have begun testing their applications for humanitarian purposes, and in combination with crowdsourced and locally derived data. As these techniques become even more refined, more work is necessary to investigate how computer algorithms, crowdsourcing, and local knowledge can work together to create valuable data for humanitarian purposes while also respecting privacy and sensitivities.

For field mapping, sustainability and long-term engagement are areas for additional growth—especially for organizations working internationally. There have been highly successful initiatives undertaken by HOT in Indonesia and by the World Bank/KLL in Kathmandu, and mapping engagement has continued following the end of the American Red Cross' mapping project in West Africa. Again, this area could benefit from additional insight into ways to effectively engage with local communities, promote local interest and ownership over data collection, and support a community of mappers, who are trained and motivated to continue mapping activities independently. Rural areas may present a particular challenge; previous tech hubs and mapping initiatives have been based out of urban centers like Nairobi, Kathmandu, and Jakarta, which benefit from more developed infrastructure, the presence of university students, and a more technically skilled volunteer base.

Finally, as the mapping community grows, it is important to bridge the gap between those who are experienced in working with data and technology, and the broader community of practitioners and decision makers, who may be less comfortable with digital tools and resources. Base data and analytics bring higher value when more people understand how to interpret and apply them to situations. For this reason, the Missing Maps partnership has emphasized efforts to increase data literacy and what we call,

¹¹0.5 m resolution.

“data readiness”—the ability of an organization to utilize data in response operations for situation awareness, planning, implementation, monitoring, and reporting.

As the Missing Maps project moves forward, the American Red Cross and its partner organizations will continue to evaluate their methods and tools for mapping, evolving new tools and engagement strategies to address the challenges experienced along the way. By mapping vulnerable communities, humanitarians are better able to share better analysis of hazards, mitigations, and response capacity in communities, enabling stronger disaster response efforts, and program planning in the future.

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