Identifying success factors in crowdsourced geographic information use in government

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GFDRR. 2018. Identifying success factors in crowdsourced geographic information use in government. Washington, DC: GFDRR. License: Creative Commons Attribution CC BY 3.0.

Acknowledgments

This report was written by Mordechai (Muki) Haklay, UCL, Vyron Antoniou, Hellenic Army Geographic Directorate, Sofia Basiouka, Hellenic Ministry of Culture and Sport, Robert Soden, World Bank, Global Facility for Disaster Reduction & Recovery (GFDRR), Vivien Deparday, World Bank, Global Facility for Disaster Reduction & Recovery (GFDRR). Matthew Ryan, University of Southampton, and Peter Mooney, National University of Ireland, Maynooth.

We would like to thank Madeleine Hatfield of Yellowback for editing. We would also want to thank Kate Chapman, Nicolas Chavent, Nama Budhathoki, Mikel Maron, Alex Barth, Celine Jacquin, Emir Hartato, Fraser Shilling, Andrew McKenna, Jim McAndrew, Abigail Baca, Yantisa Akhadi, Kate Logan, Amanda Malcolm, Sam Droege, Cristina Capineri, Antonello Romano, Liam Lysaght, Andrea Giacomelli, Alessandro Campanaro, Erin Korris, Linda See, Guillaume Touya, Ana-Maria Raimond, Elizabeth McCartney, Erica Hagen, Simon Roberts, Mark Iliffe, Svetla Borovska, Anthony Klemm, Tomas Straupis, Mark Herringer, Joaquín Huerta, Kiru Pillay, Bibiana McHugh, for their contribution to the case studies. Any errors or omissions that remain are solely the responsibility of the authors. Funding for this report was provided by the GFDRR Innovation Lab.

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Part A: Policy summary

This policy brief summarizes the findings of the research report "Identifying success factors in crowdsourced geographic information use in government" produced by the World Bank Global Facility for Disaster Reduction and Recovery (GFDRR) in partnership with scholars from University College London (UCL). This brief explains the report's context, methodology, main findings and recommendations.

Introduction

The adoption of crowdsourced geographic data, or volunteered geographic information (VGI), as a valuable source of spatial data is growing at all levels of government. VGI is crowdsourced geographic information provided by a wide range of participants with varying levels of education, knowledge and skills.[1] Despite some initial concerns about data quality during early development of VGI approaches, extensive research now demonstrates that the reliability and accuracy of VGI is suitable for official or government use.[2] Such concerns should no longer be a reason for the lack of government adoption of VGI. Nonetheless, significant challenges remain for governments seeking to take full advantage of the benefits that crowdsourcing offer.

This research used a case study approach to understand factors that have contributed to the success of government VGI efforts, some of which include supportive organizational or legal contexts, the presence of local champions, and project design elements. The 50 case studies of government

Box 1: USGS activities

The US Geological Survey (USGS) is an example of an organization with a set of well-established crowdsourcing projects. These include base mapping with The National Map Corps, collecting data on bird migration with the North American Bird Phenology Program, and the "Did you feel it?" project that documents public experience of earthquakes.

National Map Corps project volunteers are asked to collect and edit data about human-made structures and provide accurate and authoritative spatial map data for the USGS National Geospatial Program's web-based 'The National Map'. Volunteers edit 10 different structure types in all 50 states, including schools, hospitals, post offices, police stations and other important public buildings.

The North American Phenology Project ran from 1880 until 1970 when it was discontinued due to lack of financial resources. In a new project, USGS is working with volunteers to transcribe its records, curate the data, and make it publicly available.

"Did you feel it?" asks volunteers to report how they experienced an earthquake. Contributors complete an online form to describe the impact, and their experience is quantified using the Modified Mercalli Intensity (MMI) scale. Contributors do not need to have experience in seismology. The project makes up for the paucity of instrumental ground-motion data in regions of low seismicity by providing a rich data pool of observations, which are analyzed and used in maps and graphics available to the public.

involvement with VGI spanned multiple sectors, including disaster risk management, urban planning, and environmental conservation. This report argues that, while there are no "one size fits all" approaches to successful project implementation, a number of common lessons can be gleaned from analysis of prior examples.

Volunteered geographic information in government

Government organizations, from the local to the national level, rely on geographic data for many of their operations, from planning new infrastructure development to maintaining order and responding to emergencies. For this reason, geographic information systems (GIS) are now commonplace in governmental operations. VGI, which has gained recognition as a novel source of data in the past decade, offers many advantages to governments who use GIS: VGI complements professional data collection by government agencies by providing data coverage for locations and time periods not addressed by official data collection initiatives (Box 1).

- VGI enables government agencies to capture and integrate local knowledge, which is not incorporated by official processes.
- Engaging the public in governmental processes, creating space for dialogue, and supporting efforts around transparency and data-driven decision making.
- In some cases, VGI can be a cost- and time-effective alternative to standard data collection.
- VGI approaches can support the development of beneficial community skills and capacities in areas such as preparedness for natural hazards (Box 3).

Identifying factors of success in VGI projects

The analysis behind this report was based on 50 case studies. Each case features:

- a government agency at local, regional, or national level
- public outreach with a request for individuals to share their knowledge (e.g. vernacular placenames) or to create new data (e.g. map a place)
- use of information and communication technologies
- a specific intended use for the information created.

The cases were coded according to a set list of characteristics (e.g. type of partnership, existence of an organizational champion). The analysis highlights six key elements of government VGI projects:

- incentives/drivers to start a project
- scope and aims of the project
- participants, stakeholders and partnerships
- inputs such as technical and financial resources or training
- technical and organizational aspects
- challenges encountered

The first five topics were analyzed further using Qualitative Comparative Analysis (QCA) (Box 2). We discuss the main findings in each of the elements below.

Incentives to start a VGI project

The organizations studied in this report were found to start VGI projects for several reasons, including the lack of institutional data in time sensitive situations such as disaster response; lack of resources for data collection; policy change around governmental data, particularly related to open data initiatives; research and development; and environmental monitoring through citizen science where members of the public work together with scientists to collect and analyze environmental information.

Box 2: Methodology

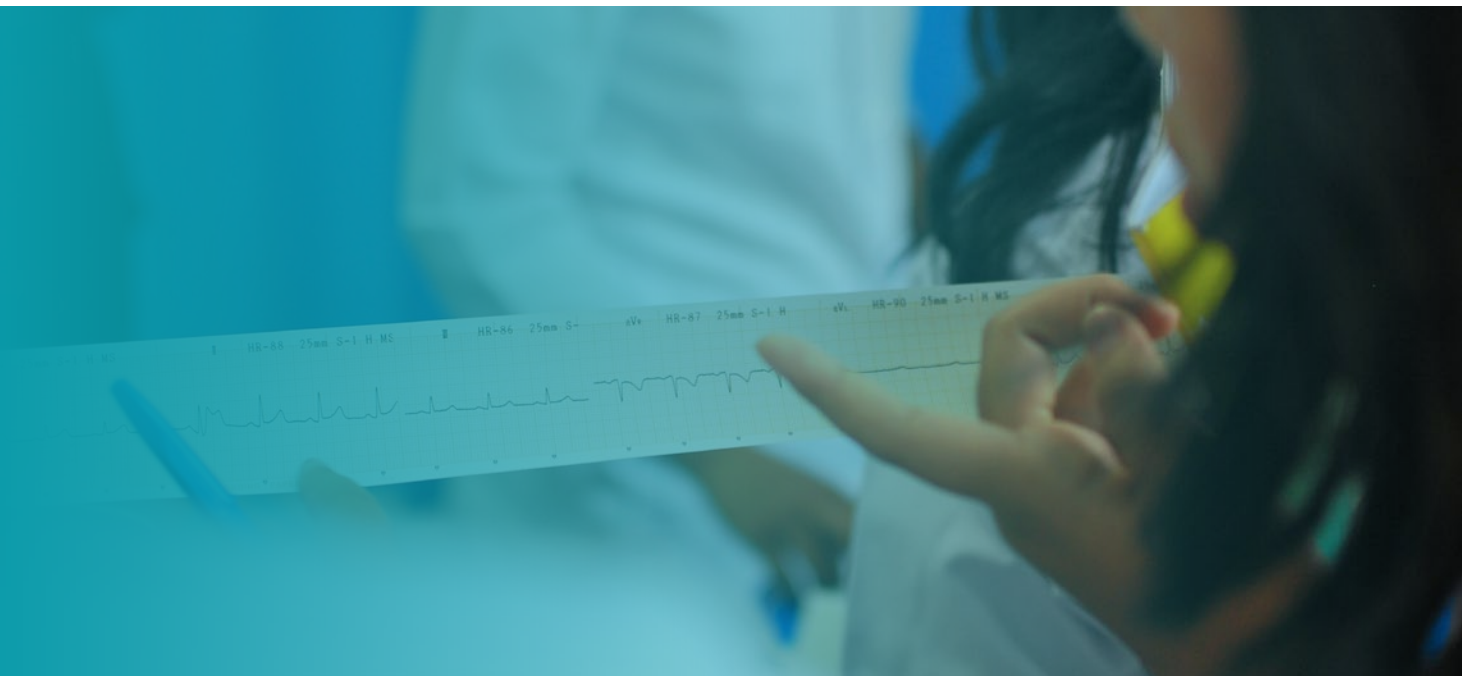
The following steps were taken to understand the scope of VGI projects in government:

An online survey about existing VGI projects in government was made available on a dedicated website, in consultation with GFDRR. The website already included 29 case studies from a 2014 report. Experts were asked to complete the survey or provide information about projects directly to the research team.

The report team identified and researched other new case studies.

72 new projects were identified and 21 selected for inclusion in the report (these were the most complete in terms of detail available), along with the 29 projects identified in 2014. In total, 50 cases were analyzed in depth and are detailed in the Appendix.

The case studies were compared and analyzed using Qualitative Comparative Analysis (QCA). QCA is a well-accepted analytical technique that uses Boolean algebra to compare and qualitatively study social phenomena. All cases were mapped against a detailed set of factors that could (positively or negatively) affect their outcome, and several QCA models were tested.



Analysis of these factors showed that, compared to other incentives, environmental monitoring through citizen science provided an especially strong foundation for successful VGI projects in government. In other contexts, open data policies provided opportunities for successful collaboration between government and the public around the maintenance or updating of authoritative datasets. Importantly, VGI projects that were driven by a lack of resources to create information for government operations, were only successful when there was also a commitment by the government to invest in internal capacity development or other sustainability measures. Without such an investment, they tended to be unsuccessful over the long term.

Scope and aims

The scope and aims of the case study projects fall into the following key categories: base mapping of an area of interest or entire country; updating authoritative datasets, such as the US National Map (Box 1); upgrading the quality of the services provided by a public sector organization; policy development or reporting on implementation; and disaster risk management and response.

The analysis showed that base mapping[3] was an important component of almost all successful cases. It was successfully combined with other aims such as disaster preparedness and response or public service improvement. Collection of base map data for the area of interest is thus considered to be an important part of successful VGI projects.

Participants, stakeholders and relationships

Most successful VGI projects involve cooperation amongst a range of partners and stakeholders. The analysis examined the range of partners in relation to the success of the VGI projects. Specifically, it examined combinations of public sector, private sector, international NGOs, local NGOs and research organizations, and considered the overall number of partners involved in the project.

Many successful projects included international NGOs, which highlights the effectiveness of NGOs with crowdsourcing experience working together with public bodies to achieve project goals. The resources of private sector organizations are valuable, but in our case studies, they were more successful when partnered with intermediaries, such as experienced NGOs.

The absence of local NGOs in our case studies might be explained by the observation that, apart from the area of environmental monitoring through citizen science, there are few well-established local NGOs with the expertise to act as VGI project champions. It is likely that, where they exist, they could play a similar intermediary role, as occurred in the aftermath of the 2015 Nepal Earthquake (Box 3).

Inputs

Governments can invest in VGI projects in a wide variety of ways. Project inputs included the release of existing data resources, such as through open data efforts; direct investment, for example, employing contributors or a government employee tasked with managing the project; investment in a new technology, such as a website or mobile app to facilitate contributions; development and delivery of training programs with key partners; and creating research and citizen science initiatives linked to government agencies.

The analysis showed that incentivizing contributions of either dedicated government staff time, or public participants, was employed by many successful projects when combined with the introduction of a new technology, such as a mobile data collection application. Training activities were also important determinants of project success, but in some cases these could be replaced by partnerships with expert communities.

Box 3: Open Cities Kathmandu

The Open Cities Kathmandu project was launched in 2013 to collect data on earthquake vulnerability using the OpenStreetMap platform. Nepal has long been recognized as one of the most at-risk countries in the world for earthquakes and other natural hazards. The Open Cities project created a partnership between local NGOs, the Nepal government, and several universities to perform detailed base mapping of Kathmandu and collect structural data for over 2000 schools and 350 health facilities for use in seismic risk assessment. At the conclusion of the project, local participants formed a new Nepali non-for-profit technology organization called Kathmandu Living Labs (KLL) which has continued working on projects related to open mapping and VGI. In the aftermath of the April 2015 earthquake in Nepal, both KLL and the OpenStreetMap platform played pivotal roles in supporting emergency response.

Technical and organizational aspects

The research also examined various technical and organizational aspects of VGI implementation within government programs. These aspects included the combination of VGI data with authoritative government data, concerns about accuracy and quality of VGI data, the intended use of VGI data, and the role of champions in the government entity.

The most important finding here was the need to formalize and standardize VGI before its use in government systems. The analysis showed that many successful projects combined the presence of an active government champion and mapping activities that were focused on creating new data (as opposed to maintaining existing, authoritative, data).

Other challenges

Some additional factors are also important in ensuring successful VGI projects in government. First, there should be careful consideration of whether the activity is designed as a one-off event or ongoing initiative. While many VGI activities are conceived as single events, the longevity of updates and maintenance remains relevant. Regardless of the length of the project, public interest and participation needs to be maintained through the life of a VGI project. Maintaining the data and relevant software is also a concern; therefore, resources should be allocated across the whole life of a project to support these activities.

Second, the quality of the VGI and its application are key considerations to be addressed at the beginning of the project, and revisited regularly throughout its lifecycle. Government agencies are responsible for providing authoritative data while also integrating public input, making accuracy and reliability areas of concern. There are multiple methodologies for quality assurance in VGI, which should be explored and integrated depending on the context and aims.

Summary of findings

The analysis identified key factors at several levels in successful established VGI projects in government.

At the **individual level**, champions and change leaders in public sector organizations are critical. Individuals who oppose public participation in data collection and analysis for reasons of information security or quality can block or hinder the integration of VGI into government. Discussions to understand and alleviate the concerns of such individuals can assist in the adoption of VGI.

At the **organizational level**, organizations that already rely on external sources for spatial data show a greater potential for VGI adoption because staff of government agencies that produce data may see the use of VGI as a threat to established modes of operation and sources of funding.

Further organizational issues can be procedural, such as existing legislation and service delivery obligations, or structural, such as responsibilities for data collection and use. This is linked to the need for having well-understood **business models** supporting the creation and maintenance of data, and consideration of how these will change with the introduction of VGI.

Technical challenges should be also noted. For example, the ability to merge datasets that have been changed by the public into existing government systems was found to be critical. This analysis suggests that governmental organizations new to VGI should use more mature technologies, or partner with experienced organizations on capacity building activities.

Finally, **conceptual or "worldview" issues** need to be recognized, as they also interact with the above categories. The adoption of VGI requires accepting a higher level of uncertainty, attention to heterogeneity, collaboration among diverse groups of participants, different ways of communicating with the public, and different operating procedures. For example, quality assurance procedures that are suitable for in-house process are methodologically unsuitable for the VGI context. Overall, government staff must be open to adjusting their beliefs about "how things are done".

Other Recommendations

In addition to the findings summarized above, the findings of the study also suggest that projects seeking to help government entities take advantage of the potential that VGI offers should:

- Identify and support an organizational champion.
- Consider a project focused on improving public services or environmental monitoring as these have been particularly successful in adopting VGI approaches.
- Aim to collect base map data or basic information, instead of attempting to update authoritative datasets.
- Dedicate appropriate resources. Using new technology requires significant investment beyond building the technology itself, and using established technology with a training program can be effective.
- Engage with a local or international NGO that has experience facilitating VGI projects, or link with other government agencies that have experience in this area.
- Plan to address the organizational, technical and worldview challenges within the government entity in order to gain support for VGI across the organization.

1 The term VGI was established by Michael Goodchild in 2007, in his paper, "Citizens as sensors: the world of volunteered geography". The terms crowdsourced geographic information and VGI are often used interchangeably.

2 For example, see Haklay, M. (2010). How Good is Volunteered Geographic Information?

3 The creation of the basic elements of mapping – streets and roads, public buildings and facilities, major landmarks and natural features

Part B: Main report

Introduction

The role of volunteered geographic information (VGI) as a valued and useful source of information is growing at all levels of government. Put simply, VGI is "crowdsourced" geographic information provided by a wide range of participants with varying levels of education, knowledge and skills.[1] While extensive research demonstrates the reliability and accuracy of VGI compared to official or government produced datasets, progression towards their adoption and wider use has yet to achieve its full potential. What this research does provide is a range of mechanisms for ensuring that crowdsourced information is fit for purpose. Therefore, concerns about data quality are no longer a reason for the lack of adoption of VGI. However, organizational practices, regulations and legal issues are more difficult challenges.

The aim of this updated report[2] is to review governmental projects that incorporate VGI and provide information that can be used to support its wider adoption of VGI. To this end, the report compiles and summarises lessons learned and successful models from government projects in different sectors and at different levels. The research presented in this report was motivated by the following interrelated issues:

- Sources of VGI data such as OpenStreetMap (OSM) are increasingly important across a range of thematic areas and user communities.
- The quality and consistency of VGI data have been assessed by a range of studies and found suited to many tasks. Therefore, concerns about these issues should not prevent the use of VGI as a valuable source of data.
- Managing VGI projects and interacting with VGI communities is a different and potentially more complex relationship than governments have had with traditional sellers and resellers

of geographical information systems (GIS) data.

- Governments have begun engaging with VGI communities in different ways and there is much to learn from these experiences.

This updated report follows the notion of information flows established in 2014 where it was observed that VGI projects rely on different kinds of information flows, summarized below:

- **Public → Government.** VGI provided by the public to government authorities also has a long history pre-dating the web, e.g. calling to report a problem at a location. This report includes several examples of such cooperation to illuminate specific aspects of VGI practice.
- **Government → Public → Government** and **Public → Government → Public.** Examples of two-way cooperation between government and the public or civic organizations form the core of this report. Again, collaboration with the public has a long history. This report refers particularly to the use of publicly contributed information to make decisions and actions (e.g. civil protection agencies using map data for disaster preparedness) and the release of government information to the public for improvement and its subsequent use by government.

In addition, there is one flow of information that is not covered in this report but is important in the context of information flows in general in order to understand the full picture:

- **Government → Public.** The flow of information from government to the public is important, but is rarely implemented in VGI projects. This report does not focus on the use of open data (data made available by government agencies without charge or restrictions to the public) as there are many examples of this in commercial and civic society. This is also covered in the OpenDRI Field Guide.

This report explores different aspects of government use of VGI, such as the maintenance of public space (streets, public buildings and parks), or collecting data about education, health, tourism and civic safety. It includes a set of case

Box 4: OpenDRI

Hosted by the World Bank's Global Facility for Disaster Reduction and Recovery, the Open Data for Resilience Initiative (OpenDRI) works to bring the philosophies and practices of the open data movement to bear on the challenges of building resilience to natural hazards and impacts of climate change. Partnering with governments, international organizations and civil society groups, this program develops open systems for creating, sharing, and using disaster risk and climate change information to ensure that a wide range of actors can participate in the challenge of building resilience. Since it was launched in 2011, OpenDRI has worked to implement these ideas in over 50 countries around the world. VGI and crowdsourcing are key elements of the OpenDRI approach. These approaches help our projects collect up-to-date and accurate information, build new partnerships across sectors, and incorporate the perspectives of the public into studies of disaster and climate impacts and risk. The research in this report was funded by the OpenDRI project as a means to support further understanding of the opportunities and challenges that emerging technologies and practices such as VGI create for governments and their partners in building resilience.

studies, which are included in the Appendix. The following sections provide background on the use of geographical information by government, as this has a long history that should be considered alongside contemporary trends. The report then turns to the methodology of the research and provides an overview of the case studies. This is followed by an analysis of the findings and recommendations for improving the use of VGI in government.

Learning from the past

The history of digital geographical information is intertwined with government activities. The system commonly recognized as the first GIS was created by the Canadian government in the 1960s to map land use and agricultural productivity and suitability. Manual predecessors were in use perhaps 100 years earlier. Moreover, the use of geographical information by government agencies at all levels – from the local to the regional, national and intergovernmental – continues to be one of the most significant applications of GIS.

By the 1980s, with the introduction of customisable and off-the-shelf software packages, GIS implementation became more common in organizations. This led to research into the processes that assist organizations in implementing GIS and how to ensure that digital geographical information is used in an effective way. Of particular importance and relevance to this report are the work of Stan Aronoff and his 1989 book, *Geographic Information Systems: a Management Perspective*, and William Huxhold's,

An introduction to Urban GIS from 1991. Both paid attention to the management of GIS projects, the importance of understanding the way organizations work and the effort required for successful GIS implementation.

In the past 15 years, a revolution has taken place in GIS that has led to dramatic change in the use and manipulation of spatial information. The changes were driven by increased access to geographic information on the internet, the increased use of connected mobile devices such as smartphones, and new techniques for data visualization and sharing. These have led to a major change in the way geographic information is produced. Sui (2008) and others refer to this as digital spatial data, which is collected and edited not by traditional data producers but by citizens, who are not experts but are willing to disseminate their spatial knowledge and observations without any special invitation.

Spatial data capture, storage, management and dissemination are particularly relevant to contemporary VGI projects. In the early days, a major part of any given GIS project was the conversion of paper maps to digital formats. The challenges of integrating varied data sources into a coherent database reflect many of the issues emerging from crowdsourced information. Since this early work, the implementation of GIS projects has received ongoing attention, with Roger Tomlinson's 2013, *Thinking about GIS: Geographic information system planning for managers*, and significant portions of leading GIS textbooks such as Longley et al.'s 2015, *Geographic Information Systems and Science*, providing the latest summaries from nearly five decades of practice.

Discussion has also arisen around citizen science projects, which are not new but have recently attracted the interest of the research community in a similar way to VGI. Much of the work undertaken in VGI is closely related to citizen science, which can be described as the scientific work that comes from the public either in collaboration or under the direction of professional scientists (Silvertown 2009). The term citizen science entered the Oxford English Dictionary only recently in June 2014 and is directly linked to participatory research and more specifically to participatory mapping, where "non-professional scientists voluntarily participate in data manipulation for scientific projects", as Cohn (2008) and Silvertown (2009) referred to it. Both VGI and citizen science are extremely dynamic and rapidly evolving fields, while their intertwining and close relationship, referred to as geographic citizen science (Haklay 2013), is gaining ground on many fronts.

While VGI projects may seem fundamentally different from governmental approaches, with their higher level of public engagement and informal participation mechanisms, there are a number of parallels. This is because the governmental systems to which VGI is integrated are often "enterprise systems" set up along the same lines. Therefore, many early lessons from when GIS was first introduced to governmental organizations are similar to the findings discussed below. For example, as with early GIS implementation, VGI use relies on specific individuals who act as "champions" inside the organization and spearhead the effort necessary to secure acceptance for this source of information. Another example is the opportunity that major events, such as disaster response, create in terms of rethinking current procedures and practices. Evaluations of organizational responses provide opportunities to reflect on the way current systems are utilized and develop new procedures for data collection and use. Major events and the response to them also facilitate

Box 5: Brabham (2013) best practices for crowdsourcing in government

1. Clearly define the problem and solution parameters.
2. Determine the level of commitment to the outcomes, commit to communicate to the online community exactly how much impact user-submitted ideas and labor will have on the organization.
3. Know the online community and their motivations. It is important to know whether a given crowdsourcing application will appeal to participants.
4. Invest in usable, stimulating, well-designed tools.
5. Craft policies that consider the legal needs of the organization and the online community.
6. Launch a promotional plan and a plan to grow and sustain the community.
7. Be honest, transparent and responsive.
8. Be involved, but share control.
9. Acknowledge users and follow through on obligations.
10. Assess the project from many angles.

governmental policy change and thus provide the opportunity to increase recognition of the value of VGI, just as for GIS.

Citizen science projects are focused on the participation of citizens in scientific observations, methods and analysis. The philosophy of these projects is thus strongly connected to public work and they have been linked to governmental initiatives in the past decade. As a consequence, many of the experiences and lessons from these projects are relevant when working with individuals who are experienced in implementing GIS in government and encouraging them to adopt VGI as a usable source of information. In other words, while VGI has specific characteristics of its own, it should not be seen as an unprecedented approach to collecting data.

To conclude, there is significant interest in how VGI can be used in government not only as an alternative source of geospatial data but also to record and reveal underlying conditions on the ground. This can provide the necessary information to address societal problems and shape governmental decisions and policies. This interest stems from the fact that VGI provides a bottom-up and tangible way of understanding citizens' perspectives on spatial phenomena.

In 2013, Brabham produced a report, "Using Crowdsourcing in Government", which outlines a more general overview of the potential for crowdsourcing in government. Brabham also attempts to classify crowdsourcing and understand when and how to deploy crowdsourcing in government. His analysis includes a small number of case studies and the report concludes with ten best practices and considerations for crowdsourcing. This summary is a helpful starting point on which this report builds.

Research methodology

The starting point for this revised report was the lessons learned from the 2014 report. Interest in the report was significant: it has been downloaded almost 1,800 times from 41 countries around the world in approximately three years, which suggests it has been useful to researchers and policymakers. In preparation for the 2017 update, the research team sought comments and reviews from experts in the field regarding possible improvements. This feedback highlighted that the seven key factors shaping VGI use in government, highlighted by the first report (namely: incentives, aims, stakeholders, engagement, technical aspects, success factors, and problems) have developed, resulting in a new reality. The new report focuses on changes to these factors and on better documenting other factors, as well as evaluating them more rigorously. The public face of the study was a dedicated website,[3] which hosted the data as it was gathered.

The methodology comprised of the following steps. First, in consultation with the OpenDRI team and according to expert recommendations, the online survey from the first report was adapted to ask for more focused information (e.g. funding schemes and duration of projects). Experts were invited to provide input about projects either by completing the survey or contacting the research team directly. In parallel, the research team gathered information about new case studies that fall within the scope of the report, with a total of 72 new cases recorded. From the online survey and research process 21 cases were selected for inclusion (these were the most complete in terms of detail available) alongside the 29 cases identified in 2014. In total, 50 cases were analyzed. Next, the research team enriched the case studies through interaction with respondents to clarify information, fill in gaps and harmonize the case studies to make them publicly available through the blog. The 2014 case studies were updated with their current status and any new details. Box 6 provides a brief overview of the case studies.

The case study collation prepared the ground for the Qualitative Comparative Analysis (QCA). QCA is an established technique that uses Boolean algebra to compare social phenomena. QCA therefore formalizes qualitative analysis. QCA can reveal patterns of causal factors that lead to certain phenomena while respecting the diversity and heterogeneity of each case. GFDRR experts, the research team and a QCA expert met to implement the analysis. During a two-day workshop, they examined which factors and variables are likely to impact VGI use in government and searched for patterns. First, all cases were mapped against a detailed set of factors that could affect (positively or negatively) the outcome of each case. Next, several scenarios were tested to adjust the QCA models and more accurately highlight the causal factors. The results were analyzed and discussed both during the workshop and through online meetings. The findings constitute the backbone of this new report. Furthermore, a policy brief was created to allow policy makers to quickly focus on the most important elements of the study.

Box 6: Case studies

Below are short descriptions of the case studies that provide the basis for this report (for full details, see the Appendix):

1. Mosquito Alert project in Spain. A citizen science project that aims to raise awareness of the tiger and yellow fever mosquito expansions, two invasive species vectors of global diseases like Zika, dengue fever and chikungunya.
2. StatCan crowdsourcing. Launched by Canada's national statistics agency (Statistics Canada) to fill gaps in national-level statistics on buildings and their attributes with the participation of local people.
3. Monitoring Insects with Public Participation (MIPP) in Italy. Aims to increase knowledge of species distribution for the conservation of insects protected under the European Commission (EC) Habitats Directive.
4. Global Healthsites Mapping Project. Aims to produce an openly accessible global geolocated healthcare facility using OSM, openly available healthcare and crowdsourced location datasets.
5. North American Bird Phenology Program. A citizen science project digitizing almost a century of bird migration patterns and population status, bringing back to life records from 1880-1970.
6. Foul & Filthy Rivers, China. Aims to reduce the percentage of polluted waters with citizens' participation. Its Blue Map app is directly linked to government reporting platforms.
7. Farma Valley Community Map, Italy. Adopts a participatory methodology to collect local placenames missing from current official basemaps.
8. Community river monitoring volunteer project, Scotland. Asks local communities to monitor how sediments move in burns (small streams) and how this can influence flood management techniques.
9. Malawi flood preparedness. The Humanitarian OpenStreetMap Team (HOT) facilitated community mapping, training the Malawi community and using satellite tracing and Global Positioning System (GPS) field survey techniques.
10. Food insecurity mapping, Bangladesh. Focuses on mapping the unmapped Khulna district, targeting agricultural production.
11. Syria Tracker Crisis Map. A recording mechanism for the names and locations of victims of the current war.
12. iCitizen, South Africa. Aims to involve the local population in reporting infrastructure problems by collecting geographic data points via mobile phones.
13. Community Mapping for Exposure in Indonesia. Aims to reduce vulnerability to natural disasters. It uses the OSM platform to create thematic maps showing potential damage.
14. Haiti disaster response. One of the most well-known crowdsourcing projects, which was launched following the Haitian earthquake in 2010. It aimed to fill the gaps left by the collapse of the national mapping agency.
15. Mapping of South Sudan. Addresses the need for an up-to-date map following the nation's creation. The project uses Google Map Maker with participation from the Sudanese diaspora and various organizations that train people in the digitization of aerial imagery.
16. Crowdsourcing The National Map, National Map Corps, US. Involves volunteers collecting and editing data about human-made structures in 50 states.
17. Crowdsourced flood resilience in Jakarta, Indonesia. Encourages heads of villages to identify critical infrastructure using paper maps and OSM (similar to 13).
18. Twitter use in Italian municipalities. A research project into the profile, activity and use of Twitter accounts of Italian municipalities. The focus was on the types of messages sent, revealing that culture and tourism are the most common topics.
19. National Biodiversity Data Centre, Ireland. Initiated to leverage the potential of outreach groups and the general public for biodiversity data survey and observation encouraging the participation of non-professional biodiversity scientists.
20. Towns Conquer gamification and Instituto Geográfico Nacional toponyms database, Spain. Citizens played an Android-based game in a competition format to submit suggested corrections and updates to a web-based map service operated by Spain's National Mapping Agency.
21. US National Park Service - Places Project. Uses tools developed by the OSM community to allows national park visitors and staff to contribute to mapping trails, tourist sites and other park infrastructure to keep park maps up to date and accurate.
22. US Geological Survey (USGS)'s "Did you feel it?". Driven by a lack of instrumental ground-motion data this website maps seismic activity reports from the public based on their perception of recent seismic activity in their local area. It is particularly useful in regions of low seismicity.
23. US Census Bureau - Building an OSM community of practice. US Census Bureau employees have built an active volunteer group of OSM contributors in the bureau. This group advocated for the incorporation of VGI practices into census operations.
24. New York City open data initiative. The City of New York has released geographic data which the company MapBox imports into OSM in partnership with the US OSM community. The city administration receives email updates as changes are made.
25. Imagery to the Crowd, State Department Humanitarian Information Unit, US. High-resolution satellite imagery is made available to the OSM community for the digitization of ground features. Resulting data has been used in humanitarian operations.

26. Humanitarian OpenStreetMap Team mapping in Ulaanbaatar, Mongolia. Ulaanbaatar's municipality embraced the volunteering work of university students for OSM data contribution towards the creation of a "Smart City".

27. Mapping schools and health facilities in Kathmandu Valley, Nepal. A proactive, crowdsourced mapping project that was disrupted (yet continued on an occasional basis) due to the need to map another earthquake-struck area.

28. Informal settlement mapping, Map Kibera, Nairobi, Kenya. Map Kibera was carried out in the most crowded slum in Nairobi, Kenya, in an effort to create an accurate picture of this dynamic area.

29. Skandobs, Scandinavian predator tracking system, Norway and Sweden. A cross-country project developed to collect observations for wildlife management and research purposes.

30. Corine Land Cover 2006 (CLC2006) in OpenStreetMap, France. A data policy change for CLC2006 enabled its one-off use by the French OSM community to update and complete the OSM land use data.

31. FixMyStreet for municipality maintenance information, UK. Engages the public to provide data about problems in the urban fabric, which are then propagated to the local authority responsible for maintenance.

32. FINTAN vernacular placenames project, Ordnance Survey and Maritime and Coastguard Agency, UK. A project leveraging "professional" crowdsourcing to record vernacular placenames to improve response time to distress calls.

33. Boston StreetBump, US. Based on the use of a mobile app to capture bumps or potholes on Boston's streets, which are then reported to the authorities responsible for maintenance.

34. California Roadkill Observation System (CROS), US. Collects crowdsourced observations of wildlife roadkills and then uses GIS and statistical modeling to predict hotspots, quantify impacts and develop remedial wildlife management actions.

35. Crowdsourcing satellite imagery in Somalia. An effort to map all shelters in the Afgooye corridor using satellite imagery to support estimates of the number and location of refugees.

36. Portland TriMet, transportation planner, Oregon, US. The Portland public transportation agency both uses and supports OSM, aiming to provide multimodal transportation plans for citizens.

37. The Base Adresse National (BAN) Project. A collaborative project between the French national mapping association, postal service, municipalities and OSM France to create the most update-to-date and complete address database in France.

38. Citizen participation in urban planning, Kirtipur, Nepal. A project where volunteers use a video game to create three-dimensional models of future designs for their local public spaces.

39. Land tenure in Tanzania. A crowdsourcing project that collects parcel borders and land ownership data to fight social injustice against women and create authoritative land rights for them.

40. Open for Business, UK. A public authority supported mapping project that calls for private business owners to contribute details about the continuation or re-opening of their businesses after a major flooding event.

41. International Hydrographic Organization's Crowdsourced Bathymetry Database. Aims to collect crowdsourced bathymetry data from trusted participants to create a more detailed and updated map of the seas and oceans.

42. Disaster Management, Early Warning and Decision Support Capacity Enhancement Project in Indonesia. Enhances the capacity of disaster management agencies through crowdsourced data that will be used to create and disseminate alert warnings to communities and populations at risk.

43. Summer Camp Guide. Under the auspices of the local authority, summer camp managers add their facilities and services to a map, enabling citizens to select the place and time that best fits their needs.

44. Ramani Huria. University students are trained to provide the necessary data for resilience and disaster reduction for the flood-prone area of Dar es Salaam.

45. Natural Resources Canada-OpenStreetMap Synergy. An early effort to use OSM in collaboration with authoritative data to update and improve both datasets.

46. Participatory mapping and decision support tools for disaster risk reduction, the Philippines. Training and technical assistance for local government units to create basemap information and impact analysis using InaSAFE impact modeling software.

47. Government open data usage in Lithuania. Combines conventional and open data for generic mapping and raises awareness of open data.

48. Xalapa collaborative transport mapping. Collaborative project to map and document the transportation network of public buses.

49. FloodTags. Short messages posted on social media are used to map flood risk and help improve preparedness and response actions.

50. Open Cities, Sri Lanka. Crowdsourced data gathering based on accumulated experience in disaster preparedness plus further training of students and civil servants.

Analysis

For the purpose of this report each project's success (defined as evidence of data creation, continued contribution, government use of the data, and acceptance of crowdsourcing in the organization) has been rated and compared against the aspects identified in the first report. First, this looked at the goals of the projects and the reasons for their implementation. Second, organizational factors were considered, including the impact of partnerships and/or input from the leading organization. Finally, the overall design of the project was considered. These led to modelling, evaluated through the QCA analysis, to identify the most important combination of factors associated with a successful VGI project outcome. The details of the analysis are beyond the scope of this report and will be provided elsewhere.

The analysis identified six key factors that need managing for successful VGI projects:

1. Incentives/drivers
2. Scope and aims
3. Participants, stakeholders and relationships
4. Inputs
5. Technical and organizational aspects
6. Other challenges

The following sections look at each of these topics and provide some insights from the individual case studies.

1. Incentives/drivers

There are many different factors that encourage organizations to search for an alternative to institutional data solutions and start VGI projects:

Lack of institutional data in time sensitive situations.
This is one of the most common drivers and its importance was shown particularly by the aftermath of Haiti earthquake, where there was an urgent need to provide mapping to facilitate humanitarian and first aid efforts. The Kathmandu case study is a proactive example of local and international stakeholders teaming up to provide basic mapping of schools and health facilities in case of earthquake.

Policy change around governmental data, particularly open data.
Policy changes and decisions to change access and use of governmental datasets can provide the motivation, or the opportunity for wider public engagement in creating information. For example, the adoption of an open data policy in New York City; the use of the released CLC2006 data by the French OSM community; and the US State Department Humanitarian Information Unit (HIU) sharing high-resolution imagery with humanitarian organizations and volunteer communities.

Low resources and the need to develop national mapping infrastructure.
Interestingly, this situation can be a driver for both well-established national mapping agencies (NMAs), as in Canada where updates are needed to mapping covering 10 million km^2, and newly established ones, as in South Sudan where mapping of basic topographic features is needed to build the first data infrastructure of the new state. Similarly, the implementation of ambitious efforts like the "Smart City" project in Ulaanbaatar, Mongolia, need support from VGI.

Research and development.
This includes exploring new products or research directions. Examples are CROS, a university-led initiative about wildlife roadkills, and Towns Conquer, which explores gamification techniques and strategies to enhance VGI. A slightly different approach is taken by FINTAN in the UK, which uses "professional" VGI to collect and preserve expert local knowledge.

Environmental monitoring through citizen science.
Public participation in scientific data collection is frequently related to monitoring the state of the environment rather than the creation of new products/research trajectories (compared to research and development, above). Examples include the USGS's "Did you feel it?" public participation in seismic monitoring; public submission of biodiversity records to Ireland's National Biodiversity Data Centre (NBDC); and Skandobs crowdsourced wildlife observations.

The QCA examined each of these drivers and their influence on project implementation. In fact, each projects' drivers can be categorized according to different combinations of these factors. The results show that the most successful projects are those driven by a need for environmental monitoring, either for management or research (e.g. understanding species distribution).

Alternatively, where the driver was different, successful projects benefited from the promotion and creation of open data by the government. Such policy changes allow the utilization of government datasets for new purposes, as in the case of the opening of the CLC2006 dataset. It might also be that a change in policy opens up an opportunity for governmental organizations to reassess the way they operate, although this requires more detailed research.

In other words, **environmental monitoring and citizen science provide a good grounding**

for successful crowdsourcing projects in government, and open data policies can bring opportunities for government agencies to collaborate with the public. Importantly, VGI projects driven by a lack of resources and the need to create the information necessary for government operations tend not to be successful.

2. Scope and aims

The scope and aims of the case study projects fall into the following key categories:

Basic mapping coverage.

In many cases the aim is as simple as the creation of a cartographic background for an area of interest or entire country. In many developing countries there is no spatial data infrastructure to support humanitarian efforts, disaster prevention and general planning. Examples include South Sudan, where the new nation was in urgent need of basic cartographic coverage, and Map Kibera, where the aim is to create a topographic backdrop of Nairobi's largest informal urban settlement.

Update authoritative spatial datasets.

A step further is the aim to support established spatial infrastructures. Keeping datasets up to date (mainly through change detection projects) is a crucial task, especially for NMAs as this guarantees the quality of their services. Examples include Natural Resources Canada (NRCan), Towns Conquer, New York City's open data initiative, Ulaanbaatar's "Smart City" and the US Census Bureau.

Upgrade public sector services.

Related to the above is the effort to collect new and unrecorded spatial datasets to upgrade the quality of the services provided by a public sector organization. Examples include the FINTAN project in the UK, which will improve HM Coastguard's response to distress calls,

Portland TriMet, iCitizen in South Africa, Boston StreetBump and FixMyStreet.

Policy development or reporting.
Local knowledge and the timely nature of participants' observations are two of the most important VGI characteristics that stakeholders are trying to tap into. Examples that combine observation gathering and policy planning are CROS, where observations about roadkills help stakeholders understand the phenomenon and the best remedial actions, and Skandobs, where wildlife observations inform actions and policies in accordance with new legislation. Ireland's NBDC and USGS's "Did you feel it?" are more report oriented and use the observations to stimulate public engagement and analysis respectively.

Natural disaster preparedness (proactive) and crisis management (reactive).
As well as being a driver, one of the most important aims of existing projects is to build spatial datasets for humanitarian purposes. This covers both crisis management after a natural disaster, as in Haiti, and proactive creation of the necessary infrastructure in an effort to minimize the consequences of a future disaster, as in the cases of Kathmandu, Indonesia and the Imagery to the Crowd project.

These five factors were examined in combination against the success of a given project. The analysis shows that updating basic mapping coverage, in combination with either improving public service delivery (but not addressing a disaster) or in addressing a disaster (but not other policy development) provide the basis for successful crowdsourcing projects. In other words, **it is possible to consider policy development when there is no current disaster (e.g. Indonesian disaster preparedness), but public service improvement cannot be central while in the midst of dealing with a disaster, as the Haiti case demonstrates. However, in both cases basemaps are required to proceed, and this requirement can lead to success.**

3. Participants, stakeholders and relationships

Public sector and NGOs / international organizations.
This type of cooperation is relevant to various contexts, including crisis management, where the active participation of all stakeholders is needed to address often difficult and complicated tasks. Those involved in such partnerships include the United Nations, World Bank, Humanitarian OpenStreetMap Team (HOT), NMAs, state mapping departments and local universities. The following examples indicate the breadth of such cooperative efforts: Haiti disaster response, Imagery to the Crowd, Ulaanbaatar's "Smart City", Kathmandu and Map Kibera (the latter involving national and international bodies).

Public sector, private sector and NGO cooperation.
An even more inclusive type of cooperation is the additional participation of the private sector. For example, MapBox joined forces with the OSM community and the New York City government to support data migration and software provision, in turn gaining valuable insight into the data released. In another case, a number of international organizations had the active support of Google in terms of software and user motivation to help the government begin the mapping of South Sudan.

Universities and research institutions.
VGI is a relatively new and dynamic phenomenon so there is much active research undertaken by universities and research institutions on its evolution (e.g. Towns Conquer) and possible real-world applications

(e.g. Skandobs, USGS's "Did you feel it?", Ireland's NBDC and CROS, California).

Private and public sector initiatives.
The private sector can also lead on projects for VGI use in government. One such example is FixMyStreet, run by social enterprise mySociety; another is the involvement of the UK's Ordnance Survey (which functions with market criteria, despite being an NMA) in the development of FINTAN for use by HM Coastguard.

The analysis examined the range of partners in relation to the success of the project. In particular, it looked at combinations of public sector, private sector, international NGOs, local NGOs and research organizations, as well as the overall number of partners. **The outcome shows that successful projects involved an international NGO, either with public bodies, but without local NGOs and research organizations; or with private and public organizations, but without local NGOs. This highlights the importance of NGOs with experience of crowdsourcing at the interface with government (e.g. HOT) working together with public bodies to achieve specific goals. The resources of private sector organizations (Google, Digital Globe) are valuable, but they work better with intermediaries, such as experienced NGOs. The absence of local NGOs might be explained by the observation that, apart from in the area of environmental monitoring through citizen science, there are few well-established local NGOs with the expertise to act as VGI project champions.**

4. Inputs

Releasing existing resources.
This can include the release of datasets (including visual databases) or license changes enabling greater use for public users, including the OSM community, and private entrepreneurs. The most characteristic cases are the Imagery to the Crowd project, New York City open data initiative and use of CLC2006 in France. The general public and NGOs are keen to utilize datasets that support their aims, such as producing new map-based art products or creating new digital service for cyclists, and thus welcome such initiatives.

Direct investment.
Directly employing contributors can help government agencies ensure that the data collected meets their immediate needs, while still benefiting from participation in the broader ecosystem. In both the Portland TriMet and Community Mapping for Exposure in Indonesia case studies, government resources were used to hire in-house mappers to contribute to OSM. Community-based projects in areas of very low income can also benefit from providing financial compensation to public participants to replace earning potential, as Map Kibera did in Kenya.

Investment in new technology.
The development of new mobile phone or web-based applications to collect data are a common aspect of crowdsourcing projects. Examples include the USGS's "Did You Feel It?" website, the mobile app for monitoring rivers in China and the Skandobs app for collecting information. Other projects can rely on established technologies which are developed for other purposes or for a general purpose (e.g. OSM).

Training.
Some projects establish specific training programs, sometimes with local students, to develop skills and knowledge in crowdsourcing

geographic information (e.g. the case studies from Dar es Salaam and Kathmandu). Training increases the local capacity to run and coordinate crowdsourcing activities.

Research and citizen science initiatives. Although giving the public the opportunity to participate in monitoring and research projects has a long and successful history, technological advances, especially in the mobile domain, offer a different level of dynamic engagement. The case studies of Towns Conquer, CROS, USGS, Skandobs and Ireland's NBDC all demonstrate this type of engagement.

The analysis showed that many successful VGI examples rely on either direct investment and the introduction of new technology, or direct investment and training where projects included a relatively low number of partners, with the latter cases using existing technology and providing training to increase capacity. The USGS case study is an example of the first scenario: as an organization with a mature understanding of crowdsourcing, it is capable of starting new projects (e.g. transcriptions of phenology records) and providing the resources to create a new website, recruit participants, and manage the overall process. Successful OSM mapping for resilience is an example of the second scenario: these projects rely on the relative maturity of OSM technology, training materials and practices of training new users. **Finally, successful VGI projects with multiple partners tend not to involve training, the use of new technology or direct investment** – these are examples where government agencies tap into an existing community with the expertise, knowledge and disposition to assist (e.g. New York City open data initiative and the local OSM community).

5. Technical and organizational aspects

The formalization and standardization of VGI is critical to its adoption by government. This issue is both technical and organizational and includes the following aspects:

Combining conventional and open source data. Many crowdsourcing projects use a wide range of software applications, both closed and open source. The CLC2006 in France and NRCan case studies prove that combining various tools in different applications can widen the technical horizons of an application and create new opportunities. However, access to the knowledge and experience of using these software tools is not available to everyone and requires high technical abilities.

Data integration. During update operations, datasets often diverge but the users and recipients of a project should know which version is the correct one and how to maintain a definitive copy. In some cases, and especially where open source software is used, the format of data is not convenient for further use in proprietary software packages, making it difficult to reintegrate. Therefore, the interoperability of data formats is a significant issue, for example the CLC2006 show that after the initial import of the dataset, the integration of further updates was beyond the interests of the French OSM community.

Authority. The authority given to data resulting from VGI projects is one of the most challenging issues for its use in government. In a departure from an era in which information is considered authoritative simply because it originates from a government organization, recognition of the inherent heterogeneity in geographical information

and the need to keep it up to date permeate many of the case studies. However, because government agencies have both the authority and the responsibility to provide accurate and comprehensive information, this requires more control over the data and its quality. Many of the case studies, such as the USGS or NRCan projects, show that governmental organizations need to put appropriate procedures in place to ensure that, regardless of the source, the information released is accepted as trustworthy and valuable.

Role of champions.

This type of engagement stems from individuals' prior knowledge of the nature and use of VGI and, often, from their cooperation with local communities such as OSM volunteers. Their personal effort pushes their organizations to engage more actively in VGI and develop methodologies and best practices that would be beneficial for all stakeholders, including governmental organizations, NGOs, and the public. This particular mode of engagement can be observed in the case studies of the US Census Bureau and NRCan.

The results of the QCA showed that successful projects are particularly defined by the presence of a champion in the governmental organization, when the project is not focused on updating an authoritative dataset. While there are some rare examples of success for updates of an authoritative dataset (e.g. crowdsourcing the National Map project) these are in the context of mature projects and in organizations that accepted the use of crowdsourcing in their operational practice.

Adopting VGI in government

The analysis of the 50 case studies shows that there are multiple routes to the successful implementation of VGI projects involving government agencies. **Unless a government organization has already reached maturity in the area of crowdsourcing (the best example in this report is the USGS), identifying a champion and starting a project that will not address authoritative datasets directly is a good way to ensure early success and start the process of organizational learning on how to use VGI. Next, if the choice is to use new technologies, this should be accompanied by appropriate resources and investment. Using an existing technology that has been successful elsewhere and investing in training and capacity building is another path for success.**

Intermediary NGOs (e.g. HOT) are also important factors of success. These organizations have the knowledge and skills to implement projects at the boundary between government agencies and the public, making valuable implementation partners. Successful VGI projects also tend to be focused on public services or environmental monitoring. Detailed basemapping of roads, buildings and other fundamental data can also provide a solid starting point.

Overall, there is no one, perfect methodology for a successful VGI project in government. However, there are a series of issues which need to be addressed when considering launching a VGI project. Attention to these issues can increase the likelihood of successful adoption by government and acceptance by the public.

Traditional GIS practices and concern over organizational change.

It is important to highlight that VGI should not be seen as an activity that replaces the work of professionals, but as one that complements and enhances it. In some cases, such as Haiti, the use of VGI was seen as a direct threat to the business model of the NMA and the OSM data could not be adopted without consideration of how this could be protected (see also Intellectual Property Rights issues). In other cases, VGI is perceived as a challenge to existing procedures, funding and professional standing, which leads to a negative response. There is also a need to integrate VGI processes, including issues of engagement and feedback to contributors, into established systems, practices and procedures. In some cases, current practice does not require such high levels of engagement so organizational transition is required. This is particularly important in emergency situations, where entrenched procedures are necessary to ensure an appropriate response, and capacity to deal with uncertainty and complexity is reduced. If VGI is considered for use in crisis response it should be evaluated and tried in preparation exercises to ensure that it is fit for purpose.

Accuracy and reliability.

The quality of the data and its application are among the main questions that must be answered at the beginning of, and during, a project. A challenge for projects launched or supported by government agencies is that they are responsible for providing authoritative data while also integrating input from the public. This makes accuracy and reliability key issues. The case studies demonstrate different levels of accuracy and ways of assessing this (e.g. Community Mapping for Exposure in Indonesia, National

Map Corps in the US). Accuracy varies depending on the new data's purpose and the existing data available as a reference. This is also relevant to hardware issues in "passive" VGI, in which data from sensors carried by members of the public is shared with government agencies. For example, in the Boston StreetBump case study, the use of smartphone-based sensor technology produced many "false positives" due to erroneous movement detection. As noted above, there are multiple methodologies for quality assurance in VGI, and these should be explored and integrated according to the specific context and aims.

Inherent coverage, temporal and participation biases.
Growing research into VGI projects demonstrates that they can exhibit certain biases in the level of participation, as well as when and where the activities take place. For example, there is a problem of coverage bias towards populated and popular places (such as large urban centers) and crowdsourcing rarely includes a representative sample of the general population. An example of a case study limited by such inherent biases is the Skandobs project, where the real areas of interest are geographically remote and present physically challenging terrain. Special incentives may be needed to encourage public involvement from specific regions and known biases of this kind should be considered during the design and implementation of such projects.

One-off event versus ongoing initiative.
While many VGI activities are conceived as single events, the longevity of updates and maintenance needs careful consideration. Projects vary significantly in this respect. For example, the use of CLC2006 in OSM in France lasted many months and resulted in an outcome which remained unexploited; other projects lasting only a few days, such as the mapping of South Sudan and the Haitian disaster response, provided a clear solution to a significant problem relatively quickly. The main differentiation concerns the strategy behind each VGI project and how it is recognized by governmental bodies and the public, whether as a one-off crowdsourcing event or as an ongoing initiative. Maintaining the data and the relevant software is also an issue of concern. Financial resources should therefore be split across the whole life of a project rather than allocated only to the beginning stages.

VGI continuation and sustainability.
In many of the case studies examined there is no specific plan for longer term adoption of VGI by the governments involved, and some projects are done on a short-term basis to accomplish a specific task. Yet, other tasks might also benefit from using VGI as a methodology and way of operation. Some projects also require ongoing engagement and long-term work with volunteers. However, adoption of crowdsourcing by government is a process subject to resource management and organizational change. Adopting VGI is likely to require additional resources in terms of managing the crowdsourcing processes, the data collected and engaging with the communities involved. Interaction with crowdsourcing projects may be terminated by governments for a number of reasons: the VGI champion may be redeployed or leave the organization, there may be a change in policy or resources may not be available to continue the engagement. Governments must consider long-term plans and assess the sustainability of their adoption of crowdsourcing. Lessons from organizations that have now accepted crowdsourcing as a way of doing business (e.g. Scottish Environmental Protection Agency and USGS) can help other bodies understand how to integrate VGI into organizational thinking.

Maintaining public interest.

Public interest and participation need to be maintained through the life of a VGI project. As noted in the previous section, the response from the participants in the activity is frequently linked to the framing, the trust that is given and the aims of the project. For example, researchers involved in iCitizen are concerned about how to convince the public to use mobile phones and applications. The experiences of other projects indicate that solutions are divided between less and more economically developed contexts. In the former, attracting volunteers means offering a small amount of compensation to replace time that could otherwise be used to generate income. In the latter, innovative techniques such as gamification and clear targets can be helpful.

Licensing and other Intellectual Property Rights (IPRs).

Concerns over data ownership and specific licensing agreements are another obstacle to the adoption of VGI in government. Incompatibility in licensing should be considered at the outset of the project. For example, the OSM license requires data to be shared-alike and Google owns all data in Google Map Maker. IPRs are especially important in geographical datasets because most of the value will not come from a single one but from linking and matching it with other datasets. This means that problems with derivation (the source that dictates the coordinates used to locate an object on the map) can emerge and create uncertainty about how the data can be used and under which conditions.

Integrating data collection and use for policy analysis or implementation.
A key concern for public contributors to VGI is how and where their data and contributions are put to use. Often it is unclear if their information has been used at all. It is important that the connection between data collection and eventual use by the government is made clear on a regular basis.

Contact points.
Open and clear lines of two-way communication between government and crowdsourcing communities are vital. Some skepticism around VGI stems from difficulty contacting those involved, compared to when governments enter into a contract with a third-party company or organization. When governments provide a general call for contributions from the public, there is often no way of contacting the leader or director of the crowdsourcing community and indeed such a person may not exist. HOT provides an example of how this can be resolved, as an established organization dedicated to providing VGI services in crisis situations. More generally, there is a need to define ownership of the process and responsibility over its management. The information should be clear so volunteers can easily identify and contact the responsible individual, especially in case of emergency.

Conflict between channels of reporting.
In some projects, channels of reporting can be confusing and conflicting for participants. An example is the relationship between FixMyStreet, which is run by an independent body, and the helpline of the local authority. In other cases, there are multiple channels, which can be important in crisis situations but require management. At the same time, it is clear that different participants will prefer different channels so enforcing the use of a single channel can be counterproductive.

Summary and way forward

This report has reviewed VGI use in government and identified factors of success as well as challenges. Brabham's (2013) suggestions of crowdsourcing best practices are relevant here, such as the need to define the problem clearly, ensure commitment from the organization and know the online community. This report identifies several factors specific to VGI projects in government. To summarize, the factors likely to influence the use of VGI relate to the following:

- individuals,
- organizations,
- business models,
- echnical problems and
- conceptual issues.

At the **individual level**, champions and change leaders in public sector organizations are critical. In the USA and France there are examples of open data enthusiasts at local government level who have led to significant changes in the way organizations use VGI. Such champions were – and will continue to be – critical in the adoption of geographic information technologies in government. On the contrary, individuals with worldviews opposed to public participation in data collection and analysis can block or hinder the integration of VGI into government. Attempts to understand and alleviate the concerns of such individuals can assist in the adoption of VGI. However, these should not focus solely on issues of data quality or motivation, but also address concerns about the status and need for professional expertise in an environment where VGI is used.

The **organizational level** is also important. In contexts where information is mostly provided by external sources (e.g. private sector) there is a higher potential for replacing this information with VGI than if information is maintained internally when the use of VGI might be seen as a threat. This is despite evidence demonstrating that successful VGI augments, rather than replaces, organizational activities. Further organizational issues can be procedural, such as existing legislation and obligations for service delivery, or structural, such as responsibilities for data collection and use. Specific regulations are emerging to support crowdsourcing and citizen science in government (e.g. the US American Innovation and Competitiveness Act of 2016, which explicitly promotes these areas to US federal agencies) and these can assist in convincing organizations to adopt them in their operations.

Next are issues that relate to **business models.** Organizations responsible for data collection, maintenance and dissemination have an incentive to use VGI to reduce costs, although additional costs might be involved in communicating with the public and maintaining their interest. However, the use of open data and release of highly valuable geographic information is a threat to the financial viability of other organizations responsible for selling data. Private sector organizations are also affected when they have committed to deliver public services based on assumptions that emerging data can be used for profit. Yet, the extensive use of crowdsourcing by private sector organizations demonstrates that issues of data ownership and use are not insurmountable and can be accommodated in a way that satisfies both the participants and the organizations concerned.

Technical problems include the ability to merge existing systems with datasets that have been changed by the public. This requires various skills, from version management to object-level metadata. In some cases, differences in formatting and fundamental data structure, as well as semantic ambiguity, add to the challenges of using VGI fully. In addition, the plurality of tools and channels through which information can reach an organization are significant challenges. It can also be a challenge to introduce a new technology (e.g. a new app or system). Government organizations new to crowdsourcing should therefore use more mature technologies, or team up with NGOs with experience in the area to build their own capacity.

Finally, **conceptual or "worldview" issues** need to be recognized and also interact with the above categories. VGI use requires accepting a higher level of uncertainty, attention to heterogeneity and the need to work closely with diverse groups and communicate with the public. It also requires adjusting some of the concepts of "how things are done" – for example, quality assurance procedures that are suitable for in-house processes are methodologically unsuitable in the crowdsourcing context. This can be challenging to people who are used to working in an isolated and top-down manner. In addition, perceptions of VGI as professionally threatening should be accepted as genuine and reasonable, and need to be addressed as noted above.

To conclude, this report has documented the early and maturing stages of VGI use in government. It has looked across 50 case studies but further research is necessary to explore the factors influencing the success and failure of VGI projects for government use in detail. Some of the problems, such as licensing terms, will require specific effort from both governmental organizations and crowdsourcing communities.

There has been some improvement in practice compared to the 2014 version of this report, but misunderstanding between these two groups remains in terms of time frames, work practices and problem solving.

At the same time, this report has demonstrated that collaboration between government organizations and the public is possible and beneficial to both parties. Recent technological and societal changes mean that opportunities for such collaboration are increasing. However, like any cooperation between established institutions and external groups or individuals, VGI projects require attention and planning. Successful projects are not "happy accidents" but evidence of commitment and investment at individual and organizational levels, which provide a return in the form of information that would otherwise be difficult to obtain. Practitioners can use the lessons identified from case studies across the world in order to further develop this field.

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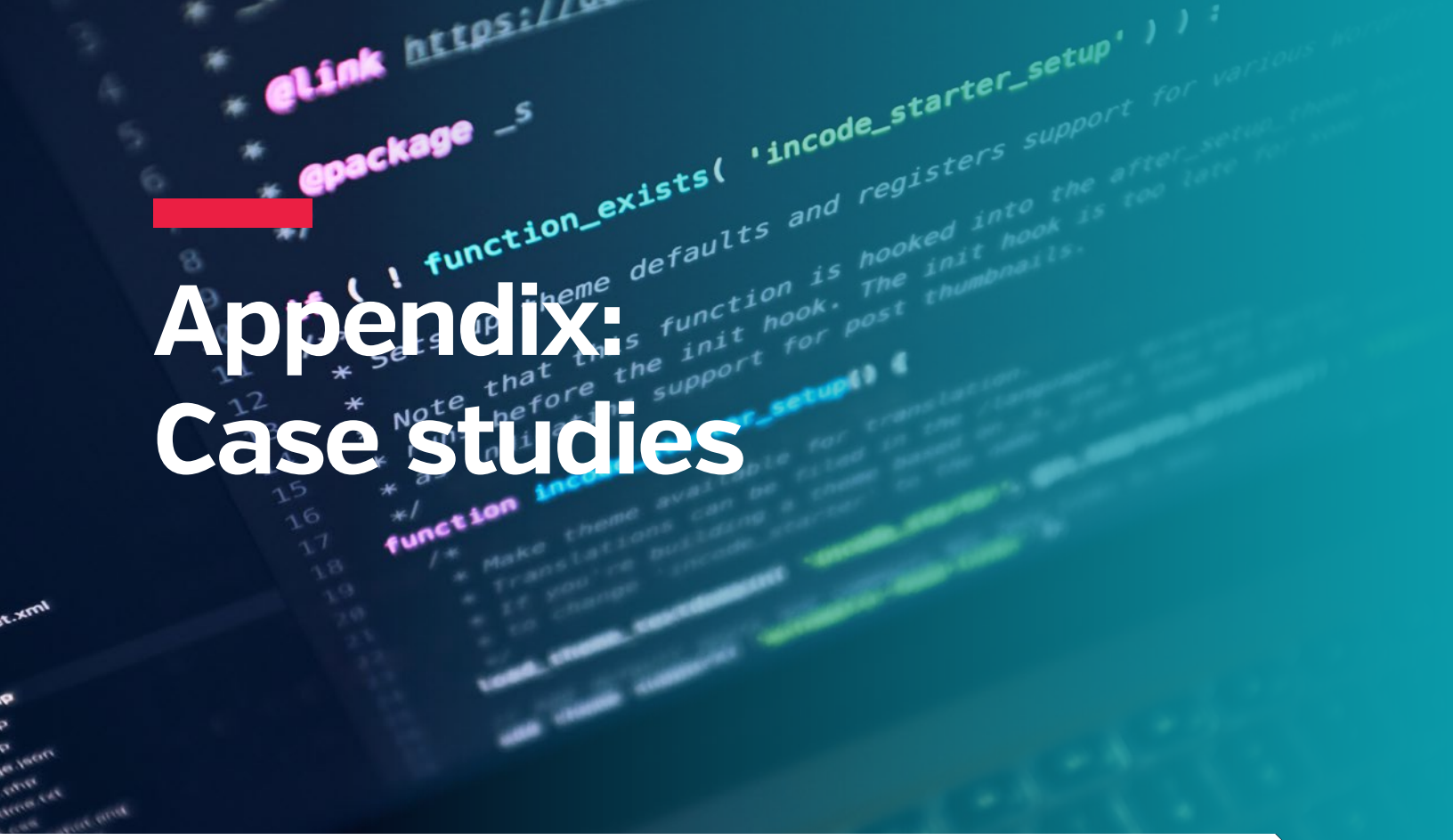
1 The term VGI was established by Michael Goodchild in 2007, in his paper "Citizens as sensors: the world of volunteered geography". The terms crowdsourced geographic information and VGI are often used interchangeably.

2 See Haklay et al. 2014 for the first report

3 The website can be visited at https://crowdgov.wordpress.com/



Appendix: Case studies

This part of the report presents a detailed analysis of the 50 case studies included in the QCA study. The case studies are from the 2014 edition of this report and about 20 new case studies were added. The case study information was compiled in conversation with the experts who ran the projects, from replies to the blog-based questionnaire circulated via social media and mailing lists, or based on research using secondary resources (websites, existing publications, messages on forums, etc.).

Readers may find it helpful to use the quick reference table, which includes the key elements of each case study.

Case studies: structure and overview

Each case study provides an example of the use of VGI by government or by the public, and summarizes the context, positive and negative outcomes, and main lessons. The case studies are presented in full in a later section and are all deliberately short, with the same structure.

First, a summary table provides general information about the case study in the format below. Second, a written summary of the project covers the context, description of the project and discussion of the positive and negative aspects of the collaboration. Finally, each case study closes with bullet points indicating the most important lessons from the project.

Sample case study table title	
Interaction type	The flow of the data (either crowdsourced or authoritative), in one of the following categories: Public → Government, Government → Public → Government, or Public → Government → Public.
Trigger event	A specific event that might have triggered the data sharing (e.g. change in data license, natural disaster, etc.).
Domain	The area in which the datasets have been used. This includes an abstract characterisation of the general area (e.g. generic mapping) as well as information about the specific field (e.g. update of national topographic database).
Organization(s)	The organization(s) that initiated the data sharing process and those that have been actively involved in the whole project.
Actors	Interested parties/stakeholders that have contributed to, or benefited from, the data sharing process in any way.
Datasets	The datasets that have been shared and used by the public or project partners (including new datasets generated).
Process	The process followed to implement the data sharing, data integration and cooperation.
Feedback	The immediate result returned to the initiator of, and/or participants in, the data sharing process, if any.
Goal	The original goal of the project and reason for exploring crowdsourced geographic information.
Side effects	Any other issues or outcomes.
Impact of the project	The impact falls into three categories: local, national and governmental.
Temporal pattern	The longevity and maintenance of the project (i.e. ongoing or one-off initiative).
Funding	The organization which is behind each project and supports it financially.
Contact point	The person who has either provided details about, or been significantly involved in, the case study, when available.

Quick reference

The table below provides summary information on each case study by thematic category.

Project title	Environmental monitoring / citizen science	Natural disaster preparedness	Updating authoritative spatial datasets	Upgrading public sector services
Mosquito Alert project in Spain	Yes	-	-	Yes
StatCan crowdsourcing	-	-	Yes	Yes
Monitoring Insects with Public Participation [MIPP] in Italy	Yes	-	Yes	-
Global Healthsites Mapping Project	-	Yes	-	Yes
North American Bird Phenology Program	Yes	-	Yes	-
Foul & Filthy Rivers, China	Yes	-	-	-
Farma Valley Community Map, Italy	-	-	Yes	-
Community river monitoring volunteer project, Scotland	Yes	Yes	Yes	-
Malawi flood prepardness	-	Yes	-	-
Food insecurity mapping, Bangladesh	Yes	Yes	-	-
Syria Tracker Crisis Map	-	Yes	-	-
iCitizen, South Africa	-	-	-	Yes
Community Mapping for Exposure in Indonesia	-	Yes	-	-
Haiti disaster response	-	Yes	-	-
Mapping of South Sudan	-	-	-	-
Crowdsourcing The National Map, National Map Corps, US	-	-	Yes	-
Crowdsourced flood resilience in Jakarta, Indonesia	-	Yes	-	-
Twitter use in Italian municipalities	-	-	-	Yes
National Biodiversity Data Centre Ireland	Yes	-	Yes	-
Towns Conquer gamification and Instituto Geográfico Nacional toponyms database, Spain	-	-	Yes	-
US National Park Service – Places Project	-	-	-	-

Project title	Environmental monitoring / citizen science	Natural disaster preparedness	Updating authoritative spatial datasets	Upgrading public sector services
USGS's "Did you feel it?"	Yes	Yes	Yes	-
US Census Bureau – Building an OSM community of practice	-	-	Yes	-
New York City open data initiative	-	-	Yes	-
Imagery to the Crowd, State Department Humanitarian Information Unit, US	-	Yes	-	-
Humanitarian OpenStreetMap Team mapping in Ulaanbaatar, Mongoli	-	-	Yes	Yes
Mapping schools and health facilities in Kathmandu Valley, Nepal	-	Yes	Yes	Yes
Informal settlement mapping, Map Kibera, Nairobi, Kenya	-	-	-	-
Skandobs, Scandinavian predator tracking system, Norway and Sweden	Yes	-	-	-
Corine Land Cover 2006 (CLC2006) in OpenStreetMap, France	Yes	-	-	-
FixMyStreet for municipality maintenance information, UK	-	-	-	Yes
FINTAN vernacular placenames project, Ordnance Survey and Maritime and Coastguard Agency, UK			Yes	Yes
Boston StreetBump, US	-	-	-	Yes
California Roadkill Observation System (CROS), US	Yes	-	-	Yes
Crowdsourcing satellite imagery in Somalia	-	Yes	-	-
Portland TriMet, transportation planner, Oregon, US	-	-	-	Yes
The Base Adresse National (BAN) Project	-	-	Yes	Yes
Citizen participation in urban planning (Kirtipur, Nepal)	-	-	-	Yes
Land tenure in Tanzania	-	-	Yes	Yes
Open for Business, UK	-	Yes	-	Yes

Project title	Environmental monitoring / citizen science	Natural disaster preparedness	Updating authoritative spatial datasets	Upgrading public sector services
International Hydrographic Organization's Crowdsourced Bathymetry Database	-	-	Yes	Yes
Disaster Management, Early Warning and Decision Support Capacity Enhancement Project in Indonesia	-	Yes	Yes	Yes
Summer Camp Guide	-	-	-	Yes
Ramani Huria	-	Yes	-	Yes
Natural Resources Canada-OpenStreetMap Synergy	-	-	Yes	Yes
Participatory mapping and decision support tools for disaster risk reduction, the Philippines	-	Yes	-	-
Government open data usage in Lithuania	-	-	Yes	-
Xalapa collaborative transport mapping	-	-	-	Yes
FloodTags	-	Yes	-	-
Open Cities, Sri Lanka	-	Yes	Yes	Yes

1. Mosquito Alert project in Spain	
Interaction type	Public → Government
Trigger event	Concern about the Asian tiger mosquito and subsequently awareness of mosquito impact through the spread of the Zika virus.
Domain	Health
Organization	Mosquito Alert
Actors	CREAF (Centre de Recerca Ecològica i Aplicacions Forestals), ICREA (Institución Catalana de Investigación y Estudios Avanzados) and CEAB-CSIC (Centro de Estudios Avanzados de Blanes), Dipsalut (Organismo de Salud Pública de la Diputació de Girona) and FECYT (Fundación Española para la Ciencia y la Tecnología), Obra Social "la Caixa" and Redbooth
Datasets	New mobile applications for citizen contributions about the locations of mosquito observations, a well-designed website and Google Maps as a basemap.
Process	Six stages: (1) citizens report their observations, (2) experts validate them, (3) spatial and attribute data is stored in an online and dynamic map, (4&5) the research community and public sector view the results and (6) awareness is raised through education.
Feedback	An online and interactive map, scientific publications and educational seminars and workshops.
Goal	Interactive map with spatial and attribute information on mosquitoes, which can be used to raise awareness among citizens, experts, the research and educational community and public sector.
Side effects	-
Impact of the project	National
Temporal pattern	Ongoing
Funding	Dipsalut and FECYT
Contact point	Aitana Oltra (CREAF)

Mosquito Alert project in Spain

Mosquito Alert is a citizen science project launched to fight the tiger and yellow fever mosquito expansions, two invasive species vectors of global diseases like Zika, dengue and chikungunya. The project has six stages:

1. Without special training, citizens are asked to use a new mobile application to (a) report any possible breeding sites, (b) report sightings of tiger or yellow fever mosquitoes, (c) validate photographs from other participants, and (d) consult the map of citizen observations. The mobile application works well both with Android and Apple smartphones. Citizen contributions are crucial as the submitted information may be the key to generating a participatory alert system to improve management of these species and minimize the risk of disease transmission. The submitted photographs will be part of a database used for research, monitoring and control of the tiger and yellow fever mosquitoes.
2. All tiger mosquito findings with photographs and breeding sites in the public area are validated by expert entomologists from Mosquito Alert.
3. Once validated, these observations appear on the map. The dynamic map includes information about the type of mosquito, possible breeding sites and distribution of participants. The interactive map uses Google Maps as a basemap.
4. Mosquito Alert focuses on the development of predictive methods and models that combine citizen data with data from other authoritative sources, such as monitoring or control entities, universities, etc.
5. A toolkit is provided for public sector representatives interested in collaborating with Mosquito Alert. Numerous municipalities are directly connected to the project so the project's tools may be transformed into preventative actions.
6. Periodic education and awareness campaigns to combat mosquito vectors of disease. Mosquito Alert "learning by doing" activities and innovative workshops promote the measures that must be taken in homes to prevent mosquitoes from proliferating.

In terms of strengths, the project relies on smartphone cameras, which are widely available and make data collection straightforward once participants have downloaded the application. Linking to other projects through collaboration with the European Citizen Science Association increased the project's potential reach and expanded it to other locations. The connection to environmental management means that public authorities can deal with the source of the mosquitoes.

The main challenge is the location of the small project team in a research institute, which limits the resources available to grow and extend the project to new locations.

Main lessons:

- Citizens can be given advice on coping with health and environmental problems.
- Projects can be extended to allow for data analysis by researchers, the public sector and schools after data validation.
- Emergent situations, such as growing concern over Zika, can provide the impetus for ongoing processes.
- A straightforward procedure guarantees viability and success.

2. StatCan crowdsourcing	
Interaction type	Government → Public → Government
Trigger event	-
Domain	Urban mapping
Organization	Canada's national statistics agency (Statistics Canada)
Actors	Statistics Canada, OSM local community, municipalities and local people
Datasets	OSM for data editing and open source dashboard for monitoring.
Process	Local people fill gaps in national-level statistics on buildings and their attributes.
Feedback	Updated OSM in Ottawa and Gatineau.
Goal	Updated georeferenced attributes of buildings and valuable information for various Statistics Canada divisions.
Side effects	-
Impact of the project	Governmental
Temporal pattern	Ongoing
Funding	Statistics Canada
Contact point	-

StatCan crowdsourcing

Canada's national statistics agency (Statistics Canada) launched a pilot crowdsourcing project in October 2016 relying on the principle that individual citizens are experts in their local environments. Volunteers are asked to fill gaps in national-level statistics on buildings and their attributes. Taking advantage of their local knowledge, citizens can input the location, physical attributes and other features of buildings such as type of use. This crowdsourced data aims to fill gaps in national datasets and produce valuable information for various Statistics Canada divisions.

Crowdsourced data is collected and edited in OSM facilitated by a customized version of OSM's iD-Editor. This adapted tool allows participants to seamlessly add points of interest and polygons to OSM although the project information underlines that OSM is a free tool that may not reach accessibility expectations. The platform also includes instructions on how to sign up for and use OSM, allowing beginners as well as more experienced users to contribute.

Statistics Canada initiated the two-year pilot project to understand the potential of data crowdsourcing for statistical purposes. To promote the project, meetings and conference calls with people from the local (Canada/Ottawa-Gatineau) OSM community took place before the project start. A webpage and communications campaign were launched in September 2016 to encourage citizens of the cities of Ottawa and Gatineau to participate. More than 200 people signed up for updates on the project within the first month.

The project is monitored using an open source dashboard developed by Statistics Canada, which records the number of buildings mapped, the number of users and the average number of tags contributed for each city. It also shows the proportion of buildings by type and the number of missing address fields.

Statistics Canada is interested in understanding how a national statistical office can mobilize contributors and existing technologies. They also hope the project will teach them about the possibilities and limitations of crowdsourcing. For the time being, traditional surveying will continue but the project will help assess the potential of supplementing it with crowdsourced data.

In the second year of the pilot, Statistics Canada intends to develop a mobile app that will allow contributors to map on the go. Outreach will be maintained and quality assessments will be conducted as more data are collected.

Main lessons:

- Crowdsourced projects of this kind are based on the principle that individual citizens are experts in their local environments.
- Crowdsourced surveying can fill gaps in traditional data collection.
- Open source dashboards can be used to monitor crowdsourcing projects.
- Stakeholders need to dedicate time to understanding how projects work and how they can benefit.

3. Monitoring Insects with Public Participation (MIPP) in Italy	
Interaction type	Government → Public → Government
Trigger event	-
Domain	Environmental monitoring
Organization	National Centre Forest Biodiversity
Actors	National Centre Forest Biodiversity, State Forestry Corps, Ministry for the Environment, Land and Sea, Lombardy Region, Sapienza University of Rome, Roma Tre University, Agricultural Research Council (CRA)
Datasets	Occurrence data of nine species listed in the EC Habitats Directive.
Process	Citizens upload spatial attribute data and pictures of insects via the web or an app. After validation by specialists, data are saved on the project map and in the government database on protected species.
Feedback	Record on map.
Goal	Increase knowledge on the distribution of species.
Side effects	-
Impact of the project	National
Temporal pattern	Ongoing
Funding	European Commission LIFE Programme
Contact point	Alessandro Campanaro

Monitoring Insects with Public Participation (MIPP) in Italy

The Monitoring Insects with Public Participation (MIPP) citizen science program is part of a project to develop standard, national-level monitoring protocols for the conservation of insects protected under the EC Habitats Directive. In many European countries the protocols are standardized through national guidelines but this has not been done in Italy.

MIPP is a State Forestry Service project co-funded by the European Commission under the LIFE Programme and conducted with a range of partners (see summary table). It operates mainly in five areas managed by the National Forestry Service: the Tarvisio Forest, the Natural Reserve of Bosco Fontana, the Casentino Forests, the Castle of Sangro and the Natural Reserve Mesola Wood.

The main objective of MIPP is to develop and test methods for monitoring five beetle species listed in Annexes II and IV of the Habitats Directive. MIPP tests methods based on direct observations, genetic analyses and trapping. A second objective is the collection of fauna data gathered from citizens via the project website or smartphone application. From 2014 to 2016, over 2,300 records were collected and validated by specialists, with nearly 1,700 (73 percent) confirmed. Step-by-step instructions are given on the project website, advising contributors how to send reports, complete the form, update the map with spatial observations and submit attribute data about insects and the place of sighting. Participants can also upload a photograph of the insect and provide other relevant information. Technical support days, seminars and workshops support and disseminate the project.

This project has increased knowledge on the distribution of protected species by 20-30 percent. Citizens have also gained awareness of forest biodiversity, Natura 2000 guidelines, beetle species and monitoring. However, according to the project coordinators, only some sections of society have participated (e.g. nature photographers, park rangers, hikers) and participation will be analyzed by an ongoing sociological study. Funding is currently guaranteed but may not be provided by the Italian government when the EC funding period ends.

Main lessons:

- EC funding can support citizen science projects.
- Various channels of training encourage participation.
- Validation of submitted data may improve accuracy and quality. A team of coordinators is required for quick and reliable evaluation.
- Only certain sections of society may become involved and more social study is required to understand this.

4. Global Healthsites Mapping Project	
Interaction type	Public → Government → Public
Trigger event	Ebola epidemic in West Africa (2013-2016), among other issues.
Domain	Health
Organization	Global Healthsites Mapping Project
Actors	Rwandan Ministry of Health, Tanzanian Ministry of Health, International Committee of the Red Cross, World Health Organization, Health Informatics Society of Sri Lanka, UNICEF, OSM, British Red Cross, United States Agency for International Development (USAID)
Datasets	Imported from OSM and other trusted providers of geolocated health data and information. Produced a geolocated health care facility dataset with a limited set of attributes.
Process	Health facility data imported from OSM and exposed to interested parties with an invitation to improve the accuracy of the data. This curated data is then shared openly as Shapefiles and an open API (Application Programing Interface). The process will complete the data lifecycle and return enriched data back to OSM. The public can also edit the health facility data directly.
Feedback	Participants can log on and edit information about health facilities. The Global Healthsites Mapping Project will make the data accessible over the internet through an API and other formats such as GeoJSON, Shapefiles, KML, CSV.
Goal	Long-term curation and validation of global health care location data – essentially an open data commons of health facility data.
Side effects	Intended future import of updated health facility information back into OSM. Envisaged wider reuse of health facility data and information for applications and citizen use.
Impact of the project	Governmental
Temporal pattern	Ongoing
Funding	Intention between the healthsites.io platform and partners to seek out ways to sustain (in terms of financial, infrastructural and human resources) its continued development and improvement.
Contact point	Mark Herringer

Global Healthsites Mapping Project

The mission of Global Healthsites Mapping Project is to help supply governments, NGOs and the private sector with accurate and up-to-date health facility information. The project is in a pilot phase and is inviting governments, NGOs and individuals to share data and establish an open data commons of health facilities in the OpenStreetMap project.

The incentive and driver for this project was, among other emergencies, the response to the Ebola outbreak in West Africa. This region has low resources and a great need for infrastructure support. Exposure to primary health care work and a goal of sharing this knowledge and insight in an open development context initiated the project. The Ebola response then presented a real need for accurate health facility data.

The dataset produced is a geolocated health care facility dataset with a limited set of attributes focused on facility type, location and essential services available. Data is also imported directly from OpenStreetMap and other trusted provides of geolocated health data and information. The data is exposed to interested parties with an invitation to improve its accuracy.

There are a number of positive aspects to this case study. The curated data is then shared openly under the Open Database License (ODbL) through downloadable Shapefiles and an open API. The process is working towards completing the data lifecycle and returning enriched data back to OpenStreetMap. OpenStreetMap is seen as the baseline repository for this data. Citizens can easily edit the data in the Healthsites databases by using their social media identification for authentication. As an open source project, all data is published as open data. The public are continually invited to engage in an Agile development process.

There are some downsides to the project. Project communications have been slow with some project partners. At the time of writing, June 2017, the project has not yet deployed operationally. Operational deployment is essential as it will assist in driving the feedback process. Organizations are currently cautious about sharing healthsite data as they are concerned with the liability and quality of VGI.

There is hesitancy to directly associate with a Healthsite update. This is a fundamental requirement of open data. Unfortunately there is a lack of consolidated learning from end users and to date there is no operational use case and working agreement with end users in an organized innovation process that generates and integrates evidence to guide the project and define the social business model. The underlying assumption is that Healthsites will improve health outcomes through the publication of accurate and up-to-date open health facility data. Until this assumption is tested it is difficult to quantify the value of accurate health facility data and make a business case that is aligned with the achievement of Sustainable Development Goals.

Main lessons:

- Triggers like Ebola create a real need for accurate health facility data in areas with low resources and limited infrastructure.
- Multi-partner projects can benefit from the contribution of various actors, from launching a pilot project to active involvement in making the project work.
- Citizens can edit data by using social media identification for authentication. Thus, registration process may be bypassed.
- Organizations remain cautious about sharing data as they are concerned about the liability and quality of VGI.
- This project has not yet deployed operationally which means that its side effects are still unknown.

5. North American Bird Phenology Program	
Interaction type	Government → Public → Government
Trigger event	Global climate change
Domain	Environmental monitoring
Organization	USGS
Actors	Federal government, academics, non-profits, individuals
Datasets	Transcription of historical data cards regarding when birds arrived.
Process	Historic cards from around North America (1880-1970) are scanned (1.1 million or so), a computer program allows online volunteers to transcribe data into the database, computer algorithms are used to compare multiple transcriptions to create validated records, volunteers and USGS personnel work on validating locations not in gazetteers, observer names and bird names.
Feedback	Transcribed records.
Goal	Volunteers enter data and help run the system.
Side effects	-
Impact of the project	Governmental
Temporal pattern	One-off
Funding	US Federal government
Contact point	Sam Droege, US Geological Survey

North American Bird Phenology Program

The North American Bird Phenology Program (BPP), part of the USA-National Phenology Network, flourished from 1880 until 1970 when lack of funding led to its closure. The project was coordinated by the federal government and sponsored by the American Ornithologists' Union. The aim of the project was to record information on first arrival dates, maximum abundance and departure dates of migratory birds across North America using a network of volunteer observers. It exists now as a historic collection of six million migration card observations, illuminating almost a century of migration patterns and population status of birds.

The historic records permit a detailed study of geographic and temporal shifts in arrivals and departures . The government has housed the historic records and now an innovative project has launched to curate the data and make them publicly available. The records are being scanned and placed on a website, where volunteers worldwide transcribe the records and add them to a public database. In other words, the scope of the current project is to update authoritative spatial datasets for environmental monitoring through citizen science. Citizens located in the Baltimore-Washington area may work as office volunteers while other participants may digitize data online. Training is provided with detailed information via the website and email assistance. A series of maps indicating migratory birds across North America over the decades has been designed with the material digitized by the volunteers.

The project has recorded millions of transcriptions by often extremely dedicated volunteers over many years. Most are high quality transcriptions with relatively few incorrectly entered pieces of information. Recruitment of dedicated project volunteers was among this projects main factors of success.

However, this project has been severely affected by a lack of resources. First, due to a lack of support it often took years to correct problems with the algorithms that run the program. Second, lack of funding has led to the loss of a dedicated coordinator.

While cumbersome, the program has successfully entered hundreds of thousands of verified records. Additionally, while the costs may have been such that it would have been cheaper to employ professional data entry personnel, the data would not have been added to the database without the novelty of the data entry program. The program still has volunteers transcribing data and a website/data entry portal at: https://www.pwrc.usgs.gov/bpp/.

Main lessons:

- Citizen science has existed since at least 1880 and may be a viable solution for a greater participation and wider data collection.
- Dedicated volunteers can contribute high quality transcriptions of records in a reliable way.
- Lack of resources can be a significant obstacle to project viability.

6. Foul & Filthy Rivers, China	
Interaction type	Public → Government → Public
Trigger event	China's Water Ten Action Plan (April 2015)
Domain	Environmental planning
Organization	Institute of Public & Environmental Affairs (IPE)
Actors	People's Republic of China (PRC) Ministry of Environmental Protection (MEP) and Ministry of Housing and Urban-Rural Development (MoHURD), Institute of Public & Environmental Affairs (IPE), local NGOs in the Green Choice Alliance (GCA) and general public
Datasets	Interactive live map of the locations of "foul and filthy rivers".
Process	Through a series of meetings and communications, IPE officially launched a cooperative relationship with MEP and MoHURD to link IPE's Blue Map app directly to the government reporting platforms that had initially been established via WeChat. Following integration, reports raised via the Blue Map app are directly sent to government ministries, whose responses are also sent directly to the app for display.
Feedback	Interactive real-time map of polluted urban water bodies across China's cities, communication records of government responses to public reports, live tracking of government's clean-up efforts.
Goal	1. Enable the public to report polluted bodies of water not initially on government lists designated for clean-up. 2. Allow the public to effectively supervise government efforts to rectify polluted waters.
Side effects	Initial reporting mechanism led to the realization that many polluted waters designated for clean-up were not on track to meet government deadlines. Therefore, while the initial module in the app only included a function for the public to report polluted rivers not already designated for clean-up, a second function was incorporated for the public to upload "supervision" reports about on-site progress (or lack thereof).
Impact of the project	National
Temporal pattern	Ongoing
Funding	The Blue Map App (蔚蓝地图) is supported by SEE Foundation and Alibaba Foundation.
Contact point	Kate Logan

Foul & Filthy Rivers, China

To address China's severe water pollution challenges, the Chinese government issued its Water Pollution Prevention & Control Action Plan in April 2015, a national plan to improve the quality of China's rivers, lakes, aquifers and other bodies of water. Part of the Water Ten action plan, as it is commonly called, is an initiative called *hei chou he*, which translates as "black and smelly" or "foul and filthy" rivers. The initiative aims to reduce the percentage of waters in urban areas designated as "foul and filthy" to less than 10 percent of the total by 2020. Those remaining must be cleaned up completely by 2030. The Ministry of Environmental Protection (MEP) and Ministry of Housing and Urban-Rural Development (MoHURD) launched the initiative just after the 2016 Chinese New Year holiday. In addition, the two ministries created a public reporting mechanism via popular Chinese social media app WeChat, where citizens can report polluted bodies of water to be included in the clean-up list and receive a guaranteed response from the government within seven working days.

Following a series of communications with MEP and MoHURD, IPE's integrated Blue Map app created an interactive, live map module and reporting mechanism, which links directly to the two ministries' back-end system. The module allows users located within 10 meters of a body of water to upload a photograph and complete a report, which will then be submitted directly to the two government bureaus. The photographs and text of the report will also appear on an interactive map on the app, and government responses are posted directly to the app as part of the report.

Building on its initial work to report polluted waters, IPE adjusted the module on the app to add a second option to report an observation. This option allows IPE to better collaborate with NGO partners to supervise on-the-ground progress toward clean-up, with an emphasis on if the waters are on track to meet their government-set deadlines, many of which are as early as 2017 and 2018. For those waters already deemed clean, local partners may assess if the judgment appears to be accurate and may upload photographs to support their observation. As the foul and filthy rivers policy is ongoing, the app's platform will continue to collect, collate and display reports and to help support the government in verifying that their clean-up work is satisfactory to the public.

The successes of the foul and filthy rivers reporting module are largely a result of two factors: 1) transparency (the platform is completely public so anyone can view the reports, photographs and responses); and 2) interactive channels for public participation (any user can complete a report as part of an official and responsive government mechanism, which allows the government to tailor its clean-up efforts to satisfy the public).

One of the shortcomings of the case study is the difference in government responsiveness across regions and limitations of public power to push for greater responsiveness. Another limitation is achieving the sustained involvement of the public.

Main lessons:

- All reports made via an app and government responses can be made publicly accessible.
- Platforms can be updated in real time with new information about reports and observations.
- Platforms like this enable the public to directly interact with the government, providing an official channel for citizens to raise concerns.
- Users need to be logged into an account before being able to upload a report.

7. Farma Valley Community Map, Italy	
Interaction type	Public → Government
Trigger event	Location-based game contest.
Domain	Heritage preservation and land planning.
Organization	Attivarti.org
Actors	Attivart.org (NGO) and citizens of Torniella, Piloni and Scalvaia, small hamlets in southern Tuscany
Datasets	1:10000 basemaps (authoritative), placenames (crowdsourced).
Process	Participatory methodology (meetings, interviews, surveys) to collect placenames missing from current official basemaps but relevant to local communities.
Feedback	Increased international and national visibility, extension of open data originated by Attivarti.org and its network of partners, improved knowledge about the Farma Valley.
Goal	Improve visibility of the Farma Valley, empower citizens via open data.
Side effects	Interest of other communities in Italy to initiate the same process (preliminary meetings have taken place).
Impact of the project	Local
Temporal pattern	Ongoing
Funding	Community-based funding (citizen-owned) but searching for funding from other sources.
Contact point	Andrea Giacomelli (info@pibinko.org)

Farma Valley Community Map, Italy

The Farma Valley, located in southern Tuscany about 100km south of Florence, is small (120 km^2) and sparsely populated (less than 500 residents, mostly concentrated in three hamlets). The valley used to be crossed by one of the roads between the coast and Siena. However, with the opening of a new highway in 1974, the hamlets have been progressively cut off from the main flows of traffic (including tourism). This has reinforced the valley's reputation as a natural paradise but has not simplified the life of local communities. The arrival of an expert in environmental geomatics has led to the development of innovative projects for the protection and promotion of the area.

This project started with the participation of the local communities, coordinated by Attivarti.org, around a contest concerning location-based games for environmental education, launched by the EU-funded INVOLEN project. The scope of the project was based on an initial effort to collect points of interest and trails known to the residents and to expose a significant number of toponyms missing from the current regional government basemaps in the area of Torniella. To extend the coverage of the community-based dataset, subsequent efforts were made to interview older residents of the other hamlets.

Contributions from the public are represented by the Web Map Service (WMS) provided by Regione Toscana with the 1:10000-scale basemaps.

Three key positive factors of the project have been recorded to date:

1. The project has created a base to document heritage from the three hamlets using an open data paradigm;
2. The dissemination of the dataset has created an additional layer of interest about the valley from tourists, researchers and professionals (especially in the tourism and environmental education sectors);
3. The project represents an effective case of a value chain starting from research efforts (related to the INVOLEN project participation) and resulting in the promotion of the local economy.

The whole process exhibits appropriate project management practices.

There are few negatives to date. With the project developing during the coming months, and more information being collected, work is needed on consolidating the relationship between the project and its institutional stakeholders. Currently, the project is in an active phase, which may conclude towards the end of 2017.

This project could be replicated in other contexts as the technology is fairly simple, but the key element is the mix of actors, linking a scientific and technologic subject to a strongly felt driver (the need to minimize the loss of local knowledge).

Main lessons:

- VGI can attract the interest of tourists, researchers and professionals.
- Maintaining public interest is key, and a well-known challenge in other VGI contexts.
- Drawbacks of a project may not be clear until it concludes.

8. Community river monitoring volunteer project, Scotland	
Interaction type	Public → Government → Public
Trigger event	The Conservation Volunteers (TCV) Scotland and Clackmannanshire Council wanted to improve volunteer understanding of the interactions between sediment movement, chokes and blockages over time in the context of flood risk management, and investigate how sediments in highly dynamic burns (small streams) may move over time.
Domain	Flood preparedness
Organization	Community river monitoring volunteer project.
Actors	TCV Scotland, Clackmannanshire Council, the Scottish government and citizen scientists
Datasets	Citizen contribution to Clackmannanshire Council's database. The sediment monitoring augments Clackmannanshire Council's existing datasets.
Process	Citizens use the Monitoring Sediment Movement and Blockages recording sheet, smartphones and cameras to report their observations and the TCV team and local authority comes back to them via email/phone call to inform them about the outcomes.
Feedback	Update of governmental datasets with crowdsourced observations.
Goal	Raise awareness of flood risk in the council area and get local communities involved in recording useful information about some of the Hillfoot Burns.
Side effects	The data source has fed into Clackmannanshire Council's forthcoming Flood Risk Assessment (FRA) options appraisal report for Tillicoultry produced by an external contractor, JBA Consulting.
Impact of the project	Local and national
Temporal pattern	Ongoing
Funding	The Scotland Counts Partnership: Scottish government, Scottish Natural Heritage (SNH), Forestry Commission Scotland (FCS) and Clackmannanshire Council.
Contact point	Amanda Malcolm (TCV) and Stuart Cullen (Clackmannanshire Council)

Community river monitoring volunteer project, Scotland

With support and funding from the Scottish government, TCV Scotland and Clackmannanshire are working in partnership to deliver a citizen science community river monitoring volunteer project. The project's aim is to help raise awareness of flood risk in the council area and get local communities involved in recording useful information about some of the Hillfoot Burns. Through the project, local communities and volunteers are actively recording data and taking photographs to monitor how sediments can move in burns and how this can influence flood management techniques.

In this project Clackmannanshire Council assisted The Conservation Volunteers (TCV) – an environmental NGO – to identify gaps in data linked to flooding and ways to fill these through a citizen science pilot project with volunteers. The main target of the project is to create new datasets for the local authority.

Volunteers map their observations by taking a photograph from the same vantage point each time they are out recording river information. The locations picked by the volunteers and TCV team are noted on their maps as a reference for the photograph locations and for consistency. Contributors are provided with feedback and thanks to indicate that the contribution has been successfully received by TCV Scotland and submitted to Clackmannanshire Council. If a blockage was reported by a contributor and removed by the local authority, the contributor received a follow up email/phone call to confirm that the debris had been cleared from the watercourse.

TCV provide training and support for the volunteers. The project has been very positive, inclusive and well received by the local community, and Clackmannanshire Council has embraced the opportunity to collaborate. The only limitation for some users was the need to access the internet to submit data, where there was a lack of access to smartphones and internet connection, or IT skills.

The final report has been passed to flooding consultants JBA Consulting Ltd., and used in their "Flood Risk Options Appraisal in Tillicoultry" report for Clackmannanshire Council.

Due to its success, the project will continue in 2017, with the TCV team commencing the second phase of the project: Become a Flood Warden Volunteer.

Main lessons:

- The scope of the project and requests to volunteers should be simple, clear and upfront.
- Short introductory meetings can be useful to break down barriers and build confidence in new users.
- Long-term contact is most effective with volunteers – it builds confidence and encourages users to continue recording and monitoring.

9. Malawi flood preparedness	
Interaction type	Government → Public → Government
Trigger event	Natural disaster (flood)
Domain	Disaster preparedness, survey of households.
Organizations	Humanitarian OpenStreetMap Team (HOT), Global Facility for Disaster Reduction and Recovery (GFDRR), the Department of Disaster Management Affairs (DoDMA), Surveys Department
Actors	Surveys Department, Department of Disaster Management Affairs (DoDMA), Housing and Physical Planning, Water Resources, Crops and Land Resource Conservation, and local universities
Datasets	InaSAFE, OSM, Satellite Imagery (Bing & WorldView-2), MASDAP.
Process	Satellite tracing and field survey using GPS.
Feedback	Maps of infrastructure (accessible through Malawi Spatial Data Portal (MASDAP)) and training manual for capacity building and future mapping projects.
Goal	Improved flood preparedness and contingency planning for floods; improved coordination between government and non-government institutions (data sharing).
Side effects	Actors are aware that open source software (OSM, QGIS, InaSAFE) is able to support flood contingency planning in the region.
Impact of the project	Governmental
Temporal pattern	One-off
Funding	GFDRR
Contact point	Severin Menard, Maning Sambale, Emir Hartato & Francis Nkoka

Malawi flood preparedness

In 2014 the Humanitarian OpenStreetMap Team (HOT) was involved in a community mapping and training project with the Malawi Department of Disaster Management Affairs (DoDMA) to prepare for flooding, a severe natural disaster.

From late July to late December 2014, HOT carried out a project in the Lower Shire, the large valley to the south whose districts, Chikwawa and Nsanje, are the most flood-prone areas of the country. The project was funded by the World Bank Global Facility for Disaster Reduction and Recovery (GFDRR), for which Malawi is one of the nine African priority countries. In addition to GFDRR and the Department of Disaster Management Affairs (DoDMA) the project engaged the Surveys Department (in charge of maps and geodata) and students, local people and other relevant government departments also participated.

The main initiatives of the project include an Integrated Flood Risk Management Plan (IFRMP) for the Shire Basin; an open data, Geonode based platform called Malawi Spatial Data Portal (MASDAP); and a specific needs assessment for Nsanje (the Nsanje 2012 Floods Post Disaster Needs Assessment).

To reach its target, HOT used:

1. OSM to trace the collected in-field GPS tracks by adapting its JOSM and Tasking Manager functions;
2. Satellite imagery as a driver for field measurements;
3. InaSAFE, an open tool which produces realistic scenarios for flood preparedness; and
4. MASDAP, Malawi's Spatial Data Portal, which is managed by a core team of administrators from various agencies and is a free and open source geospatial data portal based on GeoNode and Geoserver. Key geospatial data is available in the portal for download by the public.

This case study has three key positive factors. First, there was a follow up of the project due to a flood that critically affected the southern parts of Malawi along the Lower Shire River. The response was instant and the project was amended to serve the specific needs of the situation. Second, interns from the university become a focal point for OSM/QGIS/InaSAFE training. Third, Malawi Spatial Data Portal (MASDAP) now includes open source data (e.g. OSM).

Among the challenges that HOT had to cope with is that infrastructure development was required to support the mapping efforts as internet connection was limited, especially in remote and vulnerable areas. Mobile data was also expensive, limiting its use for collection. Further, capacity building had to include computer basics and some participants struggled to keep up with the training materials. However, countries with limited telecommunication infrastructures, such as Malawi, still have the potential to adapt crowdsourcing/VGI for geospatial data acquisition if actors support one another. The HOT team strongly believed that this project was an incentive for local people to start mapping.

Main lessons:

- A well-organized plan including funding and NGO expertise can result in a successful outcome; in this case funding from the GFDRR and technical support from HOT worked well.
- Successful programs can build on accumulated experience from other projects (see also cases 13 & 17) and to adapted to the local context.
- Limited resources in developing countries may affect participation and project progress.

10. Food insecurity mapping, Bangladesh	
Interaction type	Government → Public → Government
Trigger event	-
Domain	Mapping the Khulna District in Bangladesh as a part of an agricultural program.
Organization	Mapping for Resilience
Actors	USAID, Geo Center, Khulna University, US students, YouthMappers, local people
Datasets	High-resolution satellite imagery, GPS tracks and OSM.
Process	Tracing on high-resolution satellite images, collection of spatial and attribute data and importing all data in OSM.
Feedback	OSM indicating the transportation network and the water bodies in the vulnerable area of Khulna.
Goal	Map the unmapped Khulna district and improve land management and agricultural production.
Side effects	-
Impact of the project	Local
Temporal pattern	One-off
Funding	USAID
Contact point	-

Food insecurity mapping, Bangladesh

There are various crowdsourced projects currently running in Bangladesh to support different aspects of daily life. This project is among those completed, funded by the US Agency for International Development (USAID) and supported by YouthMappers, students of Khulda University and local people. The project is a part of the "Feed the Future" agricultural program run by USAID and its main target was to map the water bodies, human-made water catchments and the transportation network. USAID (2017) is interested in Bangladesh because itg "is one of the most densely populated and climate change-vulnerable countries in the world".

The project ran in Khulna district and its aim was to map the area and improve land management and agricultural production. Mapping was focused on linear and area features such as rivers, ditches, ponds, buildings and the road network. Four categories were used for each of pathway line features and water features (both area and lines).

Training of students and local people was based on workshops and extra tips were given on the project homepage. Editing of tracks was done in OSM and made available to the public. Once the basemap was finished using satellite imagery, the students visited the area of interest to collect attribute and spatial information such as the locations of bodies of water. USAID aims to use this project to better understand who has access to enough nutritious food to lead healthy lives.

Mapping proved difficult due to the poor quality of existing satellite imagery, the complex waterway system in rural areas, the dense population in urban areas and the monsoon seasons that alter the terrain and therefore the satellite images. YouthMappers underline that the waterway system is further complicated by human constructions in every private yard and the irrigation ditches can be easily misclassified as roads. To overcome these challenges, custom imagery from the Image Geo Center was used alongside Google Maps. Satellite imagery used was taken during the dry season. Also, local people contributed their knowledge.

This project ran under the Mapping for Resilience program established by Geo Center – a branch of USAID that offers technical assistance – and supported students in the US and Khulna University to jointly work and map Khulna district through "mapathons". It also provided high-resolution satellite imagery for the creation of the basemap, which may be shared in near-real-time on the OSM platform. This workflow and the philosophy behind it have been adopted in various projects with success.

Main lessons:

- Developed countries such as the US may fund crowdsourcing projects through their aid budgets to solve a problem such as malnutrition.
- Climate may be a great obstacle in satellite imagery and should be taken into consideration when choosing data collection periods.
- Government ethical policies may affect a project's public outreach.
- Local software companies may cultivate attitudes towards open source software.

11. Syria Tracker Crisis Map	
Interaction type	Public → Government
Trigger event	-
Domain	Humanitarian and disaster mapping.
Organization	Syria Tracker (ST), part of Humanitarian Tracker
Actors	US activists, Ushahidi, numerous human rights organizations and local people
Datasets	Google Maps in HealthMap platform.
Process	Hybrid model in near-time data collection and manipulation by a small team of volunteers.
Feedback	A continually updated list of eyewitness reports from Syria, often accompanied by media links. Aggregate reports including analysis and visualizations of deaths and atrocities in Syria. A stream of content-filtered media from news, social media (Twitter and Facebook) and official sources.
Goal	Preservation of the name and location of every victim to build memory of the disaster.
Side effects	-
Impact of the project	Local with potential governmental
Temporal pattern	Ongoing
Funding	-
Contact point	-

Syria Tracker Crisis Map

Syria Tracker Crisis Map was first started in 2011 by US volunteers located in the area when the civil uprising began. The project is still active six years later according to the online reports and mainstream news feed, in order to document human rights violations and fatalities as a result of the civil war. Due to its nature and severity, the project has attracted the attention of volunteers who have submitted over 6500 reports anonymously between April 2011 and May 2017.

The approach is based on a hybrid model where data is collected either through automated or crowdsourced methods. The automated data is collected from English online media resources such as online news websites and blogs. As the Syria Tracker (ST) team underlines, their data mining platform, "draws from a broad range of sources to reduce reporting biases". (Irevolution, 2012). The crowdsourced technique is based on participation by citizens who can submit eyewitness reports and share information via a webform, email, Twitter, Facebook, YouTube and voicemail. To protect the volunteers and encourage participation, detailed security precaution information is given on an instruction page alongside a practical guide.

Syria Tracker, a project of Humanitarian Tracker, is powered by Ushahidi's cloud-based platform, Crowdmap. To cope with data mining, the HealthMap platform has been modified to serve this project's needs. HealthMap platform uses Google Maps as basemap. Data manipulation is undertaken by volunteers who receive the crowdsourced reports and then translate, georeference, code and verify them to make them public. The reports are also filtered and duplications resulting form the hybrid approach are removed. According to Irevolutions (2012), ST and their volunteers have been able to verify almost 90 percent of the documented deaths mapped on their platform thanks to video and/or photographic evidence. Moreover, the turn-around time for a report to be mapped on Syria Tracker is between 1-3 days. The ST team collaborates with various organizations to reach its target, such as Women under Siege and The Standby Task Force.

Among its main benefits, the project has shown continuity and progression. To meet its goal and record everything it uses multiple channels. To avoid fake news, crowdsourced reporting is cross checked. It is clear that what was at first a temporary need has been transformed into an ongoing process and the project is designed to meet this challenge.

However, it is still unclear how this record will be used in practice, and this is the main challenge for the project. The instigators of the project aimed for the data to be used by future governments to deliver justice for victims of the crimes committed. Syria Tracker's ultimate goal is not simply to record plain numbers but preserve the name and location of every victim so that these crimes will not be forgotten. The material from the Libya crisis mapping project in 2011 was only recently received for further investigation by the International Criminal Court (ICC) and Amnesty International (AI).

Main lessons:

- A hybrid model where data is collected using both automated and crowdsourced methods work well.
- A disaster response project may be an ongoing effort and not a one-off event when circumstances demand.
- Crowdsourced maps in conflict areas are necessary to ensure anonymity for users.
- Social media offers near-real-time information for data collection so that the map can always be up to date.

12. iCitizen, South Africa	
Interaction type	Public → Government
Trigger event	-
Domain	Generic mapping with focus on local infrastructure issues.
Organization	University of Witwatersrand, LINK Centre
Actors	LINK Centre
Datasets	Multiple datasets per service delivery issue to be tracked.
Process	Collection of data points via mobile phones. Adoption of different ways of geotagging photographs in real time or via SMS or/and email.
Feedback	Generic and purpose-built maps for disaster preparedness.
Goal	Reporting and solving fundamental problems with basic infrastructure and services.
Side effects	-
Impact of the project	Local
Temporal pattern	One-off
Funding	-
Contact point	Dr Kiru Pillay, University of the Witwatersrand

iCitizen, South Africa

In recent years, South Africa has seen a surge in political protest against slow service delivery. While the United Nations Human Development Index considers South Africa to be a middle-income country, there is a large disparity in income distribution across the population. Social unrest is an obvious consequence of poverty, high levels of unemployment and service delivery backlogs.

In the context of these issues a new initiative was launched in 2014 to improve the daily life of citizens by collecting crowdsourced reports of service issues and passing them to the relevant authorities for resolution. The iCitizen project aimed to give members of the public the ability to report on fundamental problems with basic infrastructure and services. The researchers involved in the project intended to contact local municipalities to discuss the extent to which this project could be embedded in current initiatives around citizen monitoring and evaluation. The main aim of the project was to give citizens an active voice. A secondary research objective was to understand and identify the role of mobile phones in citizen-led monitoring and evaluation.

Members of the public would be able to report issues by forwarding geotagged photographs, sending in locations via SMS or reporting issues via email. The first iteration of iCitizen was built on the Drupal open source content management system (CMS). As an enterprise CMS, it provided a lot of services out of the box, including membership management, image upload, taxonomy (category) management, user commenting, thorough user permissions, field APIs (application programing interfaces), views templating and reporting and HTML5 theming capability. Researchers were able to extend the core functionality to include mapping enabled through geolocation, leaflet maps (using OpenStreetMap as the Map Tile server) and a voting API allowing users to verify incidents.

The designers of the application aimed to extract boundary data for South African provinces, districts and local municipalities and expose these on the online map using GeoJSON data. This would automate the process of calculating the jurisdiction of any reported incidents. A live reporting engine and online social tool would also allow for two-way communication between the web server (and its user base) and local municipalities and civil societies.

The main difficulty related to the acceptance of the project. One university found validity in the concept but was unable to commit resources for the development of the application. Going forward, two difficulties were envisaged. The first was acceptance of the validity of the generated datasets by local municipalities. The second was acceptance of the use of mobile phone and applications by the public as an effective tool for voicing service delivery concerns. Even though the penetration rate of mobile phones is fast approaching 100 percent of the adult population in South Africa, the use of mobile applications and GIS-mapping tools of this nature is largely untested.

The project has not been updated since it was documented in 2014.

Main lessons:

- Projects can be used for a variety of tasks at local level, not just that for which they were designed.
- Using a range of software, programing languages and platforms can broaden a project's horizons.
- VGI applications face financial issues due to their technological nature and the resources of the organizations involved.
- Concerns from agencies about the quality of generated datasets and improving public adoption of mobile applications are common challenges.

13. Community Mapping for Exposure in Indonesia	
Interaction Type	Government → Public → Government
Trigger event	-
Domain	A priori disaster response.
Organization	Community Mapping for Exposure in Indonesia
Actors	Indonesian Disaster Management Agency (BNPB), Disaster Management Innovation (DMInnovation or DMI), Humanitarian OpenStreetMap Team (HOT), The Australian Community Development and Civil Society Strengthening Scheme (ACCESS), GFDRR, Pacific Disaster Center (PDC)
Datasets	Satellite imagery, GPS tracks and attribute data.
Process Collecting	Spatial and attribute data and tracing in OSM platform.
Feedback	• OpenStreetMap layer showing an up-to-date basemap of vulnerable areas. • Thematic maps showing damage in case of various physical disasters. • A standardised training curriculum for capacity building purposes.
Goal	Reduction of vulnerability to natural disasters.
Side effects	Deemed a successful example of disaster relief preparedness that could be applied in other developing countries.
Impact of the project	National & with affect to governmental body
Temporal pattern	Ongoing
Funding	AusAID & BNPB
Contact point	Kate Chapman, HOT, (Phase I and II) Yantisa Akhadi, HOT, (Phase III and IV)

Community Mapping for Exposure in Indonesia

An example of an a priori disaster response, this Indonesian mapping project began in early 2011 and at the time of writing is still active. The main idea behind the project was to use OSM to collect previously unavailable data about buildings and their structure in both urban and agricultural environments and to use appropriate models to calculate likely damage in case of physical disaster. The combination of the impact models and the use of realistic data led to the development of open source risk modeling software (InaSAFE), showing the affected people, infrastructure, and damage if disaster were to hit a specific area.

The pilot phase (early 2011-2012) consisted of workshops offering training on the project and building construction as well as data collection in urban and rural areas. The approach between rural and urban areas was slightly different, although the result was similar. The original data was derived from paper maps, which were edited by local people; satellite imagery, depending on availability; and GPS tracks. Data was edited using JOSM and Potlach2 web editor and then used in QGIS. Urban areas were mapped by students who took part in a mapping competition. Rural areas were mapped with ACCESS contributors and local people.

In terms of technical support, the project was not only supported by HOT and OSM but also by open source software such as QGIS. The main innovation in data collection was the private datastore, which offered a unique ID for each object. The final output has also been a success in enabling local government to visualize where people are most in danger by combining local wisdom with scientific knowledge to produce realistic scenarios for numerous different physical disasters.

The main aspect of concern is the quality of the results, which showed great variation. Other minor deficiencies were also noticed, such as a failure to maintain constant mapping volunteers and the use of time-consuming technical methods in a few cases (e.g. Excel spreadsheets in data collection or manual methods of data manipulation).

In the second phase, which focused on scenario development for contingency planning (August 2012 – December 2013), the main aim was to use OSM data to fill gaps and QGIS and InaSAFE for spatial analysis under a curriculum program which comprise a series of training programs: beginner, intermediate and training of trainers (ToT).

Based on recommendations from previous phases, HOT (in coordination with AIFDR) proposed strategies to further expand the use of InaSAFE and OSM in Indonesia. In this phase, the focus turned to supporting the Expansion of InaSAFE and OpenStreetMap in Indonesia (December 2013 – August 2016). The proposed activities focused on harmonizing training materials with the needs of disaster management agencies while keeping them up to date with the software version. HOT continues to support local disaster management agencies in multiple provinces in the use of OSM, QGIS and InaSAFE for contingency planning development. Additional training materials on data validation have been developed to improve OSM data quality in Indonesia.

This phase introduced and promoted the use of mobile data collection using smartphones to reduce the use of pen and paper during surveys. GeoDataCollect, the in-house mobile application, has been installed in more than 5,000 devices and used by Jakarta Disaster Management agency as their official app for disaster reporting.

In phase IV, the main focus is on transferring

knowledge from HOT to BNPB. Here the core aim is to foster disaster management innovation through open geospatial data (September 2016 - April 2018). This would enable BNPB to have its own capacity to map disaster prone areas, train local partners and build collaboration with local universities. This set of skills is important as BNPB has already listed 136 priority districts/ cities of high risk of disaster, and they would like to map these areas before disaster strikes. HOT is also working closely with DMI to develop guidelines on how to use OSM, QGIS and InaSAFE for all phases of the disaster lifecycle, such as for risk assessment and situational awareness. This would be relevant to the goal of institutionalizing InaSAFE in the BNPB.

A second focus of the current phase is to build and maintain links between people and institutions in disaster management. The strategy is to leverage existing partnership with universities and bridge the connection with BNPB. HOT also expected to start building links with underrepresented groups, such as people with disabilities.

These projects show how sustained engagement and funding can bring a crowdsourcing effort into maturity, with careful piloting and testing. However, it should be noted that the project requires the ongoing engagement of external actors.

Main lessons:

- The collaboration of multiple stakeholders in disaster management is important.
- Capacity development is essential to be able to take full advantage of technical innovations in disaster management.
- Universities can be strategic partners to collaborate with local disaster management agencies as well as developing knowledge and skills on mapping and data collection
- OSM can be used to support disaster preparedness through damage impact projection to physical infrastructure.

14. Haiti disaster response	
Interaction type	Public → Government → Public
Trigger event	A natural disaster (earthquake) and humanitarian crisis.
Domain	Generic mapping (topographic maps of the area) and purpose-built maps (disaster relief management).
Organization	Humanitarian OpenStreetMap Team (HOT)
Actors	United Nations, NGOs, National Haitian Mapping Agency, National Center of Spatial Information, Haitian civil society
Datasets	Historic maps, CIA maps, high-resolution imagery from Yahoo, paper maps and GPS tracks.
Process	Tracing in OpenStreetMap (OSM) platform from different data sources and collecting GPS tracks.
Feedback	Topographic and purpose-built maps for the management of supplies of medicine and food, and location of settlements.
Goal	Facilitate disaster response management.
Side effects	The datasets created have not been used by the NMA but by international aid organizations (UN, USAID).
Impact of the project	National & with affect to governmental body
Temporal pattern	One-off
Funding	NGOs
Contact point	Mikel Maron

Haiti disaster response

Haiti was dramatically affected when a 7.0 magnitude earthquake hit the capital city of Port-au-Prince on 12 January 2010. Death toll estimates range from 100,000 to 200,000 people. More than 250,000 residents were injured and more than 30,000 buildings collapsed or were severely damaged. When the magnitude of the disaster became clear, the main issue for those responding to the disaster was that the only available spatial data was poor and last updated in 1960s. The local mapping agency collapsed in the earthquake, with the loss of most of the skilled employees. An updated map was urgently needed for the distribution of supplies and identification of collapsed buildings, damaged infrastructure and medical stations.

The Haiti disaster response is a successful example of geographic information being made open by official partners, enhanced by public volunteers and returned to government for action (although the government was reluctant about the involvement of volunteers). The first imagery was loaded on the OSM platform within 48 hours. Sixty people were trained and more that 700 contributed to the mapping, among them people from UN agencies, NGOs, National Haitian Mapping Agency, National Center of Spatial Information (CNIGS) and Haitian civil society. Historic maps, CIA maps and high-resolution imagery from Yahoo were first used for tracing in OSM to improve the basic maps. Volunteers with paper maps and GPS completed the second phase of tracing. As a result, OSM was used as a default basemap for responding organizations and the Haitian government. The effort also inspired efforts to crowdsource the analysis of satellite and aerial imagery by the World Bank, a project in which more than 30,000 damaged infrastructures were identified and classified.

One legacy of the project was the subsequent establishment of an OSM community in Haiti COSMHA (Communauté OpenStreetMap Haiti), which remained active for several years following the earthquake and conducted mapping activities throughout the country. The widespread availability of OSM information in the country was useful during the response to Hurricane Matthew (October 2016).

The disaster response's success lies in four main factors: time, cost, high participation of volunteers and official trust. The sensitization of the public to the Haitian crisis led to high participation of volunteers and immediate mobilization worldwide. The contribution of NGOs and other official partners and the release of conventional datasets as reference maps for tracing without license restrictions were vital to success. Government support was inevitable due to the critical circumstances and limited resources.

Although, the project is characterized as successful, there were a few weaknesses. All the responding organizations lacked experience and awareness of the operational norms in humanitarian response, which constitute an operational framework for the accountability of different sources. Deficiency of coordination led to the duplication of data. The national mapping agency, CNIGS, also never really engaged with OSM, although official data was given supportively at the beginning of the project.

Main lessons:

- This was the first large-scale crowdsourced mapping exercise for humanitarian reasons and shows its successful use in responding to disaster.
- An integrated methodology of this kind follows four steps: spatial data contributed by official providers, supplemented with GPS tracks, integrated into OSM and updated by a large number of volunteers worldwide.
- Time, cost and official trust of data by NGOs and other official partners are key to success.
- Lack of coordination and experience between different actors can lead to duplication of data and waste of resources.
- Differentiation between conventional and government data in terms of engagement to the project did not prevent success.

15. Mapping of South Sudan	
Interaction type	Public → Government → Public
Trigger event	On 9 July 2011 South Sudan became Africa's 54th nation after its official independence. Although it is the newest nation, it is poorly mapped.
Domain	Generic mapping of a poorly mapped area and thematic maps of essential features like roads, hospitals and schools.
Organizations	Google, NGOs along with the World Bank, United Nations Institute for Training and Research (UNITAR) Operational Satellite Applications Programme (UNOSAT) and Regional Center for Mapping of Resources for Development (RCMRD)
Actors	The Sudanese diaspora, Google, the World Bank, UNOSAT and RCMRD
Datasets	Updated satellite imagery covering 125,000 km^2 (40 percent of the UN's priority areas) uploaded to Google Earth and Maps.
Process	Workshops and editing on Google Maps via Google Map Maker.
Feedback	Generic and thematic maps covering important points of interest such as schools, hospitals and roads.
Goal	To engage and train the Sudanese diaspora and other volunteers worldwide to participate in Google Map Maker.
Side effects	Mapping the poorly mapped South Sudan so that the infrastructure and economy of the country could be developed and humanitarian aid provided to the local population.
Impact of the project	National
Temporal pattern	One-off
Funding	World Bank
Contact point	-

Mapping of South Sudan

After years of political instability, South Sudan became a new nation on 9 July 2011 after its official independence. Although South Sudan is expansive and the newest nation, it is poorly mapped. Maps are particularly important for the development of the infrastructure and economy of the country and the distribution of humanitarian aid.

Google, with the aid of World Bank, UNOSAT and RCMRD, recognized this need and started the project for the creation of better maps of South Sudan by supporting communities to map schools, hospitals, roads and more with Google Map Maker. The project was launched with a series of events to disseminate the purpose of the mapping and inspire and train participants. The first event was in April 2011 at the World Bank headquarters in Washington, DC, with a satellite event in Nairobi at the same time. The next event was in September 2011, held by the South Sudan National Bureau of Statistics in Juba.

To aid their work, updated satellite imagery of the region, covering 125,000 km² (40 percent of the UN's priority areas), was uploaded to Google Earth and Maps. In the last event volunteers worked together and made hundreds of edits in less than four hours. The process is simple: citizens edit using available web tools and their local knowledge and, after approval, edits become visible to all Google users worldwide. The mapping was used by the Satellite Sentinel Project, a collaborative project focused on human rights violations and human security concerns in Sudan and involving Google, the Enough Project, Not On Our Watch, UNITAR, UNOSAT, DigitalGlobe, the Harvard Humanitarian Initiative and Trellon.

The activity was constructed as a one-off event and while the maps are now available on Google Maps, the demise of Google Map Maker in early 2017 means that only the Google Local Guides program is open to data contribution, though the data is open for download by NGOs and research bodies on the Google website.

Among the main factors in the project's success are not only the enthusiasm and inspiration of the Sudanese diaspora, which encouraged them to convey their experience and knowledge to other people, but also the interest the local government showed in the project. The project's approval by local government and its impact in decision making policies is noticeable. Another innovation of the project is the principal role and contribution played by the Sudanese diaspora. Through VGI projects, local knowledge can be shared worldwide and from different parts of the world, not only from the area of interest. At the same time, among the main weaknesses of the mapping is that local people were not actively involved. The project lacked research in the field, and did not use GPS or open source software, although Google's involvement guaranteed high participation levels.

Main lessons:

- Crowdsourcing projects can be coordinated and implemented from a distance.
- Participation of volunteers and transmission of motivation to others are key factors in successful crowdsourcing applications.
- Inspiration for other projects and improved applications can be beneficial to areas of interest.
- Acceptance by local government as an opportunity for decision making policies and humanitarian aid can escalate the impacts of a VGI project.

16. Crowdsourcing The National Map, National Map Corps, US	
Interaction type	Public → Government → Public
Trigger event	The National Map Corps project became available nationwide.
Domain	Generic mapping (structures data in the public domain is used to update The National Map geospatial databases and US Topo maps).
Organization	US Geological Survey (USGS), National Geospatial Program
Actors	Public, local, state and federal agencies including the USGS
Datasets	USDA National Aerial Imagery Program (NAIP) imagery, National Map base layers, ESRI world imagery, Alaska community photos, the national structures database and US Topo maps.
Process	Using crowdsourcing techniques, the USGS National Map Corps VGI project known as "The National Map Corps (TNMCorps)" encourages citizen volunteers to collect and edit data about human-made structures to provide accurate and authoritative spatial map data for the USGS National Geospatial Program's (http://www.usgs.gov/ngpo/) web-based The National Map.
Feedback	Updated structures are contributed in real time. Databases are updated in near real time.
Goal	Maximize limited resources while continuing to support the National Geospatial Program by leveraging volunteers with local knowledge to update The National Map and USTopo maps. Data collected is in the public domain and freely downloadable.
Side effects	-
Impact of the project	National
Temporal pattern	Ongoing
Funding	US federal government
Contact point	Erin Korris, Elizabeth McCartney (nationalmapcorps@usgs.gov)

Crowdsourcing The National Map, National Map Corps, US

VGI is not new to the USGS, but past efforts were hampered by available technologies. Over the last two decades, the USGS has sponsored various forms of volunteer map data collection projects, including the Earth Science Corps where volunteers annotated topographic paper maps, the collection of GPS points using handheld GPS devices and, finally, web-based technology to input data in 2006. Despite these efforts, and as valuable as the updates were, technology could not keep pace with decreasing USGS resources and changing priorities, and the VGI effort was suspended in 2008. In 2010 – 2012, the perfect storm of improved technology, social media and continued decreasing resources once again made crowdsourcing an attractive option.

After several pilot projects to determine the viability of bringing back the volunteer mapping program, The National Map Corps volunteers are successfully editing 10 different structure types in all 50 states, including schools, hospitals, post offices, police stations and other important public buildings. Using National Agricultural Imagery Program (NAIP) imagery as the primary base layer, volunteers collect and improve data by adding new features, removing obsolete points and correcting existing data. Edits are contributed through a web-based mapping platform and are incorporated into The National Map geospatial databases and ultimately US Topo maps.

Data quality is a common concern regarding VGI. In order to address those concerns, an analysis of a pilot project over the state of Colorado was conducted in 2012, and a national data quality study was conducted in 2014. For all structure feature types, volunteer involvement was found to improve positional accuracy, attribute accuracy and reduce errors of omission. The studies demonstrated that volunteer edits improve baseline structures data; that further review by advanced volunteers willing to provide peer review improves the data further; and that sample-based inspection by USGS personnel can monitor these processes.

TNMCorps volunteers continue to support the National Geospatial Technical Operations Center (NGTOC) mission of the "acquisition and management of trusted geospatial data, services, and map products for the Nation". After the TNMCorps project fully expanded to all 50 states late in 2013, the project continued to grow. In 2014, a national data quality study was conducted which showed that volunteers were continuing to provide high quality data even as the project expanded from a volunteer corps consisting primarily of GIS students and professionals to the general public. More than 230,000 points had been edited by the end of 2016.

Successful crowdsourcing is not without challenges, some of which include volunteer recruitment, volunteer engagement and participant motivation. The National Map Corps endeavors to meet these challenges using gamification techniques and a mixture of traditional and social media. Gamification includes easy on-ramping, virtual recognition badges, friending, map challenges, social media interaction and a tiered editing approach. Using these techniques has been successful. The National Map Corps continues to see substantial increases in the number of volunteers and volunteer contributions to The National Map.

Other challenges continue to exist and include: organizational resistance to accepting data from volunteers as being "good enough" to populate national databases; and working through issues for which there is no well-established policy regarding government accepting data from citizens. One example is the requirement to obtain approval for conducting a "survey" from

the Office of Management and Budget as part of the Paperwork Reduction Act even though the project is not really conducting a “survey”.

Main lessons:

- Adoption of challenging techniques such as gamification has been successful and attracts volunteer interest.
- Evaluation of the quality indicated that participation improves accuracy and reduces errors.
- Organizational resistance to accepting data from volunteers is one of the major challenges for VGI projects of this kind.
- Key factors to successful crowdsourcing include building on experience, leveraging existing technology and having the support of key individuals in the organization.

17. Crowdsourced flood resilience in Jakarta, Indonesia	
Interaction type	Public → Government → Public
Trigger event	Disaster management agency of Jakarta wanted to have better basemap and data for flood planning and reporting.
Domain	Mapping for disaster management.
Organization	Jakarta Disaster Management Agency (BPBD DKI Jakarta)
Actors	Indonesian Disaster Management Agency (BNPB), Jakarta Disaster Management Agency (BPBD DKI Jakarta), Department of Foreign Affairs and Trade (DFAT) Australia, United Nations Office for Coordination of Humanitarian Affairs (UNOCHA,) University of Indonesia (UI), Humanitarian OpenStreetMap Team (HOT), GFDRR, MIT Urban Risk Lab, USAID, Pacific Disaster Center (PDC)
Datasets	OpenStreetMap (OSM) data of sub-village (Rukun Warga) boundaries, religious, health, sports and government facilities, schools, roads, flood locations.
Process Collecting	Workshops, field survey using GPS and mobile devices, satellite tracing, crowd-reporting using social media.
Feedback	Urban village leaders received paper poster maps of their villages. Public able to send and receive flood reports and alerts in near real time to help them make time-critical decisions about their safety during flood emergencies.
Goal	Improve geographic information available for flood management Improve geographic data sharing across formal and informal sectors.
Side effects	Crowdsourced flood resilience in Jakarta has made others interested in the idea of crowdsourcing and using community mapping to collect base data and record data at a relevant scale.
Impact of the project	National & with affect to governmental body
Temporal pattern	Ongoing
Funding	NGOs
Contact point	Kate Chapman, Emir Hartato, Yantisa Akhadi, & Etienne Turpin

Crowdsourced flood resilience in Jakarta, Indonesia

Jakarta, Indonesia, is a megacity that has frequent seasonal flooding issues. In 2012, Jakarta's disaster management agency (BPBD DKI Jakarta) needed better data to prepare for the flood season. DFAT-Australia, UNOCHA, HOT, GFDRR and University of Indonesia assisted in the process.

The original aim was to ask the heads of the 267 urban villages the location of their critical infrastructure, then ask university students to help with technical mapping. Impact analysis using InaSAFE open source impact modeling software was then performed as part of a contingency planning process. The data has been used to create government maps to report flood conditions and village heads have used poster maps to plan logistics when responding to flooding.

The project also created an open dataset that can be used for a variety of analyses at the village, district and provincial levels. Using an open platform means that anyone can use the data and it can be updated easily as the information becomes outdated. The data collected is useful for flood management, allowing the government of Jakarta to show more detailed maps than previously available and increasing demand for additional mapping at a higher resolution. One negative aspect of the methodology used is that while it did collect the data very quickly, urban village officials do not have an easy way to update their area as the data changes.

In 2013, Jakarta's disaster management agency (BPBD DKI Jakarta), together with SMART Infrastructure Facility (University of Wollongong) and Twitter Inc. conducted a pilot study to develop PetaJakarta.org platform, enabling Jakarta's citizens to report the locations of flood events using the social media network Twitter. The pilot study contributed to a public web-based real-time map of flood conditions powered by CogniCity Open Source Software. It produces megacity-scale visualisation of disasters using OSM basemap, crowd-sourced reporting, and government agency validations in real time. The project demonstrated the value of social media in disaster management as an operational tool to provide decision support in the event of disaster.

Since its debut in 2013, the PetaJakarta.org platform has grown into a single robust platform that integrates local knowledge from various crowdsourcing tools (mainly social media and instant messaging) and formal knowledge from government agencies. The project expanded to PetaBencana.id with support from Massachusetts Institute of Technology (MIT) Urban Risk Lab, USAID, and Pacific Disaster Center (PDC) by the end of 2016. Since then, the PetaBencana.id platform has been used by millions of Jakarta resident users to make time-critical decision about safety and navigation during emergency flood events; it has also been adopted by the National Emergency Management Agency (BNPB) to monitor flood events, improve response times, and share time-critical emergency information with residents.

Main lessons:

- Collaboration between different stakeholders, depending on their knowledge and capacity, means stakeholders can contribute to specific tasks and stages of crowdsourced disaster resilience.
- Open data can be used at different levels of decision making policies such as village, district and provincial levels.
- Difficulties in keeping data up to date is one of the most important viability concerns.
- Data can be used in a variety of ways, including by government agencies for the creation of maps.
- Sharing information and coordinating data between residents and government agencies fosters equitable and innovative practices of crowdsourcing for disaster resilience.

** This case study was in the 2014 report under the title "Flood preparedness through OpenStreetMap, Jakarta, Indonesia". The title has been changed as more agencies are currently involved in the process.*

18. Twitter use in Italian municipalities	
Interaction type	Government → Public → Government
Trigger event	-
Domain	Social Media
Organization	Ladest Lab, University of Siena (Italy)
Actors	University (UNISI); Twitter Italia; Anci (Associazione Comuni Italiani)
Datasets	New dataset creation including Twitter profile names and metrics (Tweets, followers, following, activation date); integration with other datasets.
Process	Data was collected manually for each of the 7,981 (ISTAT, 2017) Italian municipalities, then integrated with official census population data (ISTAT) by municipality code and with Large Urban Zones (Eurostat) to develop Twitter profile performance analysis.
Feedback	Official presentation of the results in public meetings; international publications.
Goal	Analysis of municipalities' performance on the social platform to foster participation and efficiency.
Side effects	More municipalities activated Twitter profiles. Creation of an on official forum #pasocial (pa = public administration). Definition of dedicated professional skills to deal with social platforms in public administration.
Impact of the project	National
Temporal pattern	Ongoing
Funding	-
Contact point	Cristina Capineri & Antonello Romano

Twitter use in Italian municipalities

The University of Siena in collaboration with Twitter-Italia and Anci (Associazione Nazionale Comuni Italiani) started a research project in 2013 to investigate the adoption of Twitter profiles by Italian municipalities. After the first survey, other updates took place in 2015 and early 2016 to analyze the spatial and temporal diffusion process.

The research identified that, at the time of the first survey (November 2013), only 461 of the 7,981 Italian municipalities had Twitter profiles, approximately 6 percent; three years later (early 2016) the number of profiles had reached 881 municipalities (approx. 11 percent) showing an increase in institutions joining the social platform. The profiles' activity is also increasing as demonstrated by Twitter metrics: 49 percent increase in Tweets sent in 2015 compared to the previous year; as well as 73 percent more followers and a 20 percent increase in following.

The geography of municipal Twitter profiles in Italy seems to reflect the urban structure of the country, which is mostly made up of many small and medium sized cities. The research highlighted that 5 percent of the profiles have been activated by large towns with more than 100,000 inhabitants (note that large municipalities represent only 1 percent of the total); 40 percent by small to medium municipalities; while 55 percent had been activated by municipalities with less than 10,000 inhabitants. Furthermore, while the larger municipalities attract the most followers (66 percent), the small and medium municipalities are the most active (77 percent of the Tweets). This demonstrates that reduced population size is not a barrier to the spread of social applications but may in fact be an advantage or a driver; small municipalities also seem to have built a tweeting atmosphere thanks to their external economies based on social proximity or on a stronger sense of place compared to high metropolitan fragmentation. The first and most active (in terms of Tweets sent and followers) municipalities on Twitter are those which started with the activation of "civic networks" (municipality websites) in the late 1990s, showing the relationship between the adoption of these kinds of technologies. It is interesting to observe the case of 11 neighbouring municipalities sharing the same profile and thus creating a sort of "tweeting district" which benefits from the common management of social communication.

The survey analyzed the messages sent, since activity profiles must be assessed not only in relation to the amount of Tweets and followers but also with respect to the quality and type of information sent. The latter includes simple messages for informational purposes up to more complex messages addressing planning and territorial management. The research team classified the hashtags used by most municipal profiles into several categories and found that the most widely represented information related to culture and tourism, followed by geographical information, utilities and weather forecasts. More recently several profiles have introduced news about open data. Messages about governance are still limited, demonstrating that the potential of Twitter as a collator and distributor of information on complex issues around which to initiate debates and discussions has not been realized. Only a few municipalities have used Twitter for emergency and risk management. Nevertheless, it is worth noting that the news about L'Aquila's severe earthquake of 2009 was first announced through Twitter before other media. Institutions still face the challenge of collecting contributions produced by their community and filtering and validating them to improve governance. These tools therefore

provide an important opportunity to establish and consolidate good governance based on efficiency, transparency, simplification and on the development of collaborative solutions for critical issues.

Main lessons:

- Social media use is growing in many contexts and represents an opportunity for collecting and analysing VGI.
- Demographics may be reflected in social media use but it can still be an efficient way to access information about less populated areas.
- Social media may be used for some types of communication more than others but has an application in disaster scenarios.

19. National Biodiversity Data Centre Ireland	
Interaction type	Public → Government
Trigger event	NBDC strategy to encourage the submission of biodiversity records by the general public.
Domain	Update and submission of National Biodiversity Database (NBD).
Organization	National Biodiversity Data Centre (NBDC) Ireland
Actors	NDBC and the Irish biodiversity community (especially university researchers)
Datasets	Existing NBDC database.
Process	Users enter their observations through the appropriate HTML forms on the NBDC website. Observational data is checked internally in NBDC and then made available for access and visualisation on the online maps and charts. Data submitted in any other file format is converted to the appropriate format to be added to the database. A free mobile phone app allows for real-time, in the field, data capture. This feeds observations directly to the online system.
Feedback	Any data submitted is mapped and viewable immediately. Contributors can visualise their own data using their own email address. Once checked and validated, the validated data are added to the NBD.
Goal	To leverage the potential of outreach groups for data survey and observation thus widening the base from which observational data may be obtained. Provide a suite of thematic data capture systems partner organizations can use for their own data capture needs, which are dynamically linked to the core system.
Side effects	-
Impact of the project	National & with affect to governmental body
Temporal pattern	Ongoing
Funding	NBDC
Contact point	Dr. Liam Lysaght, National Biodiversity Data Centre, Carriganore, WIT West Campus, Waterford, Ireland

National Biodiversity Data Centre Ireland

The Irish National Biodiversity Data Centre (NBDC) initiated this project to leverage the potential of outreach groups and the general public for data survey and observation. This widens the base from which observational biodiversity data may be obtained in Ireland. The NDBC also launched this project to initiate stronger engagement with non-professional scientists and heighten the understanding of biodiversity related matters among the general population in Ireland. There is a good tradition of observational work being performed by volunteer community groups in Ireland.

Since June 2012 there have been over 213,000 citizen science records submitted, validated and stored in the NDBC databases. Approximately 5,000 records are submitted per month. These are complemented by data provided from other sources, such as NGOs, researchers and learned societies. Currently the entire database has over 4 million records. NDBC also makes this data available to the Global Biodiversity Information Facility (GBIF), a network of 90 participants worldwide working on an open biodiversity data infrastructure funded by governments. It allows anyone, anywhere, to access data about all types of life on Earth, shared across national boundaries via the internet. The NBDC is Ireland's GBIF node and contributes Irish data to the more than 700 million biodiversity records mobilised through the GBIF data portal.

For the submission of observational data there are species and site forms, with the latter allowing a more detailed recording of biodiversity information. The species forms include birds, amphibians and reptiles, bumblebees, dragonflies, etc. The data from these forms and collections are extracted and merged with other datasets at NBDC. Data is submitted through the web application, mobile phone app or by email (for large and possibly incorrectly formatted observations). Data is quickly checked and made available for access and visualisation on an online map. Those who submit their data to the system will be able to access this data in the future. A new online capture system will be released before mid-May, 2017 which will provide far more visibility of all recording efforts, and will include leagues of records by region, by taxonomic group and even by recorder.

The NBDC has also built a species browser, which brings together information on the ecology of the species with maps of empirical data feeds from the NBDC's own data capture system and that of GBIF and links to the Encyclopedia of Life.

The NBDC ensures that contributors' efforts are well recognized and advertised online. Frequent workshops also report on the progress of the project, the uses the data is being put to, and how the project can be sustained and improved. Events such as Bioblitz (held annually) involve the general public in biodiversity data collection events which have an aspect of fun and competition.

Main lessons:

- Feedback for contributors is important and can be established in many forms.
- Providing several pathways for users to contribute their biodiversity observations improves accessibility.
- Allowing contributors to provide as much (or as little) information as they have available means there can be great diversity in the resolution of data provided, requiring manual and automated controls.

20. Towns Conquer gamification and Instituto Geográfico Nacional toponyms database, Spain	
Interaction type	Public → Government
Trigger event	Funding opportunity from AGILE and EuroSDR project on Crowdsourcing in National Mapping 2013.
Domain	Validation of a national toponyms database.
Organizations	Universities [University of Nottingham UK and Universitat Jaume I of Castellón, Spain], ESRI Europe [sponsor], Instituto Geográfico Nacional [IGN] Spain
Actors	IGN, University of Nottingham, UK, and Universitat Jaume I of Castellón, Spain
Datasets	IGN national toponyms database of Spain.
Process	Users provide updates to the database while playing a game for rewards, contributions are checked by the national mapping agency before being incorporated into the national database.
Feedback	Users played the game to gain points. Points were maintained in a league table format and when a user gained enough points they became the mayor of that particular region. The more validations the user provided, the more points they gained.
Goal	Volunteer validation of a national toponyms database. In Spain it has taken over 10 years to implement a model to standardize the nomenclature of municipalities, yet today there are still conflicts with the names of some places, especially in regions with two languages.
Side effects	Validated gamification techniques for public update and management of important national databases.
Impact of the project	National
Temporal pattern	One-off
Funding	-
Contact point	Dr. Joaquín Huerta, Universidad Jaume I, Castellón, Spain

Towns Conquer gamification and Instituto Geográfico Nacional toponyms database, Spain

The Towns Conquer application was developed when the research team were awarded a small funding prize from a joint funding venture between AGILE and EuroSDR. This funding allowed the support of one person to work in the university, in collaboration with a nominated national mapping agency (NMA). The aim of this project was the validation of a toponyms database provided by the Spanish Instituto Geográfico Nacional, with 136,454 entities requiring validation. The public is involved through mobile and web-based gamification techniques, which are used to persuade users to contribute their amendments to the given toponyms database. The goal is for citizens to amend well-known placenames while playing a game and using their knowledge of their local area or other areas/ regions in Spain.

An Android-based game was developed which was linked to a web map service at IGN. This allowed IGN Spain to deliver the toponyms database on suitable basemaps for the mobile application. Users signed up for free. There were some prizes at the end of the game (with a time limit on the number of months) for the citizens who had gained the most points (conquered the most placenames) during this time. Placenames submitted to IGN via the gamification software were checked by an IGN official before being submitted and updated in the database.

This funding allowed the NMA to test out crowdsourcing and gamification as a means of updating a national database. In Spain it has taken over 10 years to implement a model to standardize the nomenclature of municipalities, yet today there are still conflicts with the names of some places, especially in regions with two languages.

This project did highlight that gamification techniques (when properly designed and thought out) could provide a very good platform from which bodies like IGN could involve the public in updating and managing important national databases. The game also provided the mechanism to motivate users to participate.

The project was stopped in 2014 and was not subsequently rolled out on a larger scale. There were a number of issues which prevented this roll out. These were mainly centered around organizational practices, which made it difficult to deploy the project on a national scale, and funding and resource allocation for both the future development of the Android software and support of the gamification approach into the future.

Main lessons:

- Funding can drive innovative VGI projects and instigate new modes of engagement.
- Links between government agencies and research centers can generate the resources required for VGI projects.
- Gamification can be a successful way of engaging the public in VGI projects.
- Data quality issues can be addressed through checking processes done by the official organization.

21. US National Park Service – Places Project	
Interaction type	Public → Government → Public
Trigger Event	Licensing and data validation concerns.
Domain	Tourism, natural features
Organization	National Park Service
Actors	National Park Service
Datasets	OpenStreetMap
Process	The edits are currently only done by Park Service employees, so there is no validation in effect. This may change in the future.
Feedback	Internal Park datasets digitized from park maps.
Goal	To create an up-to-date map of all the parks for viewing and use by the public on the parks' websites.
Side effects	None yet, but data quality issues are anticipated.
Impact of the project	-
Temporal pattern	-
Funding	-
Contact Point	Jim McAndrew

US National Park Service – Places Project

The US National Park Service (NPS) does not have a comprehensive dataset of geographic information describing tourist infrastructure and natural features for all of the 400 or so individual territories managed by the NPS. Some parks have their own GIS departments and produce excellent data, while other parks are small and do not have these resources. The aim of the NPS Places project is to allow non-technical users to add and modify important landmarks in the parks in a single map. This map could then be used as a basemap for all National Park Service web maps.

The NPS Places project (https://www.nps.gov/maps/tools/places/) uses the OpenStreetMap (OSM) platform because of the robust open source tools available. This includes the backend API and rendering formats as well as the easy-to-use iD editor. It does not use the OSM database due to licensing restrictions on OSM data. The NPS maintains its data separately.

The project is designed to collect point data from NPS employees that will be displayed on most of the maps on the NPS website. There are plans to expand this project to allow edits from the public and to use park employees to verify the information before it is published. There is currently no easy way to extract information from the NPS Places Project although its API is open and fully documented, meaning that experienced users could do this.

The biggest success of this project is that the NPS is able to collect contributions from non-technical park staff. This includes rangers and maintenance managers who know the parks better than anyone but whose knowledge has not been captured due to a lack of dedicated GIS staff. However, there are few non-technical users to date although there are plans to visit the parks and train users. Some parks with GIS departments have already started synchronizing their own information and have been pushing to use the system for all of their webpages.

The biggest challenge is that OSM does not handle traditional GIS well. Tools are therefore being built to synchronize existing ESRI databases with the new database using the ESRI REST API. The aim is to make contributing to the system as easy as possible for the existing GIS departments, which do the bulk of GIS work in the parks. While the goal is to get non-technical people involved, existing GIS departments remain the core of the project.

Main lessons:

- It is possible and sometimes desirable to use the OSM toolset to facilitate voluntary mapping activities without using the dataset itself.
- The OSM platform can be empower non-technical users to start modifying maps. The iD editor is flexible and easy to use. The rendering tools, such as TileMill and Mapnik, allow the data to be updated in real time.
- The success of the system is predicated on existing technical experts. Non-technical users will require more training to get their contributions into the system.
- Live feedback (e.g. map updates) is important for motivating participants.

22. USGS's "Did you feel it?"	
Interaction type	Public → Government
Trigger event	Paucity of instrumental ground-motion data in regions of low seismicity.
Domain	Provision of ground-motion data to US Geological Survey Community Internet Intensity Map for public information about earthquake activity.
Organization	United States Geological Survey Community Internet Intensity Map (popularly known as "Did you feel it?", or DYFI)
Actors	US Geological Survey Earthquake Hazards Program
Datasets	Various products are developed by the USGS from the DYFI data and other earthquake sensing and monitoring programs.
Process	Citizens experiencing earthquake activity can log on to the DYFI website and submit their observation. The intensity of the earthquake is quantified using the Modified Mercalli Intensity (MMI) scale. There is no need for participants to have experience in seismology. Maps and graphics are generated automatically by the DYFI system and made available to the public.
Feedback	Participant submissions are acknowledged and DYFI provides personalized feedback to the contributor in the form of a computed intensity for their submission. Users can provide contact details in the input form.
Goal	Outreach to citizens to become part of the seismic monitoring network and to allow the USGS to continue to learn and understand more about earthquake shaking and intensities.
Side effects	The data collected from DYFI is made compatible with ShakeMap, a product of the US Geological Survey Earthquake Hazards Program in conjunction with regional seismic network operators.
Impact of the project	-
Temporal pattern	-
Funding	-
Contact Point	David Wald, US Geological Survey, wald@usgs.gov

USGS's "Did you feel it?"

The US Geological Survey's Community Internet Intensity Map (more commonly referred to as "Did you feel it?" or DYFI) is a website that automatically maps reports from citizens about their perception of recent seismic activity in their area. When a citizen feels a tremor they can visit the DYFI website, report their location and describe their experience by answering a short series of questions (with drop-down menus). DYFI is combined with a large network of sensors worldwide and these additional citizen reports allow USGS to develop a more detailed map of earthquake intensity. Over 4 million earthquake intensities have been submitted to DYFI for thousands of earthquakes; the data and DYFI maps are available to browse online in the archive section of the website. There is an option for citizens to give first-person descriptions of how the earthquake affected them. However, it is made clear on the form that if the USGS uses this qualitative information the citizen will only be referred to as "the observer". Contributors can see their report displayed on the DYFI webpage. Maps and graphics are generated automatically by the DYFI system and made available to the public. The interactive DYFI map also interfaces with 1km2 geocoded boxes, color-coded according to the USGS ShakeMap/DYFI intensity scale.

The "Did you feel it?" form interface is easy to use. Citizens can submit observations by selecting their location automatically, from an address or with the map interface. The form mostly uses drop-down lists asking for feedback on: situation when the earthquake occurred, experience of the earthquake (shaking strength, duration, reaction), earthquake effects (e.g., objects move or fall off shelves), and damage to buildings. The intensity of the earthquake is quantified using the Modified Mercalli Intensity (MMI) scale. MMI measures the intensity of ground motions from the perspective of human and structural response on a qualitative scale from 1 (not felt) to 10 (very heavy damage), based on descriptions such as "felt indoors" (MMI = 3) to "felt by all, windows, dishes, glassware broken, weak plaster cracked" (MMI = 6) to "some structures with complete collapse" (MMI = 9). DYFI allows anyone to report their earthquake experience as there is no need to have experience in seismology. This citizen reporting allows the USGS to continue to learn and understand more about earthquake shaking and effects. In addition, the USGS can use the data to quickly map the intensity of shaking in the affected region, which can help inform emergency responders, the media and the public in the immediate aftermath of an earthquake.

DYFI has wide appeal and the quality and vast quantity of the data have been used to address longstanding issues in earthquake ground-motion science. Such issues have been difficult to address due to the paucity of instrumental ground-motion data in regions of low seismicity (Atkinson and Wald, 2007). Prior to DYFI, intensity maps were rarely made for US earthquakes of a magnitude less than about 5.5; now intensities as low as magnitude 2.0. are routinely reported for the smallest felt earthquakes nationwide (Atkinson and Wald, 2007; Wald et al., 2011). DYFI data has been useful for rapid post-earthquake information and "they are also robust and of surprisingly high utility". The data collected offer the potential to not only describe ground-motion effects qualitatively but to be used in quantitative scientific studies. Atkinson and Wald (2007) state that "the key to the usefulness of the data is simply this: they make up in quantity what they may lack in quality. Because there are so many responses, stable statistics on average effects are produced, illuminating ground-motion trends and allowing effective correlation and calibration with more-quantitative ground-motion measures." Further, Wald et al. (2016) recently noted that

many academic papers are based on the data from the project (over 2000 in Google Scholar search) and that sometimes this is the only data available for parts of the US.

Main lessons:

- Quality assurance/control: website applications can be used to filter out erroneous responses. Wald et al. (2011) note that the uncertainty of the intensity reported decreases when a higher number (>3) responses are obtained per location; more responses gives a more reliable average. Project leaders can reserve the right to manually exclude any responses they deem erroneous or unnaturally low or high.
- Input forms should be easy to use and avoid the use of specialized terminology.
- VGI data can be valuable in filling in gaps in existing data collection.

23. US Census Bureau – Building an OSM community of practice	
Interaction type	Government → Public
Trigger Event	Internal champion
Domain	General mapping
Organization	United States Census Bureau
Actors	United States Census Bureau
Datasets	OpenStreetMap
Process	Mapping events and outreach in the Bureau.
Feedback	Internal project, no explicit feedback planned.
Goal	To build a group of mappers and supporters of OpenStreetMap in the US Census Bureau.
Side effects	-
Impact of the project	-
Temporal pattern	-
Funding	-
Contact Point	Steven Johnson

US Census Bureau – Building an OSM community of practice

The US Census Bureau has no formal interaction with OpenStreetMap. However, a small number of internal champions worked to build a community of mapping enthusiasts to create support for incorporation of OSM into the bureau's work in 2013 and 2014.

Advocates for the use of volunteered geographic information in the US Census Bureau's programs says that there a number of ways in which the platform could be useful. Data collection is expensive and OSM could offer a way for the census to partner with citizens to help identify areas where change has occurred and, perhaps, collect basic location about the neighborhoods where they live. OSM could also be used as a tool for helping census professionals better understand issues that census field representatives encounter in their work. For example, by participating in OSM, they would have to engage with ambiguity in tagging systems as well as better understand the geography of the areas to which they are assigned.

In order to help grow the OSM community in the Census Bureau, advocates organized mapping events during lunch hours every other week during June and July of 2013. Participants were given basic information about the OSM platform and community, taught how to map using OSM tools, and sent out in small teams to survey the area around the Suitland Federal Center, where the Census Bureau offices are located. In addition, advocates gave internal presentations about OSM and its applicability to the census's mission, and took colleagues to OSM conferences and meetups. However, as soon as the advocates left the organization, the activities stopped. The Census Bureau has no current crowdsourcing activity as part of their preparation for the 2020 census.

Advocates face a number of challenges in promoting the adoption of OSM in the census. Many in the Census Bureau, who have traditional GIS backgrounds, have difficulty accepting OSM's open source model of data production. In government datasets, databases are understood as authoritative but OSM offers no such assurances. The OSM community also has no central point of contact to provide support. Thus, learning how to engage with the distributed OSM community would be an important part of any adoption. Finally, the census could potentially use OSM as a data source for TIGER as well as the master address file but the Census Bureau would then need to release this as public domain information, which is not permitted by the current ODbL license.

Main lessons:

- Building support for VGI in government organizations requires time and willingness to learn different models of creating, validating and using data.
- Hands-on exposure to OSM tools is a useful way of helping individuals understand the platform and its potential value.
- The potential for adoption depends on the presence of an active champion, and without it, the activity stops.

24. New York City open data initiative	
Interaction type	Government → Public → Government
Trigger Event	Adoption of open data policy.
Domain	Local authority
Organization	New York City GIS Department and Department of Information Technology and Telecommunications (DoITT)
Actors	OSM community, New York City government, Mapbox
Datasets	Building footprint, addresses.
Process	Data import into OSM and crowd maintenance in OSM platform.
Feedback	Daily changes.
Goal	Leverage volunteers to help keep authoritative data current.
Side effects	-
Impact of the project	-
Temporal pattern	-
Funding	-
Contact Point	Alex Barth, Mapbox.

New York City open data initiative

In September 2013, New York City released over 200 government datasets to the public as part of a broad open data initiative to "improve the accessibility, transparency, and accountability of City government" (City of New York, n.d.a). Using the web-platform Socrata, the data is made available for download or through APIs that allow software developers to construct mobile and web-based applications that incorporate this information. This data release continues an aggressive open data push by the city government that began in 2011. New York City's Open Data law, signed by Mayor Bloomberg in March 2012, mandates that all city agencies "systematically categorize and make accessible in 'open' formats all public at no charge" (City of New York, n.d.b) before 2018. To date, over 1,100 datasets have been made available on the city's open data portal and numerous applications have been built that address issues ranging from transportation to food safety and the environment.

In partnership with the Department of Information Technology and Telecommunications (DoITT), the OpenStreetMap community and Mapbox imported city building footprint and address point datasets into the OSM database. All work was coordinated on Github and OSM mailing lists and completed in 2015. The project history can be accessed on Github: https://github.com/osmlab/nycbuildings/issues.

These critical datasets, which are necessary to support a wide variety of data analysis and visualization projects, can be difficult and expensive to keep up to date in a city as large and dynamic as New York. Thanks to software developed by Mapbox, the New York City GIS department now receives daily emails detailing changes to OSM building or address information. These emails allow the GIS team to quickly assess updates in OSM to augment city processes used to identify where new construction or other changes in the city may necessitate updates to the authoritative city dataset.

Following the import of the city data into OSM, a feedback loop between the city and the volunteer OSM community allows the government and the public to work together to create and make use of up-to-date and high quality spatial data. The import process for large and complex datasets like addresses and buildings is a complex process that requires technical resources, significant labor, and solid coordination between the OSM community and others involved. In this case the information released by DoITT was up to date and of high quality, but the same cannot be said of all municipal datasets. There has also been a great deal of communication between the city government, the OSM community and the people working on the import, which is critical to the success of these kinds of efforts. This example of cooperation between local government and the volunteer OSM community around a targeted dataset could be expanded by other projects seeking to address a wider range of open data.

Main lessons:

- Open data initiatives can increase government accessibility and transparency.
- Government datasets can be imported and then kept up to date by the OSM community. This can be especially valuable in large and dynamic urban spaces.
- Cooperation between the OSM community and government agencies can create direct links between VGI and authoritative datasets. A loop can allow both groups to work together to create and make use of up-to-date and high quality spatial data.
- Technical resources, significant labor, and solid coordination between the OSM community and others involved is required for success.
- Data quality can vary and municipal datasets may lack the detail developed in this example.

25. Imagery to the Crowd, State Department Humanitarian Information Unit, US	
Interaction type	Government → Public → Government
Trigger event	Creation of new initiative, MapGive.
Domain	Open data for humanitarian relief programs and sustainable development; generic mapping.
Organization	US Department of State
Actors	Humanitarian Information Unit
Datasets	Satellite imagery.
Process	Manual digitization of roads, buildings, other features; public diplomacy and engagement.
Feedback	Access to vector OSM data for local and international organizations.
Goal	Increase participation in the volunteer mapping community and make it easier for users to create OSM data that can support humanitarian and development efforts.
Side effects	-
Impact of the project	-
Temporal pattern	-
Funding	-
Contact point	US Department of State, MapGive Team

Imagery to the Crowd, State Department Humanitarian Information Unit, US

Facilitating access to high quality aerial and satellite imagery for volunteer mapping communities can have dramatic impacts on humanitarian and development activities. Such imagery is often prohibitively expensive or only available under licenses that would prevent their broader use. With this in mind, the US Department of State's Humanitarian Information Unit (HIU) launched an initiative in 2012 called Imagery to the Crowd (ItC), which makes high-resolution imagery – purchased and licensed by the US government from providers like DigitalGlobe – accessible to humanitarian organizations for use by the volunteer mapping communities that support them. To build on the success of this initiative, in 2014 the HIU and the Bureau of International Information Programs created MapGive, a public diplomacy initiative founded on open mapping and citizen engagement. MapGive makes it possible for large numbers of volunteers to contribute to the growing global open mapping community and leverages partnerships in the humanitarian and development communities to direct volunteer efforts to support priority mapping projects worldwide.

In addition to leveraging the imagery publishing workflow developed for ItC, MapGive provides an array of support to new and novice mappers in the volunteer community via its website. This includes beginner tutorials on mapping, toolkits for hosting mapathons and links to training resources. Since the launch of ItC and MapGive, the US Department of State has supported humanitarian response operations in the Philippines, Nepal, Haiti and many other locations worldwide. In doing so, it has partnered with multilateral international development programs such as the President's Malaria Initiative (PMI) and the President's Emergency Plan for AIDS Relief (PEPFAR). For example, in the 2013 Typhoon Haiyan disaster in the Philippines, ItC-published imagery of the affected areas supported over 1,600 volunteer mappers who contributed nearly 5 million imagery-based edits to OpenStreetMap (OSM) coordinated by the Humanitarian OpenStreetMap Team. These edits provided detailed information on the location and extent of pre-event infrastructure and provided the basis for a preliminary damage assessment. As is the case in the aftermath of other natural disasters, organizations like UNOCHA, MapAction, the World Bank, the American Red Cross and others used the OSM data created through these efforts for the humanitarian response. Another project, implemented in partnership with the Global Facility for Disaster Reduction and Recovery and USAID, organized volunteers in Nepal, the United States, Germany and the United Kingdom to digitize roads and building footprints in the Kathmandu Valley of Nepal. Kathmandu is one of the most seismically at-risk cities in the world and the data created through this program helped inform an earthquake retrofitting program led by the government of Nepal and disaster response planning by USAID, which ultimately played a critical role in the response to the 2015 earthquake. MapGive continued to operate in different activities and events in 2016.

These examples demonstrate that sharing US government-purchased imagery with volunteer mapping communities has resulted in the creation of valuable spatial data that is accessible to governments, international agencies, and the public. Moreover, technical and policy efforts at the Department of State resulted in an increase in the speed and quality with which imagery is served to the volunteer mapping community. The technical workflow for processing and managing

the imagery is available on the Department's GitHub page and is completely open source. At the programmatic level, in cases like USAID's work in Nepal, this also becomes a full-cycle example where a US government agency makes direct use of the data created as a result of the imagery release. In other instances, the users are UN agencies or not-for-profit organizations working towards primarily humanitarian ends. MapGive was included in the *Quadrennial Development and Diplomacy Review* and the *Open Government Partnership's Third National Action Plan*, which are recent fundamental US government policy documents on open data, open government and diplomacy.

Main lessons:

- Direct government initiative can grow the volunteer mapping community, especially when supported by the release of high-resolution imagery, purchased and licensed by the government for use by humanitarian organizations and volunteer mapping communities.
- Government initiatives of this kind can result in partnerships with numerous humanitarian and development programs throughout the world, including responses to natural disasters and health campaigns.
- The release of data is most successful when accompanied by a robust open source methodology for processing and hosting (e.g. in the OSM Tasking Manager (tasks.hotosm.org)).
- Government initiatives can achieve demonstrable results by creating projects that produce data for use by the government itself, as well as its international partners.

26. Humanitarian OpenStreetMap Team mapping in Ulaanbaatar, Mongolia	
Interaction type	Public → Government → Public
Trigger event	A greater vision to create a “smart city”.
Domain	Topographic mapping
Organization	Ulaanbaatar City Governor’s Office
Actors	World Bank/ICT, HOT, Mongolian University of Science and Technology, city officials, Mongolian Land Management, Geodesy, and Cartography Department
Datasets	Aerial and satellite imagery (Bing Maps), field survey.
Process	Training core group of people in field data collection, mapping a part of the city, creating conditions for the project to continue by setting up an OSM community.
Feedback	Topographic maps of the city.
Goal	Map a part of the city, create an OSM community and train local people to continue the mapping effort in order to support the vision to transform Ulaanbaatar into a “smart city”.
Side effects	–
Impact of the project	National
Temporal pattern	Ongoing
Funding	Public
Contact point	-

Humanitarian OpenStreetMap Team mapping in Ulaanbaatar, Mongolia

In March 2013, the local authorities of Ulaanbaatar in Mongolia announced their vision to turn their city into a "smart city" by 2020. The aim is to enable city residents to access information regarding public services, provide a consolidated list of public service assets and allow citizens to send comments, reports and requests to relevant officials via the internet. To support this effort a project to map the city under OSM guidance was funded by World Bank/ICT.

The process started with basic training on tracing features from imagery and moved to the handling of GPS devices in data collection. The datasets were documented by field papers and ground photographs which facilitated data management before the final uploading. A consensus on the best tagging practice had to be achieved in order to describe geographic features that do not exist in other areas of the world and are therefore not documented elsewhere.

An important challenge was that the city of Ulaanbaatar was undergoing a great reconstruction phase and thus the available imagery datasets might not provide up-to-date information, raising quality concerns. On the positive side, after five weeks the project had: created an OSM community to continue the mapping project, improved the awareness of local officials of the use of VGI and open data and also caught the attention of the private sector, which can enhance OSM community efforts by providing resources while at the same time drawing more official attention to them.

The project continued on a volunteer basis. One of the main events was when a group of student interns spent part of their spring semester helping the remote mapping of areas around Ulaanbaatar. These students continued their effort during the fall semester by joining technical projects.

Another event was a two-day mapathon, during which over 20,000 edits were made to OSM using unmanned aerial vehicle (UAV) imagery as a base layer. The Governor and Mayor of Ulaanbaatar embraced this effort, presenting awards to the three top teams, and intend to incorporate publicly collected OSM data in future policymaking. The datasets created could also be used by city's planning department to augment their own mapping.

Main lessons:

- Building an OSM community from scratch is likely be time and resource-intensive, and slow to begin with.
- Spatial datasets and mapping products might suffer from low quality, at least until an active OSM community forms.
- Local tagging requirements might be missing from the overall OSM project or might be considered as outliers when it comes to normalizing the dataset into a spatial product (e.g. Shapefiles, import into a database schema, etc.).
- Both governmental officials and private sector organizations recognize the value and potential of VGI and open data.
- The existence of active volunteering communities can easily embrace the use of innovative and largely disruptive solutions such as the replacement of satellite imagery with UAV images.
- Continuous training of new volunteers and organizations, plus the support of events such as mapathons, can support project sustainability.
- Communicating the results of volunteered efforts to the public sector is important for recognizing the merit and the potential of such projects.

27. Mapping schools and health facilities in Kathmandu Valley, Nepal	
Interaction type	Public → Government → Public
Trigger event	Increasing natural disasters worldwide, including earthquake in Haiti.
Domain	Generic mapping of schools and health facilities.
Organization	Department of Education and Kathmandu Living Labs (KLL) with support from the World Bank / GFDRR
Actors	Citizens, Department of Education, KLL, The World Bank/GFDRR, Nepal Risk Reduction Consortium, NSET
Datasets	Aerial imagery from Bing and HIU, and list of schools and hospitals from government were used. Datasets on road network and other points-of-interest with focus on school and health facilities have been generated.
Process	Initial data about schools and hospitals were mapped using a variety of techniques and the results were presented to authorities and discussed.
Feedback	Interactive thematic map (for schools and hospitals) showing structural and non-structural attributes. More detailed online map of Kathmandu Valley.
Goal	To increase resilience of schools and hospitals to earthquake risks.
Side effects	-
Impact of the project	Local
Temporal pattern	One-off
Funding	World Bank
Contact point	Nama Budhathoki

Mapping schools and health facilities in Kathmandu Valley, Nepal

Nepal is considered one of the countries most exposed to natural hazards, especially earthquakes. The capital city of Kathmandu has experienced rapid urbanization in the last decades and is considered to be vulnerable to earthquakes as the majority of the houses do not meet earthquake safety requirements. In Kathmandu, local stakeholders have recognized the danger and have tried to be proactive by initiating an effort to create an OSM map of the city. The aim is to provide a critical resource for disaster risk mitigation and emergency planning. In 2012 the World Bank's South Asia Region launched the Open Cities project to create an asset and exposure database for urban areas and facilitate its use for urban planning and disaster resilience.

As part of this project, Open Cities Kathmandu was started in November 2012 as a pilot initiative. The process was to use GPS, paper field maps, satellite imagery, web and mobile technology to collect exposure data of schools/colleges and health facilities in the field. This was followed by a rigorous data validation process, which ensured that data were accurate. Open Cities Kathmandu has to date mapped over 130,000 buildings and collected exposure data for 2256 educational and 350 health facilities.

The outcome of the project has sparked a policy-level discussion about ensuring the safety of schools and health facilities in emergency situations and encouraged some government agencies to explore ways to integrate VGI in their workflows and others to share their datasets with the public. As part of the Open Cities program, more than 1,500 people received training on OSM procedures and a large number of presentations were delivered to universities in an effort to build a robust OSM community.

In April and May 2015, two high-magnitude earthquakes struck Nepal, killing nearly 9,000 people and destroying over a half a million homes. Scarce and outdated geographic information hindered government understanding of their needs and assets, in turn making it difficult for them to effectively prepare for, or manage, a natural disaster, handle logistics and support medical care, shelter, food and water needs. In this context, the KLL personnel and the volunteer community focused on supporting the disaster management efforts and then on the reconstruction work, discontinuing the initial project. However, the information gathered from the schools and health facilities mapping project proved crucial and helped inform humanitarian responders and support recovery efforts. The information was also helpful in determining which facilities must be retrofitted to withstand tremors.

Main lessons:

- Being proactive is key to ensure that an area is prepared for future natural disasters.
- A solid mapping background is needed for relief efforts following disaster. Creating or updating an existing map is of great importance.
- A well-managed and coordinated effort to drum up public support can provide valuable input from both local and international contributors.
- As well as a short, intensive mapping effort, it is also vital to create a community that will continue the task to complete or update the maps.

28. Informal settlement mapping, Map Kibera, Nairobi, Kenya	
Interaction type	Public → Government → Public
Trigger event	-
Domain	Generic mapping of the biggest informal urban settlement area and thematic mapping of security, water sanitation, health and education.
Organization	Map Kibera
Actors	Map Kibera team, GroundTruth Initiative and various partners
Datasets	OSM
Process	Field mapping in OSM with GPS devices or mobile phones after training workshops.
Feedback	Thematic maps for the management of supplies in infrastructure (roads, paths, railway tracks), health (locations of medical facilities), education (locations of schools), water (locations of wells or spigots) and sanitation (locations of pit latrines, sewers).
Goal	Map the unmapped Kibera and actively involve local people.
Side effects	-
Impact of the project	National
Temporal pattern	Ongoing
Funding	GroundTruth Initiative
Contact point	Erica Hagen, GroundTruth Initiative

Informal settlement mapping, Map Kibera, Nairobi, Kenya

The homepage of this project welcomes visitors by stating that, "Kibera in Nairobi, Kenya, was a blank spot on the map until November 2009, when young Kiberans created the first free and open digital map of their own community." The welcome message summarizes the main idea behind the project, which is to map one of the biggest informal settlements of the world by putting marginalized communities on the map.

Map Kibera was launched in 2009 by Mikel Maron and Erica Hagen with initial funding from Jumpstart International, an NGO specializing in community-based mapping. The first phase, which lasted three weeks from October to December 2009, involved 13 young people who were trained to collect and edit GPS tracks. OpenStreetMap (OSM) was used to create a dynamic and easily editable map and QGIS software was adopted to do further analysis and create specialty maps. ARCGIS, a non-open source software, TileMill and other MapBox products were also used.

From February to August 2010, mappers had the opportunity to enhance points of interest such as water, public toilets, schools, police stations and clinics. It also included two other mini projects: Voice of Kibera and the Kibera News Network. The first offered the opportunity to submit reports, write articles and add breaking news with the aid of Wordpress blogging and Ushahidi software. Work could be sent by SMS and published after approval by an editorial team. The second is a video journalism initiative offering more local people the opportunity to participate, ensuring the wider acceptance of the project and hence its longevity. A YouTube channel also reports on priority issues.

Since then, the map has been updated in real time by users who report service gaps and incidents. As the data constantly changes, the project makes use of the OSM platform, which crowdsources updates and corrections to improve accuracy.

Among the main successes is the project's acceptance by local government, by which it was embraced from the beginning. At the end of the project, Map Kibera representatives presented the analysis to government officials. The negotiation between the two sides had a positive impact on the community, which became recognized as a real neighborhood, and residents gained new technological knowledge.

The project faced various challenges. First, the voluntary participation model was unrealistic in Kibera – local people face great survival issues so a small daily compensation was given for their participation. Second, residents found it hard to understand the benefits of participation and the potential impact of the project. Finally, NGOs found it difficult to cooperate and share information. They had learned to work separately and competitively for a long time, which meant that voluntary work was divided into small pieces, for different purposes.

As of May 2017, the project is still active with part of the original team. Interest has also extended to various fields, such as the mapping of more than 350 schools. MapKibera also played a critical role in the elections of 2013 where citizen mapping pinpointed major issues such as crime hot spots. Its intervention led to a parliament member committing to addressing those specific issues.

Main lessons:

- Slum mapping can be achieved by young local people relatively quickly.
- Compensation may be needed to improve participation in locations where participants face great survival issues.
- Innovative methods such as SMS, voice and video reporting can support the appeal of mapping projects.

29. Skandobs, Scandinavian predator tracking system, Norway and Sweden	
Interaction type	Public → Government → Public
Trigger event	Policy requirements for wildlife monitoring in Scandinavia.
Domain	Species population observation and tracking.
Organization	Rovdata (an independent part of the Norwegian Institute for Nature Research (NINA)) and the Swedish Environmental Protection Agency (EPA)
Actors	Rovdata in Norway and the Swedish Environmental Protection Agency
Datasets	Citizens submit their observations to Skandobs. A Google Maps-based visualisation tool is also available to allow map-based visualisation of the Skandobs database.
Process	Participants can submit observations using either smartphone applications or the Skandobs website. Geographical data is required with each observation and anonymous submissions are not allowed. Quality checks are performed by Skandobs staff.
Feedback	The number of observations in the database is updated on the website every 15 minutes. A table provides summary information of the total number of observations for the current year and month. League tables also show top contributors by individual and municipality.
Goal	To collect observations for lynx, wolverine, brown bear and wolf locations and population sizes to increase knowledge about species populations in Scandinavia.
Side effects	Increasing expectations from NGOs, the media and the public who want information on numbers and distribution of carnivore populations in their countries.
Impact of the project	International
Temporal pattern	Ongoing
Funding	Public funding
Contact point	-

Skandobs, Scandinavian predator tracking system, Norway and Sweden

Skandobs was developed to collect observations for lynx, wolverine, brown bear and wolf locations and population sizes, driven by new legislation, international conventions and directives. Reliable observations help to inform management objectives including long-term conservation and population level management. Monitoring is complicated and expensive for many reasons, including the geographical size of the area under observation but involving the public has been very successful.

In January 2017, there were more than 20,000 registered users of Skandobs, presenting a greater growth in the Swedish territory. There were about 7,800 Norwegian registered users and about 12,500 registered users from Sweden. There are more than 16,000 registered users, while in the last seven years the system has received more than 14,000 reports of large carnivores, with more than 3,000 observations from July 2016 to January 2017. More observations have been recorded in the Swedish territory (9,500 reports against approximately 4600 in Norway) but this is an expected bias since there are more people and carnivores in the Swedish territory.

The Skandobs database is jointly maintained by two national agencies, Norway's Rovdata and Sweden's EPA. Citizens can submit their observations at any time, using iPhone or Android smartphone applications or through the website. The addition of photographs and other information is encouraged. The Skandobs database is made available for download via a search interface on the website. A Google Maps-based visualisation tool is also available to allow map-based visualisation of the Skandobs database.

User observations are subjected to internal validation and when this is completed they are assigned a validation status, which appears in the list of observations. Only rated observations are also added to Rovbase, the primary database for national population monitoring data in Norway and Sweden. The number of observations in the database is updated on the website every 15 minutes with tables summarizing the total number of observations plus totals for the year and month. Observation totals are also provided for key species.

There are concerns about the potential bias in the observational data. For example, because there is greater population density in southern Sweden, there will be more observations than in northern Sweden. This problem of the distribution of observations/observers is a challenge in citizen science and VGI more generally.

Main lessons:

- Feedback can be provided to participants through real-time summaries of the types and quantities of contributions.
- Nations can work together on VGI initiatives to meet policy requirements and reduce costs.
- VGI initiatives can work well in transboundary situations.
- VGI projects can improve volunteer and public awareness about the topics of concern.
- Observational bias due to population distribution remains an inherent challenge in VGI.

30. Corine Land Cover 2006 (CLC2006) in OpenStreetMap, France	
Interaction type	Government → Public
Trigger event	Change in the license policy of the Corine Land Cover dataset.
Domain	Generic mapping (update of land cover/ environmental datasets).
Organization	European Environment Agency (EEA)
Actors	OpenStreetMap France, EEA
Datasets	44 land cover classes for France.
Process	CLC2006 data not overlapping existing OSM data have been imported to the dataset (account for ~60 percent of the land). The CLC2006 typology has been adjusted to match OSM.
Feedback	–
Goal	The goal was to update the OSM database with land cover information, mainly in rural areas, as the contribution in such areas is limited.
Side effects	Other OSM communities followed the example and have integrated CLC2006 into their OSM database.
Impact of the project	National
Temporal pattern	One-off
Funding	None
Contact person	Dr. Guillaume Touya

Corine Land Cover 2006 (CLC2006) in OpenStreetMap, France

Corine Land Cover (CLC) is a European Commission-supported program that aims to provide land cover data for 39 European countries. The image production for the land cover digitization was centrally coordinated by the European Environment Agency (EEA) and the actual data production was undertaken by EEA member states to "benefit from local knowledge". CLC2006 includes 44 land cover classes.

As permitted under the release terms of CLC2006, the French OSM community imported the CLC2006 into the OSM database. However, only about 60 percent of the original was automatically imported, which was for those areas where there was no OSM data. The rest was not imported because it was in conflict with existing land cover polygons created manually by OSM contributors. This was deemed more efficient as the OSM community realized that land cover polygons created by OSM contributors were more accurate than CLC2006. Moreover, as OSM contributors now have access to high-resolution Bing aerial imagery, their data should be even more accurate than the CLC, which is based on IMAGE2006.

The integration of CLC2006 to the OSM datasets instantly enriched the latter with data regarding 60 percent of the French territory. Land cover classification based on imagery interpretation needs considerably more expertise than road classification and in general attracts fewer contributors than the "high-profile" urban fabrics. However, in this case, the land cover parcels imported serve as first-class photograph interpretation keys to aid the OSM community.

The integration brought to light a number of issues. First, importing authoritative data into a VGI database brings both positive and negative endogenous issues, such as the failure to keep the data up to date, the creation of a false impression that such datasets are more accurate or more recent than they actually are, the need to address semantic inconsistencies and differences in the level of detail.

All these factors have probably contributed to the subsequent stance of the French OSM community towards newer CLC datasets (CLC 2012, released at the end of 2014) as the prevailing solution was that the bulk import should be considered only as a starting point and now the community prefer not to use CLC datasets at all. Moreover, the community is urged to remove the CLC identifiers and to update the "source" tag by adding the actual source of imagery that was used in order to update the polygons.

Main lessons:

- The existence of active public communities facilitates take up of opportunities to work on open source data.
- Data integration should not be considered easy or straightforward. This should also be made clear to volunteers as any integration initiative might mean large workloads with moderate results.
- Considerable expertise among volunteers is required for success.
- Successful, community-led efforts can be replicated by others now experience in solving problems has been built and often shared.
- Multiple datasets often have semantic inconsistencies and temporal accuracy should be addressed during integration
- The difficulties of authoritative and crowdsourced data conflation might deter VGI communities from relying on, or using, authoritative data and instead try to create the data needed on their own.

31. FixMyStreet for municipality maintenance information, UK	
Interaction type	Public → Government
Trigger event	–
Domain	Local authority/municipality maintenance.
Organization	mySociety (originally developed with central government funding)
Actors	–
Datasets	Originally, the website used government datasets: postcodes, basemaps, local authority boundaries, contact details and email addresses of relevant personnel in local authorities.
Process	Problem reported on a website using the location's postcode, which creates an email that alerts the local authority to the problem. The authority can respond to the complaint on the website.
Feedback	Update to participants provided through the website and by email that can be triggered when a person registers.
Goal	Provide online tools for residents to report local problems to their local authority and follow up the exchange with the public body in an open way.
Side effects	The application's source code has been released under the GNU Affero GPL software license and has been used in other countries as well.
Impact of the project	Global
Temporal pattern	Ongoing
Funding	Local authorities funding and donations
Contact point	–

FixMyStreet for municipality maintenance information, UK

FixMyStreet is a web-based application, which enables the public to report local problems (e.g. abandoned vehicles, graffiti, potholes). Issues reported by users are propagated to the relevant local authorities by email. Users reporting a problem are contacted by FixMyStreet after four weeks to check if the issue has been resolved.

FixMyStreet was built and administered by mySociety and is free to the public. However, there is also a FixMyStreet for Councils application, which is a paid version adapted to local authority needs for handling the problem reports. FixMyStreet enables the public to voice concerns regarding local issues and has succeeded in engaging people and opening a channel for public input into problem solving. Moreover, it has resulted in public value creation both direct (i.e. social gain through an immediate relationship with the user that reports the problem and his/her neighbors) and indirect (i.e. social gain that is dispersed to the entire community).

However, there are some issues of concern especially when it comes to the data created: the cycle of public data creation, propagation, consumption and diffusion back to the public creates inconsistencies. More specifically, councils themselves have an independent channel for local problem reporting and thus the launch of FixMyStreet created a parallel channel that often simply duplicates problems already known to the council or, in the worst case, confuses the authorities as descriptions of the same problem appear slightly different. Additionally, when the council fixes the problem (which might take more than four weeks), it is not able to report progress on the issue in the application. This is the driving force behind FixMyStreet for Councils but as this is a paid version, few local authorities have adopted it so far.

Today, FixMyStreet continues its success and its codebase has been used to set up similar sites in more than 20 countries worldwide. FixMyStreet staff also work in partnership with the authorities to develop new features that make it as useful and simple to use as possible.

Main lessons:

- Given technological advances it should be expected that the public will find their way to web applications of this kind.
- Authorities should develop processes and methods to integrate data from the public in order to avoid issues of data duplication, confusion and misunderstandings.
- Public VGI initiatives that address community problems might overshadow existing authoritative structures. Flexibility in embracing such initiatives might minimize future problems for local authorities and maximize impact on society.
- Successful examples of public participation can increase pressure on authorities for data sharing under flexible license schemes.

32. FINTAN vernacular placenames project, Ordnance Survey and Maritime and Coastguard Agency, UK	
Interaction type	Government → Public → Government
Trigger event	Increasing recognition of the use of vernacular placenames and their importance to emergency services.
Domain	Emergency operations such as search and rescue.
Organizations	Ordnance Survey (OS) and Maritime and Coastguard Agency (MCA)
Actors	OS (research staff, data capture staff), MCA (coastguards), volunteer coastguards, general public
Datasets	OS topographic maps; address and placename gazetteers containing current known placenames.
Process	FINTAN application developed by OS to enable MCA and their volunteers to enter, locate and classify vernacular placenames; OS then assessed the quality of the data.
Feedback	Many new vernacular placenames that are assessed and quality controlled by OS.
Goal	Improve ability of the Coastguard to locate people when contacted in emergency situations; improve OS database of placenames for use in new and existing products.
Side effects	Tensions in areas where English is not the first language – some groups unwilling to report English names even when in common usage by local people.
Impact of the project	-
Temporal pattern	-
Funding	-
Contact point	Glen Hart, Ordnance Survey, glen.hart@ordnancesurvey.co.uk

FINTAN vernacular placenames project, Ordnance Survey and Maritime and Coastguard Agency, UK

Two of the most prominent UK governmental agencies, the HM Coastguard of the Maritime and Coastguard Agency (MCA), responsible for the initiation and coordination of all civilian maritime search and rescue operations, and Ordnance Survey (OS), the UK's national mapping agency, have joined forces to create an up-to-date dataset of vernacular placenames. Vernacular placenames are those in common usage irrespective of whether they are official names or not.

There has been an increasing recognition by the OS of the need to capture richer and more detailed vernacular placenames. At the same time, the UK Coastguard were in the process of closing approximately half of their coastguard centers and recognized that a lot of local knowledge could be lost. In that context, both sides recognized the mutual benefit of capturing vernacular coastal placenames using the knowledge of the coastguards (professional crowdsourcing) and local coastguard volunteers (local people who can assist in certain coastguard operations).

An updated database of vernacular placenames is a priceless tool when it comes to providing swift response to life-threatening situations. One of the most important parts of the response process is to understand the position of the person in difficulty and often official mapping products might not provide all the necessary information. It is common for people in need to use local names that do not exist in official gazetteers.

FINTAN is an OS application that enables the crowdsourcing of vernacular local names of coastal areas. FINTAN includes topographic mapping on a wide range of scales provided to the Coastguard to enable the recording of placenames. Additionally, address and placename gazetteers containing current known placenames have been used. Special care has been taken to allow other emergency services that use different reference systems to work to a common geography and terminology.

Through FINTAN, HM Coastguard and their volunteers can enter, locate and classify vernacular placenames of features such as beaches or rocks to update the existing database. Personal connection with participants has been helpful in encouraging participation, facilitated by coastguards inputting data from their local volunteers, and the specialist application has been targeted at their specific interest (as opposed to more generic approaches like OpenStreetMap). While the future of FINTAN was promising in 2014, the project is now supported by one permanent staff member at the OS, who is responsible for code maintenance and debugging. To date, the project has not been upscaled.

On the negative side, tensions in areas where English is not the first language have been observed as some groups are unwilling to report English names even when these are in common usage by local people.

Main lessons:

- Crowdsourcing can be a valuable tool when it comes to existing knowledge preservation.
- Professional crowdsourcing might be equally or even more productive compared to general crowdsourcing practices when collecting data for specific areas or subjects.
- Local and regional interests and perceptions might introduce biases to the data collected.
- Two-way data flow can be a win-win situation for all involved parties as well as the general public, and is facilitated by shared interests and benefits.

33. Boston StreetBump, US	
Interaction type	Public → Government
Trigger event	In 2012 Boston Mayor Thomas Menino announced that the city could take a more proactive approach to road maintenance by engaging the city's citizens and their smartphones.
Domain	Road network maintenance.
Organization	Mayor's office, City of Boston
Actors	City of Boston Roads and Public Infrastructure Division
Datasets	There are no specific datasets in use.
Process	Using the accelerometer and GPS devices on smartphones, users with the StreetBump application automatically report "bump" or pothole information to the City of Boston. These reports are collected in a database. The Roads and Public Infrastructure Division carefully monitor these reports. If a specific area receives many reports, an engineer will physically examine that location.
Feedback	Users of the StreetBump application can gain points ["street cred"] for each pothole they assist in reporting, which is subsequently fixed or repaired by the city engineers.
Goal	To overcome the manual, antiquated method of reporting potholes from citizen complaints or manual survey by city inspectors.
Side effects	The City of Boston uses this information to plan long-term investments in road and street infrastructure repair, upgrade and construction.
Impact of the project	Local
Temporal pattern	Ongoing
Funding	Public
Contact point	Information extracted from various websites.

Boston StreetBump, US

Boston's Mayor's Office of New Urban Mechanics (MONUM) pilots experiments that offer the potential to improve the quality of city services. New technology – from smartphones to GPS – and a resurgent spirit of civic engagement have created increased opportunities for closer connection and communication between the city government and its citizens.

Using the motion-sensing capabilities of smartphones, volunteers who download Boston's StreetBump application automatically send information to the city about the condition of the streets they are driving on. When their cars hit a pothole their phone sends the accelerometer data to a server application, which combines the information from many other phones to pinpoint problem areas on the streets. If three or more bumps occur at the same location, the City of Boston will physically inspect this obstacle and assign it to a queue for short-term repair or record its location to assist with longer-term repair planning.

There are some problems around the reporting of "false positives". The use of phone accelerometers means that other vibrations felt/absorbed by the phone can be incorrectly calculated as a pothole or bump in the road surface. Now the app uses accelerometers, smartphone GPS and machine intelligence to successfully detect problems while keeping false positives under 10 percent. The City of Boston plans to open source the StreetBump code so that it can easily be adopted by other cities. Another issue is that the app is tedious to use since users need to record any given road trip – even more demanding is the fact that the app cannot run in the background and thus limits access to other apps (i.e. navigation, telephone, etc.). Finally, social bias has been recorded since the app can only run on smartphones and be used by people with cars. This directed repair crews to wealthier neighborhoods, where people were more likely to carry smartphones and download the app. The project ended in 2015.

Main lessons:

- VGI can be used to address urban service issues such as problems with roads and street infrastructure.
- "False positives" in reports can be effectively handled by applying a limit to the number of reports which are required before action is taken by the government agency.
- The types of devices and their hardware capabilities must be considered when planning to use VGI. Some technologies can be unreliable, over-sensitive or unsuited to particular applications.
- Social biases can occur when there are fiscal prerequisites in the use of technology.
- Careful study of the data contributed might reveal patterns or other sources of problems that usually pass unnoticed by the authorities

34. California Roadkill Observation System (CROS), US	
Interaction type	Public → Government
Trigger event	A university-based education and research project.
Domain	Development of a database of user contributed observations of roadkill incidents.
Organization	Road Ecology Center at UC Davis
Actors	Members of the public are asked to contribute. No experience is necessary. Anonymous contributions are possible. ~50 percent of active contributors are professional biologists
Datasets	CROS developed a spatial database to store all of the roadkill information and on which GIS analysis is performed.
Process	A user can contribute details of incidents of roadkill in California (location, type of animal, photographs, etc.). Contributions are uploaded on the CROS website then submitted to the CROS database and displayed on the public web map interface.
Feedback	The contributor of roadkill information is provided with feedback through the project's website. In addition, data is periodically analyzed to produce "hotspot" maps shared with users and the public.
Goal	To understand the ecology of wildlife-road interactions, wildlife behavior and how transportation contributes to wildlife loss. This includes the application of GIS and statistical modeling to predict roadkill hotspots, to measure the factors contributing to roadkill, to quantify impacts, and to estimate benefits of different remedial actions.
Side effects	The California Department of Transportation (Caltrans) and consultant organizations use the spatial information to support mitigation planning.
Impact of the project	Local, national and international
Temporal pattern	Ongoing
Funding	None, supported by volunteer effort by contributors and staff.
Contact point	Dr. Fraser Shilling

California Roadkill Observation System (CROS), US

The California Roadkill Observation System (CROS) system (http://www.wildlifecrossing.net/california/) can be used to record observations from reporters out in the field who come across identifiable road-killed wildlife. According to the Humane Society of the United States, over a million animals are killed every day on US highways.

The CROS website provides a systematic and consistent way for data input using mainly forms and drop-down lists. The observations recorded include information such as the type of animal and/or species found, where the roadkill was located, when it was found, how long it might have been dead, pictures of the roadkill, and various other additional details about road or traffic conditions. Information about where wildlife vehicle collisions occur, what animals are involved, on what kinds of roads, and other data can help inform policy, management, and financial investment in reducing roadkill. CROS has been successful in gathering a large amount of data and by June 2017 it had gathered over 54,100 road observations about 425 species, contributed by 1,340 observers.

The observations are used in a geographic information system (GIS) to find stretches of highway where wildlife-vehicle collisions (WVC) occur more frequently (high density) and places where there are statistically significant clusters of WVC (hotspots). The use of data also includes GIS and statistical modeling to predict roadkill hotspots, measure the factors contributing to roadkill, quantify impacts, and estimate benefits of different remedial actions. The research organization collecting this data at the University of California, Davis, hope to use this data and their GIS analysis of the roadkill problem to inform transportation planning in the state of California.

One of the main obstacles to the project has been the tension between agency scientists' desire to use the data to inform transportation decision making and the concerns the same agencies express regarding public access to information about WVC. Moreover, it is possible to litigate against public transportation organizations if an individual is injured on a public highway/road in a place where the organization knew, or should have known, there was a hazard (such as wildlife crossing the road). As a result, these organizations oppose data collection and public dissemination, even though their staff contribute to the database and use the data.

Main lessons:

- Internet-based training materials can be provided to allow contributors to undertake training in scientific methods of surveying.
- The user interface for contribution should be easy to use and include widgets such as predefined lists and clickable maps to decrease the opportunities for erroneous data submission.
- Photographs submitted in addition to basic geographical data can provide useful visual context information.
- Tensions may exist between agencies due to legal issues that might arise from public dissemination of the data.

35. Crowdsourcing satellite imagery in Somalia	
Interaction type	Public → Government
Trigger event	-
Domain	Humanitarian/disaster mapping
Organizations	Standby Volunteer Task Force (SBTF) and UNHCR
Actors	Standby Volunteer Task Force, UNHCR, DigitalGlobe, Tomnod and Ushahidi
Datasets	Satellite imagery provided by the Standby Volunteer Task Force in Tomnod platform.
Process	Volunteers identify shelters by using satellite imagery. Data is stored in Tomnod platform and is evaluated using theCrowdRank algorithm. Data is then pushed to a dedicated UNHCR Ushahidi platform for further analysis.
Feedback	Thematic maps to identify and count shelters in the Afgooye corridor in Somalia.
Goal	Map and count shelters in a sensitive area in order to help refugees and internally displaced people.
Side effects	-
Impact of the project	Local
Temporal pattern	One-off (seasonal)
Funding	UNHCR
Contact point	-

Crowdsourcing satellite imagery in Somalia

This was a humanitarian project to geolocate all shelters in Somalia's Afgooye corridor with the aid of satellite imagery provided by the Standby Volunteer Task Force (SBTF). UNHCR, DigitalGlobe, Tomnod, SBTF and Ushahidi are the main organizational bodies cooperating so that crowdsourcing can take place with the aid of volunteers. The aim of the project is to map all shelters by dividing them into three main categories: large permanent structures, temporary structures with a metal roof and temporary shelters without a metal roof. The rule set describes the shape, color, tone and clustering of the different shelter types. The project was divided into two phases: a trial and an official launch where specific instructions were given to participants. The goal of the project is to test the feasibility of crowdsourcing rapid shelter enumerations of internally displaced persons to support population estimates. The process cannot be replaced by an automated system of image identification because such a system could not identify the type of shelter.

The satellite imagery methodology was selected instead of on the ground survey because access to the area of interest is limited. The main task was to find out how many people are in the shelters and need humanitarian aid in order to inform decision making around logistics and planning policies. During the project, over 253,700 tags were created and more than 9,400 shelters visually identified after the processing of about 3900 satellite images.

Satellite imagery was provided by DigitalGlobe to meet the requirements for high resolution. Tomnod also offered its CrowdRank algorithm to triangulate the data and a dedicated crowdsourcing platform for imagery analysis free of charge. The algorithm determined which tags had the most consensus across volunteers. This built-in quality control mechanism is a distinct advantage of using micro-tasking platforms like Tomnod. The tags with the most consensus were then pushed to a dedicated UNHCR Ushahidi platform for further analysis. SBTF and students from the American Society for Photogrammetry and Remote Sensing were among the volunteers who contributed to this project.

The strength of the project was in the rapid recruitment of volunteers, and the collaboration with data providers with access to high-resolution imagery. At the same time, there are challenges in creating a systematic data classification system for buildings that rely only on satellite imagery, and therefore access to high-resolution imagery continues to be needed.

Main lessons:

- Innovative techniques and algorithms can be used to evaluate volunteers' work.
- Customized platforms and high-resolution satellite imagery may significantly support a crowdsourced project.
- A trial period may indicate crucial factors to avoid.

36. Portland TriMet, transportation planner, Oregon, US	
Interaction type	Public → Government → Public
Trigger event	Need for a new generation of data that traditional proprietary datasets cannot provide.
Domain	Transportation data
Organization	Tri-County Metropolitan Transportation District of Oregon (TriMet)
Actors	OSM and public transportation authorities.
Datasets	The streets and trails are fromOpenStreetMap; transit routes and schedules from TriMet; and elevation data come from the US Geological Survey.
Process	The project uses OSM data to provide intelligent services to the public and at the same time improves OSM data.
Feedback	Improved services to the public.
Goal	Improve the provision of public transportation services.
Side effects	Development of an ecosystem of transportation applications.
Impact of the project	Local
Temporal pattern	Ongoing
Funding	Public
Contact point	Bibiana McHugh

Portland TriMet, transportation planner, Oregon, US

The Tri-County Metropolitan Transportation District of Oregon (TriMet) serves approximately 1.5 million people in the 533 mile urban portion of the three-county Portland metropolitan area. In an effort to keep the services provided to the public at the highest possible level, TriMet is incorporating a range of services such as multimodal trip planning and service change analysis.

TriMet needed a new generation of data that traditional proprietary datasets cannot provide. To solve this problem, TriMet turned to OSM, since it provides data about pedestrian paths and bicycle routes that can enable TriMet to provide multimodal services to the citizens of Portland. OSM datasets are now used by all internal systems and applications that need routing data. Moreover, city officials realized that by releasing governmental data to the public, the OSM community would contribute to data improvement and will enable TriMet to provide better services to the public. Many transit agencies also share their networks and schedules as public datasets, using the General Transit Feed Specification (GTFS) format created by Portland TriMet and Google. Combining the geographic information of OSM and the temporal information of GTFS feeds provides many possibilities for TriMet.

TriMet also led efforts to bring OSM to a high level of accuracy for their area of interest and is the first government agency in the US to adopt OSM and commit to continued improvement of the map data as the city changes or new data elements are tracked. More recently, TriMet was awarded a $678,000 grant from the Federal Transit Administration to develop a multimodal, integrated, automated, accessible and connected transportation system in which personalized mobility will be a key feature. TriMet is working with the OSM community and other local jurisdictions to improve OSM data, in particular on sidewalks, to support the next generation of trip planning.

The intertwining of OSM and TriMet has sparked the creation of 57 TriMet apps and the development of several OSM wiki pages dedicated to Open Trip Planner and TriMet applications with directions and best practices for mapping and tagging.

Main lessons:

- Strong commitment to open source software, open data and crowdsourced data can create a full spectrum of useful web/mobile applications
- Cooperation with sources of crowdsourced geographic information should be a two-way partnership that includes both use of VGI data and support for further improvement of those datasets.
- Continuous funding is needed for applications, services and datasets to remain up to date and in line with the latest trends of application development, both in terms of usability and functionality.

37. The Base Adresse National (BAN) Project	
Interaction type	Government → Public
Trigger event	Adoption of new government policies.
Domain	Topographic data (national address database).
Organizations	IGN, La Poste, the OpenStreetMap France association, local authorities, government agencies and the General Secretariat for Modernization of Public Action (SGMAP) through Etalab
Actors	IGN, La Poste, the OpenStreetMap France association, local authorities, government agencies and the General Secretariat for Modernization of Public Action (SGMAP) through Etalab
Datasets	Addresses
Process	All involved partners will contribute their existing data and, with the help of citizen contributors, the consolidated database will be kept up to date.
Feedback	A national address database which functions as a common reference dataset.
Goal	Create a complete and up-to-date address database for France which will be free and open for everyone.
Side effects	The creation of novel synergies between government and citizens.
Impact of the project	National
Temporal pattern	Ongoing
Funding	Public
Contact point	-

The Base Adresse National (BAN) project

The Base Adresse National (BAN) project aims to provide all necessary data about French addresses, facilitate access for all interested parties including citizens, provide online tools and services to use the recorded data and enable everyone to contribute to the improvement of its content. The project is available from adresse.data.gouv.fr, developed by Etalab. Etalab is responsible for the French government's policy of opening and sharing public data. The French government sees BAN as a project that highlights the will of the administration to create and maintain large collaborative common goods, such as addresses, to build them with open source information systems and to serve their economic dynamics, the efficiency of public services and the autonomy of citizens.

The BAN project solves a number of practical problems like the fact that authorities had many, yet different, incomplete and incompatible address databases, making it complicated, costly and time-consuming to keep them all up to date. BAN was built from the address databases of the participating government agencies and citizen contributions. The data contributed have been harmonized, reconciled and redundant names have been eliminated. Through the project's website, municipalities, enterprises and citizens can contribute and freely use this database on the principles of collaboration (share, improve and reuse a common good). The database is designed to quickly identify all addresses on French territory and also manage the 200,000 to 300,000 addresses created each year.

The BAN project, apart from data curation, offers benefits to all stakeholders including municipalities, who can use it to handle their daily address management; the private sector, by providing a reliable tool for their mailing lists; and emergency services and first responders, where it can improve their efficiency.

BAN offers a number of tools and services such as a free downloader for the address files, a geocoder, APIs for programmable integration and management, a Local Address Counter to support municipalities in creating, identifying and numbering the road network and an interactive map for exploring the data. Moreover, error reporting is under development and until its completion errors can be reported to the managing bodies.

The project's data is available under a dual license system: either a share-alike license (which can be either the dedicated license developed by La Poste and the IGN or an ODbL license via the diffusion made by OpenStreetMap France) and a paid-for license for traditional customers who not wish to contribute.

Main lessons:

- High level government support can quickly establish the basis for solving long-standing bureaucratic problems.
- A collaborative mentality can lead to successful projects.
- Public participation is crucial for mass data collection and curation.

38. Citizen participation in urban planning, Kirtipur, Nepal	
Interaction type	Public → Government → Public
Trigger event	Lack of public spaces.
Domain	Urban planning
Organizations	Kirtipur Municipality, UN-Habitat and Mojang
Actors	Kirtipur Municipality, UN-Habitat, Mojang, local NGOs and local communities
Datasets	Minecraft digital models of public spaces.
Process	A series of workshops for engaging young people in the geo-design of public spaces.
Feedback	–
Goal	Implement a collaborative approach to improve the functionality of public parks.
Side effects	Social impact on several levels..
Impact of the project	Local
Temporal pattern	Ongoing (in other cases)
Funding	NGOs
Contact point	-

Citizen participation in urban planning, Kirtipur, Nepal

Kirtipur is a city in the Kathmandu Valley, Nepal, south-west of country's capital Kathmandu. The city faces an intense and urgent issue of public space availability. The public spaces of Kirtipur are under pressure because of unplanned urbanization and poor land administration by the authorities. Public spaces play a vital role in the well-being of citizens, especially when they lack alternative places, a common observation in poor and deprived neighborhoods. Once a city has been developed, it is difficult, if not impossible, to create new public spaces or considerably alter the functionality of existing ones.

In this context, the Kirtipur Municipality, supported by UN-Habitat, along with local NGOs and local communities, worked on a participatory method to revitalize public spaces. The main tool for achieving this goal was the computer game Minecraft, aiming to encourage youth participation in urban design, as this demographic group is usually marginalized or excluded from decision making. The project (Block by Block) is co-managed with Mojang, the developer of Minecraft. The objective of the overall project is to develop public spaces in low income countries by using Minecraft as an urban planning tool.

Minecraft was used in a series of workshops to allow young people to produce a new design for an existing public space. The workshops, apart from designing a new version of the park, included observations of, and a questionnaire and interviews with, the participants and the different stakeholders. The results showed that Minecraft enabled participants to design a more functional and useful version of the public space. This alone is important as new tools are added to existing participatory methods of geo-design. Moreover, it was shown that this method attracts the interest of young people and considerably shortens the planning process. The use of the online game also increased youth interest in urban design in general, provided an efficient tool for overcoming the participation barrier to decision making, and helped young people to develop important skill and networks.

However, it was shown that there was a gender bias towards males and that digital literacy influenced individuals' representation, participation and voice, and thus participants with better digital skills had more influence in the design process.

Main lessons:

- New technology can enable the implementation of innovative approaches to solve long-lasting problems, both spatial (e.g. geo-design) and social (e.g. marginalized citizens).
- Biases due to digital literacy and gender inequality should be expected and proactive measures should be taken to address them.
- Projects that run under the umbrella of bigger efforts and initiatives (e.g. Block by Block) gain from the management competence of the personnel involved.
- Crowdsourcing spatial local knowledge can improve government practices in terms of time needed and outcome produced.
- Innovative participatory methods can help authoritative decision making processes to become more inclusive.

39. Land tenure in Tanzania	
Interaction type	Public → Government → Public
Trigger event	Protect human rights.
Domain	Land tenure
Organization	USAID, Cloudburst Group
Actors	USAID, Tanzania's government, local authorities and citizens
Datasets	Parcel data and land ownership documentation.
Process	Trained mappers collect and document land tenure rights using mobile mapping devices in mutual agreement with owners to support government authorities.
Feedback	–
Goal	Improve the land administration system.
Side effects	Social improvement and promotion of gender equality.
Impact of the project	National
Temporal pattern	One-off
Funding	USAID
Contact point	-

Land tenure in Tanzania

The Land tenure project in Tanzania ran from 2014 to 2016 as a USAID project funded with $1 million. The aim of the project was to enhance economic growth in the country by securing land tenure rights since there is no properly functioning land administration system in place. The existing processes are costly, poorly managed, and corruption and lack of transparency are common. This means rural dwellers and marginalized social groups, like women and children, find it hard to secure and document their rights to their land. This creates social tensions, poor asset exploitation and little, if any, investment in land. Due to customary norms and social prejudice, it is hard for women to obtain land rights as these go through male family members or spouses. USAID launched a project to map geographic and demographic data using mobile phone technology. The Mobile Application to Secure Tenure (MAST) project enables villagers to identify property boundaries and gather the information officials need to issue land ownership documents.

The project builds on a participatory approach for capturing land rights information and helps to create a collaborative and participatory mentality by crowdsourcing the recording and documentation process, thus securing land rights without excluding anyone. The land rights recorded will be linked to databases that Tanzania's government can use to issue formal documentation in a more cost-effective and time sensitive manner, or serve as an independent registry of claims, thus increasing land tenure security and transparency.

This project offers multiple benefits to government and citizens alike. The participatory crowdsourced approach can help the government to change traditional and more expensive land administration processes, and considerably increase the speed of data collection. By lowering the cost of land certification programs the process becomes more inclusive and accessible, and thus more transparent. In turn, this could minimize, or even eliminate, land disputes, which can improve investment opportunities. In parallel, this process could help raise women's awareness of their right to own and inherit land, and help minimize social disputes and turmoil around land ownership.

However, this process requires citizen contributors to have basic technical competency and be comfortable using applications in handheld devices (e.g. smartphones and tablets) to map and document land parcels. Otherwise, citizens need to be trained to use the technology and applications developed for this purpose. To increase acceptance and minimize interpersonal disagreements, the local mappers also have to ensure that landowners or their representatives and neighbors are present during the process.

Main lessons:

- Deep-rooted social problems can be addressed through participatory and crowdsourced approaches.
- Familiarization with technology, even at a basic level, is the cornerstone for crowdsourced efforts in the digital era.
- Land tenure rights and transparent land management processes are fundamental for social development and economic growth. Thus, up-to-date and accurate geographic information is a key enabler.
- A positive impact and optimum results need well-designed, managed and funded projects.

40. Open for Business, UK	
Interaction type	Public → Government → Public
Trigger event	2015 UK flooding events.
Domain	Mapping of business locations after a flooding event.
Organization	Department for Communities and Local Government (DCLG)
Actors	DCLG Communications and GIS staff, local businesses in the North of England
Datasets	Locations of businesses that were "Open for Business" after 2015 flooding.
Process	A simple ArcGIS web map was set up to capture the data. This was then embedded with the ArcGIS online (AGOL) crowdsourcing web map application template and a simple form created to capture the relevant data.
Feedback	From the outset there was excellent take up and the map provided a useful communication tool for highlighting which areas were getting back to normal after the catastrophic flooding events.
Goal	To inexpensively and efficiently obtain data from businesses in the north of England about which ones were Open for Business.
Side effects	The data will no doubt be skewed to the more digitally literate (and social media engaged) businesses and individuals. However, there is good geographical coverage.
Impact of the project	National
Temporal pattern	One-off (seasonal)
Funding	Public funding
Contact point	Simon Roberts

Open for Business, UK

During December 2015 heavy rainfall led to widespread flooding in many areas of northern Britain causing disruption in businesses services. The Department for Communities and Local Government (DCLG) aimed to inexpensively and efficiently obtain data from businesses in the north of England about which ones were "Open for Business". The GIS and communications staff at DCLG held several discussions regarding the design of the mapping application that could support this aim. Given the fact that DCLG was openly embracing ArcGIS web mapping at the time of the national floods, they decided to trial their crowdsourced data collection web mapping application to capture this data. A simple ArcGIS online (AGOL) map was quickly set up to capture the data, which played a key role in the success of the project given the urgent situation. Although the technology was not specifically designed for a crowdsourced activity, it served its purpose perfectly. The application was then embedded with AGOL's crowdsourcing web map application template and a simple form created to capture the relevant data.

The application helped businesses to inform local communities and visitors that they were open, customers to support local businesses recovering from the flood, and tourists to see what was open in any particular area. The mapping application was supported by a communication strategy and social media feeds, and was quickly embraced by local businesses. Businesses could upload updated details regarding their re-opening or the services and products available using the online mapping application and complete a simple form including their location and opening times. In parallel, a Twitter hashtag (#OpenforBusiness) further increased visibility.

Only businesses comfortable with digital means and social networks could take advantage of the project, but no geographic bias was observed. There was no quality assurance of the data being captured but DCLG GIS staff did have the capability to delete fake or misleading data.

Main lessons:

- In disaster situations authorities can be overwhelmed but crowdsourcing and participatory approaches might fill the gap.
- Crowdsourcing data can provide an accurate image of the reality on the ground even in cases of disaster.
- The ability to quickly set up mapping applications that will gather all the necessary information is fundamental to the success of the effort.
- Poor familiarisation with technology might cause bias in the data.

41. International Hydrographic Organization's Crowdsourced Bathymetry Database (CBD)	
Interaction type	Public → Government → Public
Trigger event	Safety requirements and need to improve services.
Domain	Hydrography, ocean mapping, navigation, marine spatial planning, physical oceanography.
Organization	International Hydrographic Organization (IHO)
Actors	IHO, National Oceanic and Atmospheric Administration (NOAA), ocean scientists, Rose Point Navigation Systems
Datasets	The IHO's Data Centre for Digital Bathymetry (DCDB) Crowdsourced Bathymetry Database (CBD).
Process	Volunteers contribute anonymous GPS position and soundings data to a new international database managed by NOAA's National Centers for Environmental Information (NCEI).
Feedback	A more informed and up-to-date bathymetric database.
Goal	Cover with bathymetric data as many sea areas as possible.
Side effects	–
Impact of the project	Global
Temporal pattern	Ongoing
Funding	Public
Contact point	LT Anthony Klemm

International Hydrographic Organization's Crowdsourced Bathymetry Database (CBD)

According to IHO, less than fifteen percent of the world's ocean depths have been measured; the rest of the data used to compile seafloor maps is estimated depths. These estimated depths are largely derived from satellite gravity measurements, which can miss significant features and provide only coarse-resolution depictions of the largest seamounts, ridges and canyons. About fifty percent of the world's coastal waters shallower than 200 meters remain unsurveyed. In this context, the shortfall in bathymetric data is important as knowledge of the depth and shape of the seafloor underpins the safe, sustainable and cost-effective execution of almost every human activity on, or beneath, the sea. Recognizing the relevance of bathymetry to international maritime policy and the blue economy, and noting that crowdsourced bathymetry may be useful for many potential users of the world's seas, oceans and waterways, the IHO has developed a guidance document to state its policy towards, and provide best practices for collecting, crowdsourced bathymetry dealing with subjects such as data contribution, data collection, data and metadata, uncertainty and legal considerations.

All data, hosted by IHO's Data Centre for Digital Bathymetry (DCDB), is accessible online via interactive web map services (https://www.ngdc.noaa.gov/iho/). The DCDB currently accepts crowdsourced bathymetry contributions through a network of Trusted Nodes, which are organizations or individuals that serve as data liaisons between mariners (data collectors) and the DCDB. Trusted Nodes may assist the mariner by supplying data logging equipment, providing technical support to vessels, downloading data from data loggers, and providing the information to the DCDB. The DCDB works with each Trusted Node to standardize metadata and data formats and define data delivery requirements. This model standardizes data contributions and minimizes the requirements and effort for mariners. In the future, the DCDB plans to support other models, including individual mariner contributions.

While CBD data may not meet accuracy requirements for charting areas of critical under-keel clearance, it holds limitless potential for myriad other uses. If vessels collect and supply depth information while on passage, the data can be used to identify uncharted features, to assist in verifying charted information, and to help confirm that existing charts are appropriate for the latest traffic patterns. CBD can also provide vital information to support national and regional development activities, and scientific studies in areas where little or no other data exists. Providing crowdsourced bathymetry data allows hydrographic organizations to access valuable reconnaissance data that can be used to rapidly assess the adequacy of nautical charts, which can lead to more targeted and faster nautical chart updates. Finally, for the success of the project a number of factors need to be considered. First, as in all crowdsourced projects, the recruitment of volunteers is a challenging task. Maintaining public engagement and interest is another important issue.

Main lessons:

- The adoption of a high-level participatory strategy can considerably facilitate the realization of crowdsourced projects.
- Technological developments allow massive in-situ data gathering.
- In-situ data gathering and data update at the global scale cannot be achieved efficiently without citizen participation.
- Crowdsourcing projects prove a valuable tool even in more demanding cases in terms of accuracy and overall quality of the datasets produced.

42. Disaster Management, Early Warning and Decision Support Capacity Enhancement Project in Indonesia	
Interaction type	Public → Government → Public
Trigger event	-
Domain	Disaster management
Organizations	Humanitarian OpenStreetMap Team (HOT), United States Agency for International Development (USAID), Office of US Foreign Disaster Assistance (OFDA), Pacific Disaster Centre (PDC), Massachusetts Institute of Technology (MIT), Badan Nasional Penanggulangan Bencana (BNPB)
Actors	Local communities and Indonesian government
Datasets	Infrastructure data
Process	-
Feedback	Datasets that can be used for disaster management.
Goal	The project aims to enhance the capacity of national and provincial disaster management agencies to access automated international, regional, national and local hazard information; support infrastructure data; share information between agencies, and disseminate alert warnings to communities and populations at risk.
Side effects	–
Impact of the project	National
Temporal pattern	One-off (year-long project)
Funding	NGOs
Contact point	-

Disaster Management, Early Warning and Decision Support Capacity Enhancement Project in Indonesia

The Disaster Management, Early Warning and Decision Support Capacity Enhancement Project focused on the two major cities of Indonesia, Surabaya and Jakarta. Due to local particularities, issues and difficulties in mapping might stem from dense settlements, surveying permits, low-resolution imagery, inaccurate GPS points, weather conditions, ambiguity in road classifications and overlapping boundaries. The project's overall aim is to enhance the capacity of national and provincial disaster management agencies to access automated international, regional, national and local hazard information and support infrastructure data, as well as share information between agencies, and disseminate alert warnings to communities and populations at risk.

The program is based and focuses on the development of InAWARE, a disaster management tool, to improve overall risk assessment, early warning, and disaster-management decision making in Indonesia (http://inaware.bnpb.go.id/inaware/). The project needs to develop a geospatial database for disaster risk, which will include administrative boundaries, building footprints, road networks and disaster vulnerability characteristics. Data collection processes include remote mapping using OSM's Tasking Manager for buildings footprints; in-situ raw data gathering and feature attribute enrichment with the use of the OpenMapKit and GeoDataCollect (GDC) applications' close collaboration and consultation with local authorities; importing existing datasets; and training and collaboration with local universities. Common approaches to speed up the process of data collection are mapathons and mapping parties. Both of these have been used by the project's partners to gather as much information as possible. Once the information is mapped by the data entry specialists, it will be reviewed and validated by a team of dedicated data quality specialists.

During the lifespan of the project, particular attention was paid to user engagement, training and capacity building of local communities and volunteers. For example, mapathons were open not only to university students but to all volunteers and citizens. A collaboration with a local radio station helped to drum up support and urge citizens to participate in collaborative mapping, and socialisation kick-off workshops with BNPB and BPBD took place in Jakarta and Surabaya. The HOT team was actively involved in training local BPBD staff and aspiring youth and university students. A structured university curriculum had been developed from HOT Indonesia's previous experience.

The OSM data collected will be used by Indonesia's Disaster Management Agency, BNPB, as well as its sub-national agencies BPBD DKI Jakarta and East Java to enhance its real-time early warning and decision making support with the use of InAWARE. In addition, OpenStreetMap and its exposure data provides the basemap for Peta Bencana, a project initiated by the Urban Risk Lab at MIT as a free platform for emergency response and disaster management in megacities in South and Southeast Asia. As part of the project, the team will also distribute print-outs of the areas mapped as a token of appreciation of the collaborative efforts of volunteers.

Main lessons:

- The existence of efficient tools can considerably enhance collaborative efforts.
- The use of OSM and up-to-date satellite imagery can provide basemaps for the collection of specific data.
- The collaboration and active involvement of experienced partners considerably helps the success of a project.
- Volunteer engagement, training and capacity building are fundamental for the success and continuation of a project.

43. Summer Camp Guide	
Interaction type	Public → Government → Public
Trigger event	County GIS staff members became involved with web mapping development.
Domain	Public and private services
Organization	Tompkins County, NY
Actors	Ithaca Times newspaper, Tompkins County Youth Department, Tompkins County ITS – GIS Division
Datasets	GIS point data with attributes, links to websites and photos.
Process	Summer camp managers upload details and locations of their facilities, which citizens can search to find what suits them best.
Feedback	Summer Guide Web Application enables young people, parents and guardians to easily search and find concise information with links to additional information by age group and keyword.
Goal	Create a user-friendly web interface with searchable web applications and maps to benefit summer camp agencies, the county's youth services, and community.
Side effects	Transformed the paper copy of the county's Summer Camp Guide into an all-encompassing user-friendly web interface featuring searchable web applications and maps.
Impact of the project	Local
Temporal pattern	One-off (seasonal)
Funding	Public
Contact point	Svetla Borovska

Summer Camp Guide

A collaborative, crowdsourced-driven effort has been supported by Tompkins County, NY, US, around the county's Summer Camp Guide. The aim was to create a user-friendly web interface with searchable web applications and maps to benefit summer camp agencies, the county's youth services, and the community by providing updated information for all summer programs and camps for 2017 in and around Tompkins County. The project has been supported by local actors and stakeholders. The application consists of a data collection GeoForm that enables summer camp managers to describe and record their facilities on a map; an informative website with all the necessary details for the public and a web mapping application that enables the public to search, find and locate the most suitable summer camp for their needs.

The application transformed the way citizens are informed as it provides an alternative to the paper copy of county's Summer Camp Guide through an all-encompassing user-friendly web interface featuring searchable web applications and maps. Moreover, the application reduced the workload and turnaround time for the county's youth services staff; gave summer camp agencies more control (and responsibility) in presenting their business and enabled young people, parents and guardians to easily search and find concise information with links to additional information (webpages belonging to agencies providing camps and programs) by age group and keyword. While developing the web application, various old and longstanding issues were solved using GIS technology and crowdsourcing all of the mapping and background information about the summer camps, which at the same time upgraded public sector services.

However, a small number of summer camp managers did not have internet access, so a staff member from the youth services department had to complete the GeoForm for them. Moreover, a number of possible improvements have been identified in the first version of the application, and it only works with point-based layers that contain the locations of available summer camps with their attributes, links to websites and photos.

Main lessons:

- Simple yet handy web mapping applications can considerably improve the level of public services provided.
- "Professional" crowdsourcing can generate a critical mass of data to fuel a new way of disseminating information.
- A handful of champions inside a public authority can change and improve its culture and methodologies.
- Given the availability of technological solutions, a small investment of time and effort in crowdsourced mapping applications can create the basis for innovative solutions for public services.

44. Ramani Huria	
Interaction type	Public → Government → Public
Trigger event	The fastest growing city in Tanzania has a high level of flood risk due to rapid, unplanned urban development.
Domain	Community mapping
Organization	World Bank
Actors	World Bank, Red Cross, Tanzanian Commission of Science and Technology, University of Dar es Salaam, Ardhi University, Buni Innovation Hub, Tanzania Data Lab, City Council of Dar es Salaam
Datasets	Infrastructure data contributed to OpenStreetMap; aerial imagery from UAVs added to OpenAerialMap.
Process	University students and community members are trained to provide necessary data for resilience and disaster reduction. The content generated is freely available and is used in software that produces realistic natural hazard impact scenarios to inform better planning against natural hazards. Selected community members also become Red Cross disaster risk responders/volunteers, supporting their wider community with risk mitigation measures and support.
Feedback	Better planning, preparedness and response for disaster.
Goal	Collect data and generate an understanding of flood-prone areas for flood resilience across Dar es Salaam.
Side effects	Launch of the project to other areas: Bukoba in Tanzania, Mozambique, and Zanzibar.
Impact of the project	National
Temporal pattern	Ongoing
Funding	NGOs
Contact point	Mark Iliffe

Ramani Huria

Dar es Salaam is Africa's fastest growing city and Tanzania's primary city with a population of around 5.5 million and is projected to be a megacity by 2030. The city's urbanization process is largely unplanned and its pace challenges traditional methods of planning and public service provision. Every year during the rainy season, Dar es Salaam suffers from devastating floods. In response to this, Ramani Huria was created as a community-based mapping project in Dar es Salaam, training university students and local community members to create accurate maps of the most flood-prone areas of the city. The project is now being transferred to other parts of East Africa.

There are two key factors contributing to the success of Ramani Huria. The first is how the project has been administered and pushed for by stakeholders in the local government. It began in 2011 as a World Bank project, which has slowly moved towards a collaborative governance model, with all stakeholders currently in the process of forming committees to execute and administer the project. This has changed the dynamic away from a World Bank-driven project, towards a community-driven one. This has engendered a deeper collaborative mentality between outsiders (WB, Red Cross), government, universities, and community members, as they all feel that this is their project and that they have the capacity and ability to shape and make decisions. This negates issues of acceptance and supports a wider re-use of the data. The second key factor is the nature of the open platforms and tools used by Ramani Huria (OSM, InaSAFE, QGIS, etc.), which allows for benefits to be achieved at scale and shared throughout a global community. Improvements to software made in Indonesia can and have been applied in Tanzania, and vice versa. This allows for more intelligent use of time and money in a resource-constrained environment.

However, data coverage was not as full as initially required. Reasons for this include poor quality assurance and control coupled with the complexity of tools (and potentially language challenges for non-native English speakers). Further iterations of Ramani Huria will include research components to understand and mitigate these challenges, while expanding the geographic scope of data collection across Tanzania's urban environments.

Main lessons:

- The development of a project as part of a larger effort and support from strong institutions play a major role in success.
- Project management oriented to capacity building facilitates project sustainability as it can be passed from the initiators to local communities.
- The use of open source software frees projects from unnecessary costs that could hamper their development and allows for diffusion in local communities.
- Interconnection among similar projects can spread best practice and effective methodologies.

45. Natural Resources Canada-OpenStreetMap Synergy	
Interaction type	Government → Public → Government
Trigger event	The proven inability of the NMA to keep datasets up to date along with the familiarisation of its personnel with OSM data, quality and processes.
Domain	Update of national topographic database.
Organization	Mapping Information Branch (MIB) at Natural Resources Canada (NRCan)
Actors	OSM Community, MIB, NRCan
Datasets	Canvec (mainly the road network).
Process	NRCan releases its database into .osm format. The data is imported into OSM and updated/modified by the OSM community. NRCan regularly compares OSM datasets with its own database as a change detection mechanism to keep its database up to date.
Feedback	Change detection datasets that were verified in the field by NMA employees.
Goal	Keep national databases up-to-date.
Side effects	OSM data cannot directly be used by the authorities due to IPRs and licensing issues.
Impact of the project	National
Temporal pattern	One-off
Funding	Public
Contact point	–

Natural Resources Canada-OpenStreetMap Synergy

The role of the Mapping Information Branch (MIB) at Natural Resources Canada (NRCan) is to provide accurate geographic information of landmass at the scale of 1:50000. This task translates into the need to update 13,200 map-sheets. Taking into account the results of ongoing research regarding VGI quality, Canadian authorities experimented with the OSM community. The first step was made by the Centre for Topographic Information in Sherbrooke (CTIS) which released the Canvec product (digital topographic map of Canada) in .osm format. This move further enabled the integration of Canadian authoritative data into OSM and gave the OSM community the opportunity to interact with it. The next step was to regularly compare the OSM database with the Canvec data to pinpoint differences, which were treated as potential changes and verified in the field.

On the positive side, the work of keeping the datasets up to date has been facilitated by the OSM community. Leveraging the OSM crowd-sourcing mechanism the Canadian authorities have developed a change detection process which helps concentrate resources and effort on potential changes. This is important when one takes into account that not all original spatial entities in the authoritative database have been updated.

Challenges of the project included the compatibility of the two datasets (in terms of semantic and attribution differences), the lack of metadata for OSM data and the differences in coverage (OSM mainly covers urban areas compared to uniform authoritative coverage), which needed to be addressed. Moreover, there is a conflict between the license and use terms of OSM and the intellectual property rights of Canadian authorities that needs to be solved.

The project stopped when the person championing the project retired from NRCan. The team was gradually reallocated to other projects deemed of higher priority and was never restarted, despite the fact that most map content provided by NRCan (buildings and their functions, land use, power lines, tracks and trails, etc.) has not been updated since the mid 1990s. Today, NRCan uses other authoritative data to update some of its own data (road, railway and water networks).

Main lessons:

- VGI projects can be triggered by government need to provide up-to-date and accurate topographic maps.
- Updates from OSM could have been used for change detection to update authoritative data.
- Differences in data structure and licensing hindered progress.
- The role of championing personnel inside government agencies is paramount, especially in the first stages of a project.
- Poor support for long-term innovative ideas from higher level managers can damage the development of successful projects.

46. Participatory mapping and decision support tools for disaster risk reduction, the Philippines	
Interaction type	Government → Public → Government
Trigger event	The Department of Interior and Local Government (DILG) in the Philippines wanted to better support local government units (LGUs) to prepare risk-sensitive land-use plans, structural audits of public infrastructure and disaster contingency plans. Detailed data to be used for planning was not available.
Domain	Generic mapping by local government.
Organization	Department of Interior and Local Government (DILG)
Actors	World Bank - East Asia Pacific (EAP), Environment Science for Social Change (ESSC), DILG, LGUs of Pampanga, Project NOAH, OpenStreetMap (OSM) Philippines Community, GeoRepublic Japan, Humanitarian OSM Team (HOT)
Datasets	OSM data describing standard features, land use and administrative boundaries.
Process	New training materials were created specifically aimed at LGUs in the Philippines. Next, training and mapping activities were conducted in the selected LGUs. Further community building activities to support the growth of the OSM community in the Philippines were also conducted. Key to this was inviting community members to all the training sessions, either to learn or assist in delivering the training.
Feedback	Success in the data collection in OSM varied by participating municipality. In two municipalities, little data collection occurred after the initial training and mapping phase, but one continued to map afterwards.
Goal	Collect detailed data to better support LGUs in developing disaster plans.
Side effects	-
Impact of the project	-
Temporal pattern	-
Funding	-
Contact point	Kate Chapman, HOT

Participatory mapping and decision support tools for disaster risk reduction, the Philippines

The goal of this project was to use participatory mapping and InaSAFE impact modeling software to support Philippines LGUs in disaster risk reduction activities. DILG needed to better support such activities and determined that participatory mapping and use of InaSAFE was the best way to accomplish this.

The project provided training and technical assistance to LGUs to create basemap information and then perform impact analysis using InaSAFE. Three LGUs participated in the program from the province of Pampanga (Candaba, Lubao and Guagua). Eighty-five local people participated alongside six OSM volunteers who also assisted the training team. Initial training was about the collection of infrastructure data using OSM. Later InaSAFE workshops were held to show how the collected data could be analyzed.

The intention was for LGUs to continue mapping in OSM to improve the analysis in InaSAFE and create a more detailed basemap for other uses. Freely available data of the areas are now available in OSM. During training, the OSM Philippines community assisted with the goal of further strengthening and supporting the OSM community as a whole.

Teaching LGUs how to map in OSM and then analyze the data in InaSAFE was of benefit, though it was difficult for LGUs to continue mapping after their initial workshops. Little mapping occurred outside of the scheduled mapping activities during the training. Only one LGU continued to map afterwards. New methods for better supporting mapping are being explored, including creating a Training of Trainers (ToT) program to expand the community in the Philippines to provide support in OSM. Creating and discovering local champions in LGUs will help to ensure greater support for mapping after training. Using these methodologies in other places is certainly possible, but it would be important to take into account the context and government structure to ensure support for mapping outside of initial training.

Main lessons:

- It is important to highlight the benefit of mapping outside of the immediate context, to encourage continued work and data collection after the project period concludes.
- Efforts to build broader VGI communities as part of focused data collection activities can be valuable and should be encouraged.
- With care, VGI data can be an important complement to official data sources and used for scientific modeling.

47. Government open data usage in Lithuania	
Interaction type	Government → Public → Government
Trigger event	-
Domain	Generic mapping
Organization	OpenStreetMap Lithuania
Actors	OSM, GIS-Centras, National Land Agency, Road Administration, Vilnius city municipality
Datasets	Road network, places, water bodies, public transport, Vilnius addresses.
Process	Government openly publishes data which is downloaded and compared to OSM data. Problems are fixed in OSM or reported to appointed government communication point.
Feedback	Improved data and update speed on all sides.
Goal	To improve data quality, data completeness and update speed.
Side effects	-
Impact of the project	National
Temporal pattern	Ongoing
Funding	-
Contact point	Tomas Straupis (association Atvirasis žemėlapis)

Government open data usage in Lithuania

Lack of open data in generic mapping and of government data on some topics (e.g. tourism) was the principle reason for the OSM team taking action in Lithuania. In Lithuania, although there was some publicly accessible data, almost none of it was open and there was little or no knowledge about open data and open data projects in the government sector. The aim was to update authoritative spatial datasets by combining conventional and open source data. Public sector and NGO/international organizations worked together to fill this gap, and successfully achieved appropriate cooperation between the public and government.

The project started in 2015 and Lithuanian OSM members first approached different government agencies with requests for open data to start the project. Once legal and knowledge issues were solved, data began to be released. Government contact points were assigned and feedback allowed the corresponding government datasets to be updated. The OSM community corrects OSM errors, and GIS-Centras corrects the government data. Thus, the integration between OSM and government is done by synchronisation – checking for differences and taking mostly manual action on both datasets.

Among the positive outcomes were that knowledge about open data increased and data quality and update speed of both OSM and government datasets improved. However, one institution (Registrų Centras), which holds the national dataset of addresses, was unwilling not only to share their data, but even to communicate with the OSM community.

Official conferences with the participation of both government institutions and open data (OSM) presenters were important in establishing the project. They boosted knowledge about open data and created personal and institutional links. Without personal meetings, communication was close to zero. It was also important to find at least one person in each agency, who would champion the open data cause and explain how both sides would benefit. Lithuania is a small country and in this context the interaction between OSM and the government worked well.

Main lessons:

- Collaboration between open data communities and government may result in the mutual improvement of datasets.
- Conferences can raise awareness about open data and develop networks.
- Institutional open data champions play a vital role in government agencies.

48. Xalapa collaborative transport mapping	
Interaction type	Public → Government
Trigger event	Absence of information regarding public transportation routes.
Domain	Transportation data
Organization	Codeando Xalapa
Actors	Codeando México, "Buen Gobierno" Office of Municipal Government of Xalapa, WRI Mexico, OpenStreetMap, Telenav-OpenStreetCam, Mapillary, Computer Science and Administrative Computer Systems School of the University of Veracruz
Datasets	General Transit Feed Specification (GTFS) feeds, passenger counts, public transit routes.
Process	Meetings attended by all stakeholders, including representatives of government, transport companies, citizens and specialists in mobility, to document existing routes; bus schedules, costs and areas covered analyzed; data collected, and participants trained to use the mobile application developed; publicity campaigns disseminate the project through the media; datasets collected are verified and published.
Feedback	Detailed transit routes for further use and transportation planning.
Goal	To collect public transportation datasets.
Side effects	The realization that spatial data requires regular updates and thus established processes are needed to keep them up to date.
Impact of the project	National
Temporal pattern	Ongoing
Funding	Funding was provided by the Office of Municipal Government of Xalapa and the OpenStreetView/ Telenav while support in equipment was provided by Mapillary.
Contact point	mapaton.org

Xalapa collaborative transport mapping

In Xalapa, as in most Mexican cities, public transportation is governed by private companies. However, the transport itineraries are not fully known, and thus the 480,000 inhabitants, 45 percent of whom are workers and 30 percent are students, cannot effectively program their daily mobility. In this context, the public sector, NGOs and international organizations, universities and the local government joined forces to overcome low resources and build the data infrastructure needed to upgrade public sector transportation services. The main objective is to collect a public transportation dataset through citizen participation.

The project was led by Codeando Xalapa (codeandoxalapa.org) in collaboration with the local government. Together they began a process to collect public transportation routes called Mapatón Ciudadano (mapaton.org). The work was strengthened with the participation, support and input of entities such as WRI Mexico (wrimexico.org), OpenStreetMap and Telenav. An open source mobile application (transitwand.com) was customized and improved to perform dataset collection. However, before tracking routes, several meetings were organized with all stakeholders including representatives of the government, transport companies, citizens and specialists in mobility. The aim was to identify where routes start and end, the schedules of the buses, the cost and the geographical areas covered. Then, the data collecting process started with parallel training of participants on how to use the mobile application. At the same time, part of the team participated in publicity campaigns to disseminate the project in media such as radio and television. During the mapping process, teams of citizens were created to gather information on routes close to their home, work or school. All information was stored in a central repository. After the data collection process, the information was verified, participants were informed, route data was cleared and the datasets were published. More than 200 routes were collected (almost 100km), which can be used on official platforms by the federal government as well as by open civic platforms.

The project received monetary support from the Office of Municipal Government of Xalapa, which was used to sponsor users' travel costs when tracing and collecting information to create a feed of the route. A contribution was received from OpenStreetView/Telenav, which was used to buy fuel and map routes from a private car. Finally, Mapillary provided basic equipment (e.g. selfie sticks) for taking photographs. The project gained support from more than 300 citizens who helped to trace their routes from start to finish while the Mapillary application helped to upload 18,400 photographs of the routes.

One negative aspect of the project is the difficulty of involving private companies active in the public transportation business. The absence of federation between these companies multiplies the number of partners and makes collaboration difficult. Another challenge is the lack of continuity, as authoritative support is diminishing and there is no clear actor to take on the role of promoting this process. Finally, datasets need constant updating, particularly in an unregulated transport system, which represents a crucial challenge that must be addressed effectively.

Main lessons:

- Constant funding support is needed throughout a collaborative project.
- Leadership of the project is important both during the first – enthusiastic – phases and for future support and development.
- Data updates should be considered as important as data capture. Continuity of participation and public support is crucial to keep data up to date.

49. FloodTags	
Interaction type	Public → Government → Public
Trigger event	Witnessing an Indonesian NGO manually transcribe tweeted data onto a map to inform disaster response actions.
Domain	Disaster management
Organizations	Deltares, Radboud University, VU University Amsterdam, Universitas Padjadjaran
Actors	Citizens, ICT research community COMMIT and Topconsortia Kennis en Innovatie (TKI), the Red Cross Climate Centre, Deltares, Radboud University, VU University Amsterdam, World Bank, United Nations
Datasets	Data from social media (Twitter, Instagram, blogs) plus SMS and online news media combined with hydrologic models.
Process	Messages shared on social media during a developing flood event are used to map flood risk.
Feedback	Flood risk maps that can be lifesaving.
Goal	Create an efficient solution to capture risk information generated on social media to help improve preparedness and response actions.
Side effects	-
Impact of the project	National
Temporal pattern	Ongoing
Funding	Social enterprise
Contact point	-

FloodTags

FloodTags is a social enterprise located in The Hague (Netherlands) which brings together a large number of researchers from universities and other institutions to develop and implement data analysis scripts for water management. The project invests in the power of citizens and communities as key resources in the solution to many water management problems.

Indonesia was selected as a case study for the project due to its disaster-prone location but also because the local population is familiar with, and active in, the use of social media. The project developed a process that combines natural language processing and flood modeling to improve risk information. The project was inspired after witnessing an Indonesian NGO manually transcribe tweeted data onto a map to inform disaster response actions public to various social media outlets. When a disaster (e.g. a flood) happens, people increasingly find out about it from social media, as individuals and groups use the internet and social media to spread the word. For example, after the Indonesian capital Jakarta was hit by floods in February 2017, related Tweets peaked at almost 900 a minute, with a significant number including information about location and water depth, according to a joint study by two Dutch organizations, Deltares and Floodtags. Spontaneous Tweets about major floods are being turned into a mapping tool that could be used by emergency services and disaster response teams to save lives and provide aid, Dutch researchers said.

The project presents the information in standardized maps, tables and graphs to effectively support response and preparedness procedures. Thus, anyone using the "event server" can obtain timing and location of new floods as observed via Twitter and take appropriate and effective measures. The maps could also be used to speed up recovery work after a disaster or to identify flood-prone areas that would benefit from protection. The project can improve reporting during disasters and, in turn, support timelier and better informed response and preparedness actions. Ultimately this will help to improve outcomes for those vulnerable to disasters. The next steps would be to link the existing social media analysis to national forecasting tools.

However, since crowd-based observations tend to be rough estimates, the data need to be filtered, enriched, validated and transformed into easily interpretable maps that can be used by disaster managers. When the researchers compared their results with photographs of the Jakarta floods at more than 100 points, they found they had modeled the floods correctly in around two thirds of them and in three quarters of the districts. The project aims to minimise false positives while allowing for a fair amount of false negatives. This is the reverse approach to what FloodTags had been doing so far (i.e. using all observations, ending up with a fair amount of false positives).

Main lessons:

- Crowdsourced geographic information can come in many formats and from various sources. The development of appropriate methodologies can turn such unstructured data into valuable geographic products.
- Technical limitations can occur during the first steps of a project but these can be addressed once the proof of concept has been established.

50. Open Cities, Sri Lanka	
Interaction type	Public → Government
Trigger event	Disaster-prone area
Domain	Disaster preparedness
Organization	OpenDRI
Actors	World Bank/GFDRR, United Nations Development Programme (UNDP), local authorities, local universities, HOT
Datasets	Building footprints, road network, key infrastructure, street names, road conditions, land uses and other crucial data for disaster management.
Process	An OSM expert trained 30 students in initial data collection and the 10 most promising ones were further employed to complete the data capture and help train district secretariat staff.
Feedback	A rich dataset with all the necessary elements that could be used for risk preparedness.
Goal	The goal of the project was to create useful data for risk preparedness and equip the government to use and maintain it.
Side effects	-
Impact of the project	Local, but also served as a paradigm for other cases as part of the Open Cities project (international)
Temporal pattern	Ongoing
Funding	World Bank/GFDRR, OpenDRI
Contact point	-

Open Cities, Sri Lanka

Since 2000, flood and drought events have cumulatively affected more than 13 million people across Sri Lanka. Nearly $500 million in unplanned expenditure resulting from flooding in 2010 and 2011 has strained government budgets and required reallocation from other planned development priorities. In this context, in Batticaloa city successive disaster exposure-mapping exercises gradually built a constituency for larger institutional adoption of crowdsourced VGI data and tools in the provincial government. OpenDRI first supported a tsunami exposure survey in the Manmunai North Divisional Secretariat (DS) in 2013. Forty-eight recent university graduates collected building footprints and basic characteristics for all 30,000 buildings in the area, including number of floors, usage and construction materials of walls and roofs.

Mappers used what would become the baseline toolkit for exposure mapping: heads-up, remote digitization into OpenStreetMap via freely available Bing imagery; follow-up field surveys using Field Papers; and finally, office-based data validation. A series of maps was developed from the data and DS staff were trained to download, update and analyze the resulting OpenStreetMap data. Since that time DS government staff have used the OSM data to maintain building addresses and update local roadways.

Inspired by the success of the original project and its scaled-up successor in Gampaha province, the Government Agent (GA) of Batticaloa District asked the World Bank/GFDRR to support field-based data collection for a further six disaster-vulnerable DSs and satellite-based data collection for the entire district. This was supported by an OSM expert working in partnership with the United Nations Development Programme (UNDP), preparing local universities and the DS staff to collect, validate and ultimately maintain the data. The effort is part of the Open Cities project, which aims to learn from these experiences to create a scalable approach to understanding urban challenges and disaster risk in South Asian cities.

At the project outset, the OSM expert recruited and trained a team of 30 students from the Eastern University to lead an intensive, 30-day remote (satellite-based) data collection exercise across the six priority DSs and then the rest of the district. Visible buildings, roads and land uses were all digitized in this way. After the initial push, the 10 most promising students were retained for a further two months to create the remaining data, validate results and assist in training DS staff.

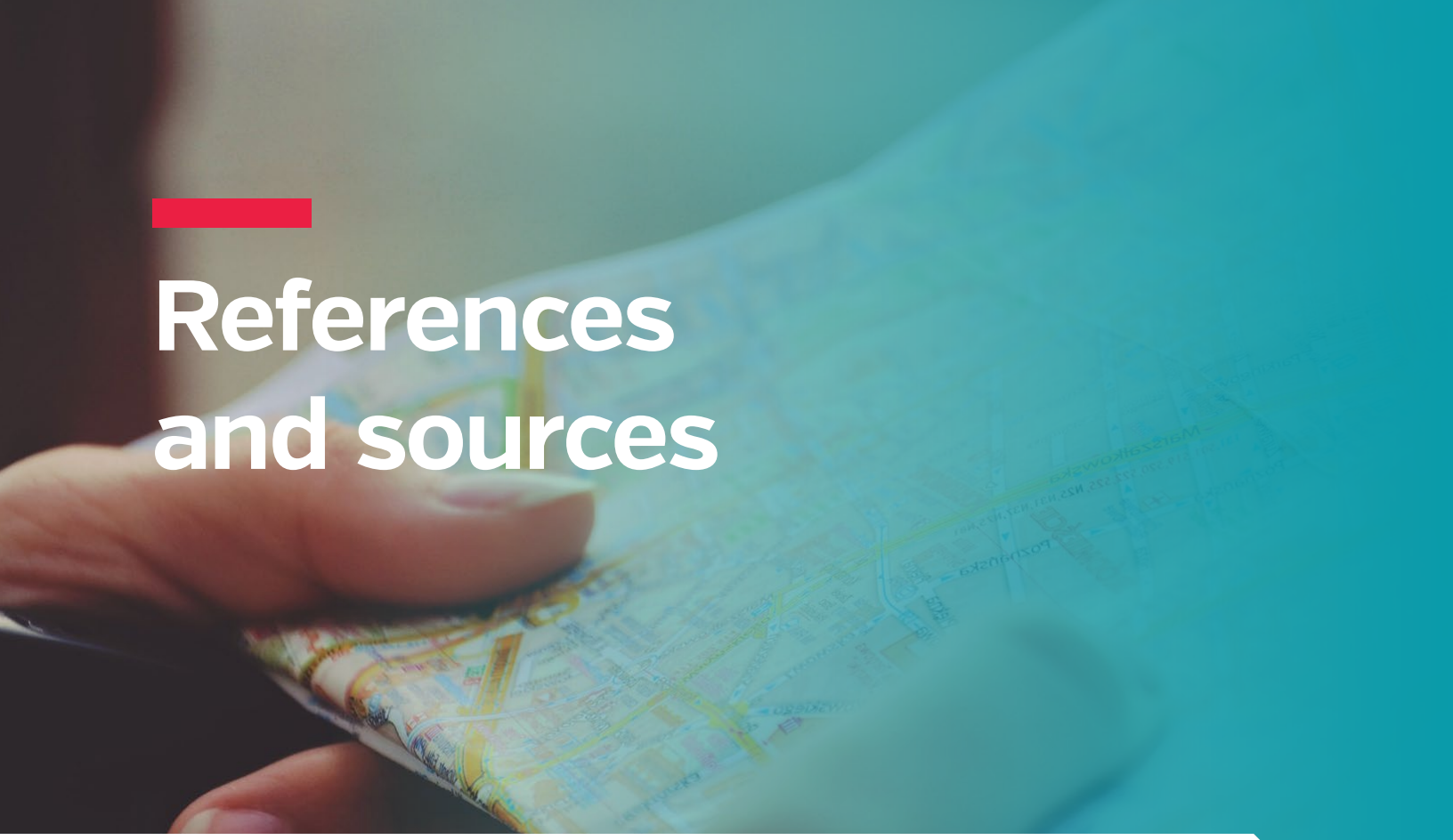
These staff were trained on Field Papers and the iD editor, then deployed across the six priority DSs to collect key infrastructure, street names, road conditions, land uses and other crucial data for disaster management, transport planning and normal business operations. By the end of the project, over 160,000 buildings and 500km of roads has been digitized.

The goal of the project was not merely to create useful data but equip the government to use and maintain it. To do this, it collaborated with an ongoing, multi-year UNDP project to upgrade the GIS capacity of the Batticaloa district and DS governments. The UNDP saw an opportunity to create more and better data for newly trained officers to use with their new skills; the project team saw an opportunity to make their work sustainable. Staff were trained to collect, use and update OSM data. Training covered OSM editing software, field data collection methods, downloading OSM data and using it with the industry-standard ArcGIS software provided by the UNDP. At the project's conclusion, a series of thematic maps was prepared by the newly trained DS staff for the six priority DSs. The data is now

freely available on OSM and in the government geospatial data sharing platform RiskInfo (www.riskinfo.lk).

Main lessons:

- Previous experience on crowdsourced projects can greatly facilitate the adoption and development of new efforts, both at community and authority level.
- Funding and active support by international (and experienced) organizations considerably contributes to the success of the project.
- Being part of a greater project means smaller projects can benefit from the experience developed so far.



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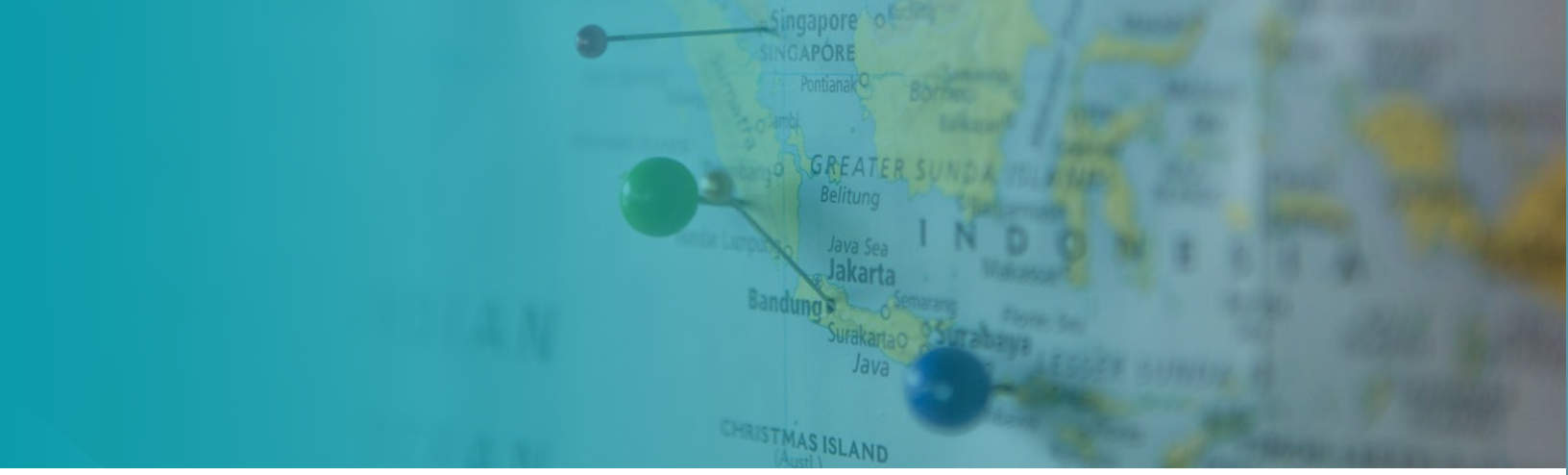

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