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To the reader

This publication is part of the *"Integrated Flood Management Tools Series"* being compiled by the Associated Programme on Flood Management. The *Crisis Mapping and Crowdsourcing in Flood Management* Tool is based on available literature and draws on the findings from relevant works wherever possible.

This Tool addresses the needs of practitioners and allows them to easily access relevant guidance materials. The Tool is considered as a resource guide/material for practitioners and not an academic paper. References used are mostly available on the Internet and hyperlinks are provided in the References section.

This Tool is a "living document" and will be updated based on sharing of experiences with its readers. The Associated Programme on Flood Management encourages flood managers and related experts around the globe who are engaged in the Social Impact Assessment or whose activities are related to the perception of risk by social actors to participate in the enrichment of the Tool. For this purpose, comments and other inputs are cordially invited. Authorship and contributions will be appropriately acknowledged. Please kindly submit your inputs to the following email address: apfm@wmo.int under Subject: *"Crisis Mapping and Crowdsourcing in Flood Management"*.

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Note

This publication is part of the Flood Management Tools Series being compiled by the Associated Programme on Flood Management. The present Tool Crisis-mapping and Crowdsourcing in Flood Management is based on available literature and draws findings from relevant works wherever possible. It addresses the needs of practitioners and allows easy access to relevant guidance materials. The Tool is considered as a resource guide/material for practitioners and not an academic paper. References used are mostly available on the Internet and links are provided in the References section.

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PART I

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CROWDSOURCING AND CRISIS-MAPPING

1 This chapter is focused on crowdsourcing as an innovative and useful approach for facilitating crisis-mapping as a whole. To that end, a first definition is provided of the notions of "crowdsourcing" and "crisis map" and of their relationships. There follows a description of their characteristics, both in terms of benefits/potentialities, and in terms of limits (and related possible solutions). Thirdly, some well-liked crisis-mapping platforms are briefly described.

1 WHAT ARE CROWDSOURCING AND CRISIS-MAPPING?

2 In the following pages we provide some definitions of what are crowdsourcing and crisis-mapping. These are new ways of organizing the collection and dissemination of information and to produce knowledge, with important impacts on the practical level[1].

1.1 Definitions

1.1.1 Crowdsourcing

3 The term "crowdsourcing" was coined in 2005 by Jeff Howe and Mark Robinson, editors at Wired Magazine, to describe the act of obtaining information, ideas and services from a large group of people. The notion of crowdsourcing is now closely linked to the potential and developments of information and communications technology, and in particular the Internet and social media **(Box 1)**.

Box 1 — Definitions of crowdsourcing: examples

Simply defined, crowdsourcing represents the act of a company or institution taking a function once performed by employees and outsourcing it to an undefined (and generally large) network of people in the form of an open call. This can take the form of peer-production (when the job is performed collaboratively), but is also often undertaken by individuals. The crucial prerequisite is the use of the open-call format and the large network of potential labourers. (crowdsourcing.typepad.com/cs/2006/06/crowdsourcing_a.html)

Crowdsourcing is *"the practice of obtaining needed services, ideas, or content by soliciting contributions from a large group of people and especially from the online community rather than from traditional employees or suppliers."* (www.merriam-webster.com/dictionary/crowdsourcing)

1 For the sake of easy reading, some bibliographic citations inside the boxes have been omitted in the text. For these, please refer to the original texts mentioned or their weblinks.

Box 1 — Definitions of crowdsourcing: examples *(continued)*

Crowdsourcing is the process of getting work or funding, usually online, from a crowd of people. The word is a combination of the words "crowd" and "outsourcing". The idea is to take work and outsource it to a crowd of workers. A well-known example is Wikipedia. Instead of Wikipedia being created as an encyclopedia on its own, hiring writers and editors, a group of people were given the ability to create the information on their own. The result of this approach is probably the most comprehensive encyclopaedia in the world, with more than 5 million articles at the end of 2015. In terms of quality control, the principle of crowdsourcing is that by canvassing a large crowd of people for ideas, skills or participation, the quality of content and idea generation will be superior than with a single, specialized source, i.e. *"several heads are better than one"*.

(Adapted from dailycrowdsource.com/training/crowdsourcing/what-is-crowdsourcing)

4 The word crowdsourcing is used for a wide group of activities that take on different forms. Based on a comparative study, an overall definition of crowdsourcing was attempted:

> *"Crowdsourcing is a type of participative online activity in which an individual, organization, or company with enough means proposes to a group of individuals of varying knowledge, heterogeneity, and number, via a flexible open call, the voluntary undertaking of a task. The undertaking of the task, of variable complexity and modularity, and in which the crowd should participate bringing their work, money, knowledge and/or experience, always entails mutual benefit. The user will receive the satisfaction of a given type of need, be it economic, social recognition, self-esteem, or the development of individual skills, while the crowdsourcer will obtain and utilize to their advantage that what the user has brought to the venture, whose form will depend on the type of activity undertaken"* (Estelles Arolas and González-Ladrón-De-Guevara, 2012).

5 There are several forms of crowdsourcing. For instance, a problem-based typology of crowdsourcing approaches encompasses (Brabham, 2013):

- Knowledge discovery and management: for information-management problems, where an organization mobilizes a crowd to find and assemble information; ideal for creating collective resources;
- Distributed human intelligence tasking: for information-management problems where an organization has a set of information in hand and mobilizes a crowd to process or analyse the information; ideal for processing large datasets that computers cannot easily do;
- Broadcast search: for ideation problems where an organization mobilizes a crowd to produce a solution to a problem that has an objective, provable correct answer; ideal for scientific problem-solving;
- Peer-vetted creative production: for ideation problems where an organization mobilizes a crowd to produce a solution to a problem which has an answer that is subjective or dependent on public support; ideal for design, aesthetic, or policy problems.

1.1.2 Crisis-mapping

6 The crisis map is a real-time gathering, display and analysis of data during a crisis, including political, social and environmental ones, having different development intensity (from slow-burn crises to sudden-onset disasters). Crisis-mapping allows a large number of people to control, even at a distance, the carrying out of a crisis, by providing information to manage it.

7 As described by Patrick Meier (Meyer, 2011), *"Crisis-mapping can be described as a combination of three components: information collection, visualization and analysis. All of them are incorporated in a dynamic, interactive map"*. A possible taxonomy includes:

– Crisis-map sourcing (about the multiple methodologies and technologies that can be used for information collection);
– Crisis-map visualization (about rendering the information collected on a dynamic, interactive map in such a way that the rendering provides maximum insight into the data collected and any potential visual patterns);
– Crisis-map analysis (about the application of statistical techniques to spatial data for pattern detection, etc.).

1.2 Crowdsourcing in crisis-mapping

8 After a brief definition of crowdsourcing and crisis-mapping, some basic information is provided below on the relationship between these two types of activity, focusing on two important aspects: the "mashup" and the management of "big data". The evolution of the use of multi-stakeholders' information before and after the advent of the Internet will then be considered.

1.2.1 Crowdsourcing, crisis-mapping and mashup

9 "Mashup" is an emerging technique in the context of crisis-mapping, especially through social media. A "mashup" can be described as the combination of multiple sources of data that are then displayed on a map **(see Box 2)**.

Box 2 — Mashups

The mapping of crisis information online is on the rise among non-professional cartographers. Map "mashups" result from social media or web 2.0 technology. Map mashups combine or "mash up" multiple sources of data, which are displayed in some geographic form. "Participatory" forms of geo-technology – such as Google My Maps – make maps and geographical information relatively accessible. Obligations of accuracy and careful interpretation do fall (expectedly and unexpectedly) to the neo-geographers who pursue this new form of technical enterprise. The rise of the neo-geographer in the hazards and crisis context is of particular interest, as the desire to mitigate crises through some sort of participation and assistance by members of the public is strong.

(Liu et al., 2010)

1.2.2 Crowdsourcing, crisis-mapping and "big data"

10 Crowdsourcing and crisis-mapping have to deal with the management of large amounts of data from very different sources: data from structured sources (databases), data from semi-structured sources (metadata tagging) and data from unstructured sources (social media). Hence, big data describe the availability of data that are generated every second by individuals, businesses and governments. As the technology sector is constantly expanding in an era of open-source coding and embraces real-time and user-generated content, the amount of available data would grow exponentially every year (Bajoghli , Mantaro and Horowitz, 2015). The theme of the so-called "big data" is therefore deeply connected to what interests us in this Tool.

11 "Crisis-mapping is the use of real-time crowdsourced crisis event data, satellite images, data visualization, data modelling and web-based applications to develop early warning and response systems for use in crisis events worldwide. Crisis mappers perform big data analytics and data-mapping in order to glean insights about what and where crisis events are occurring on a real-time basis" (Pierson, 2012). An example is provided in **Box 3**.

Box 3 — Crisis-mapping during Typhoon Pablo

Days before Typhoon Pablo made landfall in the Philippines, the Philippine Government began to inform its citizens about what Twitter hash tags to follow and tweet during the emergency event. After the typhoon hit land, the United Nations Office for the Coordination of Humanitarian Affairs (OCHA) activated the Digital Humanitarian Network and tasked the Network's stand-by volunteer task force with monitoring and analysing all tweets generated within the first two days of the event. This analysis had to be completed and results submitted to the United Nations within 12 hours.

The taskforce utilized crowdsourcing and the Pybossa microtasking platform in order to isolate and analyse over 20 000 tweets that provided information and video footage about damage caused by the disaster. The results of this analysis were then taken by OCHA and used to generate the crisis map. This is the first-ever United Nations crisis map that was generated solely from social media data. It was used as part of the coordinated damage assessment support that was led by OCHA.

(Pierson, 2012)

1.2.3 Crowdsourcing in crisis-mapping before and after advent of the Internet

12 The use of crowdsourcing (or other forms of collection of information from a large number of citizens) in crisis-mapping did not begin with the advent of the Internet. Several research experiences have shown the empirical importance of collecting "popular information" on environmental and social risks. An example among the first is a research carried out by the *Centre for Research and Documentation February 74* (CERFE) on hydro-geological risk factors, made in Italy between 1986 and 1987, which resulted in an inventory of landslides in all municipalities at risk in this country, making use of knowledge locally available (CERFE, 1987).

13 Under several UN projects, similar mapping of social and environmental risks has been developed in some parts of the world. A prototype of this kind of activity, the PRODERE programme (Development project for displaced, refugees and returnees) was thus applied in Central America by the United Nations Development Programme (UNDP), the United Nations Office for Project Services, the Pan American Health Organization, the United Nations High Commission for Refugees and the International Labour Office[2]. The interaction between local communities and technicians led to the identification of a set of environmental and social risk factors affecting several communities involved in the programme and to illustrate them on maps (UNDP, 1996). Similar actions were carried out around the world, including Cambodia, Mozambique, Angola and in the Balkan region.

14 The mapping of the environmental and social risks, therefore, can also rely on popular information (provided by the general public), based on the "somatic" memory (that is internal and non-

2 An example of maps prepared following the PRODERE approach (but some years later) is available at: www.ucl.ac.uk/drrconference/posters/LBowman.pdf

verbal) and "extra-somatic" (that is recorded in a document) of the populations inhabiting a given territory.

15 Since then, it has emerged as a key issue (see also below), as to how popular information should be carefully considered by technicians (although it may be biased by their subjectivity). Convergence points can then be observed between "technical knowledge" and "popular knowledge".

16 Latterly, the Internet has facilitated the collection and utilization of popular knowledge in the management of natural hazards. **Box 4** contains an interesting example of the transition towards the use of the Internet in crowdsourcing.

Box 4 — Collaborative response during a crisis: crowdsourcing is key!

Experiences in designing collaborative responses during crises were carried out even before the development of social media and the Internet. In the early 1990s (when the Internet was not yet widespread and browser-available), during a customer co-design session in New York, a group of more than 100 clients was required to design a "crisis response" system that could be used to coordinate government agencies, non-governmental organizations (NGOs) and subject-matter experts around the globe whenever a crisis (natural or man-made) occurred.

One of the issues the group was asked to consider by Mitre Labs (the NGO that mandated the workshop) was the "problem statement" that once two or three different emergencies occurred around the globe, traditional media (e.g. CNN) provision of real-time video coverage and reporting was not sufficient to cover the information needed by Mitre Labs to take appropriate action. The conclusion of this group predicted fairly accurately a near-term solution that would take advantage of Internet standards and information exchange and ad hoc conferencing calls, with quick-and-cheap-to-deploy emergency communication equipment, including video, cell phone or satellite phone, to get the required information from cross-disciplinary subject matter experts to Mitre Labs, who could then provide advice and support.

A few years later, once Internet technology was affordable and widespread, the foreseen ad hoc real-time crisis collaboration is standard practice: using Internet standards, video feeds, mapping tools, mobile phones and global networks, Mitre Labs can efficiently coordinate and intervene to respond to crisis situations.

The key difference in what was envisioned in the early 1990s and what has been experienced two decades later is that, at the time, focus was given to getting information from cross-disciplinary subject matter experts who could then provide advice and support; whereas today "citizen journalists" – engaged people who are on site and have the "ground truth" – are often the most important asset in times of real crisis for Mitre Labs (and other crisis-response NGOs).

(Adapated from Seybold, 2010)

1.3 Collaborative production of knowledge

17 The advent of new information and communications technology, and the ongoing debate about the way knowledge is produced and shared in the contemporary world, are shedding light on the existence of new forms of "collaborative production of knowledge", where knowledge is elaborated by multiple actors in synergy.

18 If we consider the experience of Wikipedia and other forms of knowledge-processing through the Internet and social media, we note that contemporary notions of knowledge production and intellectual property are challenged by forms of authorship that defy romantic ideas of the singular, creative genius author. They require the active rather than passive consumption of knowledge and blur the distinction between producers and consumers; they even raise concerns about the reliability of knowledge and responsibility (Höppner, 2010).

19 Even in the field of scientific research, there is growing awareness that science is not responding adequately to the global challenges of the 21st century. Addressing complicated, "wicked" current and future environmental issues requires, first of all, theoretical approaches, insights and methods from many disciplines. Furthermore, to reach social robustness in a context of uncertainty and multiple values and objectives, the participation of relevant social actors is required. As a consequence, interdisciplinary research teams with stakeholder or practitioner involvement are becoming an emerging (although not yet consolidated) pattern for the organization of integrative scientific research or integrated assessments (Podestà et al., 2013).

20 If we take into account this context, we can consider crowdsourcing in crisis-mapping as a specific form of collaborative production of knowledge, having very important practical effects. An example of "collaborative production of knowledge" and crowdsourcing in crisis-mapping is the so-called "volunteered geographic information", in which the production of information is carried out by both experts and citizens, through the new technologies related to the Internet (see **Box 5**).

Box 5 — Collaborative production of knowledge, volunteered geographic information, crowdsourcing in crisis-mapping

With the advancement of Internet and mobile devices, users start not only to use the geographic information available online, but also provide it. Formerly, geographic information was created only by official agencies. However, with the increase of interactions made possible by Web 2.0, the widespread use of devices equipped with GPS (Global Positioning System) and the availability of broadband access to the Internet, geographic information is being produced by people who have little formal qualification. This type of information is called volunteered geographic information (VGI).

Among the advantages associated with VGI, researchers emphasize its use to enhance, update or complement existing geospatial datasets. Recent natural disasters have shown that volunteered information, provided through the Internet, can improve situational awareness by providing an overview of the present situation. This is because VGI offers a great opportunity to raise awareness due to the potentially large number of volunteers – more than six billion people – who can potentially act as "sensors", recording important parameters for disaster management in a local environment.

Currently, several crowd-sourcing platforms support disaster management, enabling the gathering of information from citizens about the affected areas, as well as their analysis and visualization. The term crowdsourcing refers to a way of organizing the work, which involves an information system to coordinate and monitor tasks performed by people. Moreover, this term can be understood as a production model where the intelligence and knowledge of volunteers are used to solve problems, create content and develop new technologies.

Volunteers performing a specific task, such as environmental monitoring, collectively make a citizen observatory (CO), where data can be collected, collated and published. Thus, the term citizen observatory can be understood as a software platform for obtaining volunteered information about a specific topic through different devices (e.g. Web browser, mobile application and SMS) and allow their visualization.

(Adapted from Castro Degrossi et al., 2014)

2 BENEFITS AND POTENTIALITIES

21 We shall now try to identify some benefits and potentialities of crowdsourcing applied to crisis-mapping at large. These benefits and potentialities are of different kinds.

2.1 Magnitude

22 A first element is connected to the huge availability of networks for the collection and dissemination of information related to the most popular network. According to the online statistics portal Statista[3], as of November 2015, ranked by number of active accounts, Facebook was the most popular network worldwide. Facebook surpasses 1 billion registered accounts, followed by WhatsApp with 900 million accounts. The photo-sharing app Instagram had over 400 million monthly active accounts. Blogging service Tumblr had more than 230 million active blog users on their site, and Twitter had 316 000 accounts.

23 Compared to traditional media and the manner in which news is disseminated, social media are able to create a dense network of observers who are able to rapidly publish and share information. This is a powerful tool for crisis communication. The benefit of social media for crisis management is that it is created by a crowd and available to all. Rapid sharing of information would not be possible without such openness. This developing culture of "open data" exchange is important because those data can be recycled in many forms and re-used in ways not necessarily intended by the original creator to produce new information and insights (Bielski and Zeug, 2015). For example, pictures of flooded areas taken by citizens to document damages to their property, can be analysed later on to reconstruct a map of flooded areas in a specific event.

3 www.statista.com/statistics/272014/global-social-networks-ranked-by-number-of-users/

2.2 Flexibility and speed

24 Another benefit of crowdsourcing applied to crisis-mapping is its flexibility, linked to the speed of information circulation. As noted, an important emphasis is today placed on flexibility in response speed, above all in developing countries, so that emergency responders can adjust their actions to changing demands. "Informal data sources, such as crowdsourcing, along with advances in wireless infrastructure, GPS capabilities, sensors, and others, allow resilient cities to communicate forecasts and advisory information to those in affected areas prior to a disaster, and effective advice during and afterward. Thus social media – through pre-existing social structures, as well as communication infrastructure – reduces the impact of disasters by community engagement and improved real-time management of information" (Zook et al., 2010; Tierney, 2014).

Box 6 — Local reporting

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

(Zook et al., 2010)

2.3 Cheapness and optimization

25 For various reasons, another important feature of crowdsourcing applied to crisis-mapping is its cheapness. In fact, by using crowdsourcing, technical infrastructure, tools, and existing human resources are optimized on a large scale, with lower investments (e.g. for software and platforms – see below) than those traditionally used in crisis-mapping (see **Box 7**).

Box 7 — Working with limited resources

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

(Zook et al., 2010)

The main advantages of the combination of online volunteering, crowdsourcing and crisis-mapping lie in the ability to process large amounts of data from affected populations in real-time and distil the most critical information from them. Workflows and tasks (or rather micro-tasks) can be very flexible and complement the face-to-face information-sharing often impossible due to human resources constraints and logistical problems.

(Zgrzywa, 2012)

Box 7 — Working with limited resources *(continued)*

Social media today have become an important information channel. Citizens use platforms such as Twitter and Facebook to report their observations and inform friends and families about their well-being. They can also send help requests directly to emergency response organizations. These same organizations use social media to inform citizens about their response activities and the overall emergency situation. This novel two-way information flow is also much faster than traditional disaster communications because the crowd can have eyes in many more places at once. One of the advantages of this form of communication is that the sender using a mobile device can provide descriptions, pictures and location information. Plus, the large amount of data being made available makes it possible to build a comprehensive situational overview.

(Bielski and Zeug, 2015)

2.4 Accuracy

26 Accuracy is a further important benefit of crowdsourcing applied to crisis-mapping. Actually, the information and communication technologies applied within the context of disasters allow for an exchange and reciprocity between those providing information and those seeking it.

27 By using this approach, not only can experts provide assistance from non-proximate locations, but locals can also actively seek out this help in order to gain access to otherwise inaccessible information. This is the case not only for immediate response to disasters, but also for gaining a more complete picture of potential secondary effects, which can foster elements of estimates, as already mentioned above (Zook et al., 2010).

2.5 Broader citizens/societal engagement and awareness

28 It has been recently stated that crowdsourced crisis-mapping represents a significant step towards bridging the gap between the formulating and sharing of knowledge and action based on that information[4].

29 By engaging with various kinds of stakeholders, including government officials, local communities and organizations and the private sector, crowdsourced crisis-mapping helps to raise disaster awareness, increase the understanding of risk and encourage cooperation, thus strengthening the collective resilience and related action of affected communities in many ways. Specific apps, social media, participatory mapping tools, local language materials and training programmes, as well as working closely with local partners, can help increase programme outreach and strengthens stakeholder engagement (Gunawan, 2013) (See also **Box 8**).

4 theconversation.com/crowdsourced-crisis-mapping-how-it-works-and-why-it-matters-7014

Box 8 — Crowdsourcing as a participatory action

Crowdsourcing efforts can contribute to emergency assessment in two different ways: (a) citizen development of software platforms that contribute voluntary information regarding response needs and activities (however, this effort requires technical expertise) and (b) crisis-mapping that redraws or updates online maps of disaster-stricken areas. Here, little or no technical expertise is needed to participate. Ad hoc software platforms, developed by volunteers, allow citizen users to combine best practices with user-friendly social media toolkits for risk mitigation and community response. They also allow for crowd-vetting of information. In less than two years, open-source platforms have helped hundreds of thousands of people to find information, aid, and assistance with recovery efforts.

(Tierney, 2014)

2.6 Solidarity action

30 For the various reasons already mentioned, crowdsourcing, applied to crisis-mapping, also improves the actions of solidarity in favour of those most in trouble and who need special and urgent interventions. Tools such as Twitter, Facebook and others help international agencies, municipalities, and citizens' organizations in providing support to the weakest and most disadvantaged in crisis situations (See **Box 9**).

Box 9 — Using social media for local solidarity

Communication in crisis situations is a key factor in mitigating risks which requires the coordination of the authorities and the participation of organizations and civil society. The use of social networks has not only transformed the perception of risk and crisis, but expectations about the emergency response by public administration, private sector and voluntary organizations. Besides, YouTube, Facebook and Twitter became the best sources of information in real time about what is happening, by its popularity, low cost, easy user access and use worldwide.

The Alberta fire in Canada in April/May 2016 devastated Fort McMurray and forced the evacuation of more than 90 000 persons. Under these circumstances, telephone systems collapsed, websites failed and radio stations went off air. Social media therefore became a good and useful alternative to maintain communication with the affected area and to create the only communication lifeline for many people.

In addition to the existing twitters (@511Alberta, @YMMHelp or @Ftmcmurrayfire), an important number of hashtags were created (#Ymmfire, #Formacfire, #Albertafire) to help the population keep up with the latest details on mandatory evacuations, evacuation routes and the shelters location **(Figure 1)**. The role of emergency services and government agencies are as important as the crowdsourced resources for evacuees. Facebook played therein a key role helping small groups of neighbours and friends to raise funds.

Figure 1 — Tweets from people offering assistance and Fort Mcmurray Evacuee Open Source Help Page

2.7 Improved governance in areas of limited statehood

31 In light of the above considerations, it is evident that the typical tools of crowdsourcing applied to crisis-mapping can be particularly valuable in situations where the national authorities are weaker for various reasons, as a result of diverse political, economic and social contexts.

32 For instance, in several contexts, there is a very limited capacity of the State to provide effective emergency response. Information technologies – and crowdsourcing tools and platforms in particular – can help in filling the gap of the limited statehood, enhancing the available resources and interpersonal relations already existing at the local level (Livingston and Walter-Drop, 2014).

Box 10 — Crisis maps and crowdsourcing in areas of limited statehood

Crises can present challenges to governments, but they can also lead disaster-affected communities to adopt collective, self-help actions – particularly in areas of limited statehood – where central government lacks the capacity to implement policies or carry out relief and rescue operations.

Such collective action, facilitated by new information and communication technologies, has grown and developed and one of the results has been the production of live crisis maps that identify the impacts of a given crisis, along with needs for services that are normally provided by the government. These subnational crisis maps are often crowdsourced in near-real time. They empirically reveal the sectors where governance is limited, as well as the ways in which power is both perceived and projected.

(Livingston and Walter-Drop, 2014)

3 LIMITS AND POSSIBLE STRATEGY SOLUTIONS

33 After illustrating some benefits and potentialities of crowdsourcing applied to crisis-mapping, we can now examine some limitations of this approach. The identification of such limits also leads to identifying specific proposals for solutions.

3.1 Data validity

34 One important issue related to crowdsourcing is related to the validity of the data generated by the particular relationship between professionals and amateurs. In other words, the question generally is *"Are the data produced by crowdsourcing applied to crisis-mapping reliable?"*.

35 This question is illustrated in **Box 11**.

> Box 11 — The accuracy and validity of information in crowdsourcing
>
> Reliance on crowdsourced labour has led, however, to a return to concerns regarding the accuracy and validity of data that are not being centrally managed. Will the maps be as good as the traditional means of mapping in disaster situations or will they contain flaws that would have been prevented by professional cartographers? While this remains a point of debate, a key benefit of peer-produced knowledge is the idea that with enough people working together, any errors by one individual can be easily corrected by another. Indeed, this crosschecking by many can be used as an argument for the superiority of peer-produced mapping over more traditional means. It has even been argued that Internet users are faster to report earthquakes than are the seismological procedures currently in place.

Box 11 — The accuracy and validity of information in crowdsourcing *(continued)*

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

(Adapted from Zook et al., 2010)

36 A particular aspect of data validity (e.g. in VGI) is the credibility of the sources. But, more generally, it is noted that this type of collection and processing of information is poorly structured, documented and validated (see **Box 12**).

Box 12 — Some limits of volunteered geographical information (VGI)

Despite the potential of VGI, data quality is a major concern. Information from many individuals can lead to doubts about their credibility. (…) the credibility of VGI can be understood as a subjective concept that describes whether a piece of information can be trusted, considering any possible intentional or unintentional omission or exaggeration error. Moreover, it is not known beforehand how and from where the information will be provided.

Another challenge refers to the location, because volunteers are in constant movement.

Furthermore, VGI is often regarded as poorly structured, documented and validated. In this scenario, different software platforms have been employed in order to collect volunteered information, allowing its visualization and analysis. In particular, these are used as tools to help the victims of natural disasters (Castro Degrossi et al., 2014).

While social media platforms are contributing to greater urban resilience, problems with volunteer-produced information still persist. Social media does not automatically provide the coordination capability for easily synchronizing and sharing information, resources, and plans among disparate relief organizations.

While initiatives such as Ushahidi **(see Section 4.1)** and Innovative Support to Emergencies Diseases and Disasters (INSTEDD), among others, are attempting to resolve this problem, United Nations policy analyst Bob Narvaez says that humanitarian agencies, governments and local communities must work to develop platforms that accommodate two important features: (a) information flows must be reciprocal to be effective, which means agencies need to be able to easily communicate with citizens and vice versa; and (b) information must also come from trusted sources for it to be useful.

Authentication of information is crucial because of the obvious risks associated with an unregulated stream of information, especially as it can spread misinformation rapidly online. As is often the case, disasters present a context in which uncertainty and high stress are prevalent, which is why information ideally needs to be transparent, accurate and accessible beforehand.

(Adapted from Tierney, 2014 and Degrossi Castro et al., 2014)

37 Taking into account these critical remarks, there is the need for common and structured procedures for verification of submitted data.

3.2 Data quality and quantity

38 Another open question linked to crowdsourcing applied to crisis-mapping is that of data quality and quantity. Are data in a usable format? How to manage a large amount of data?

39 In this regard, what is commonly a strength of crowdsourcing can become a point of weakness, if not managed properly. Before dealing with data coming from a crowdsourcing approach, analysts should organize and compartmentalize information systematically and take note of signal error (large gaps of data) and confirmation bias (the use of data to support a pre-existing viewpoint), otherwise they could reach skewed conclusions that lead to detrimental outcomes (Bajoghli, Mantaro and Horowitz, 2015). Some 16% of the population uses Twitter. They are mainly younger, wealthier and more urban than the general population. When analysing Twitter data during a disaster, therefore, response agencies must ensure that poorer and less urban areas are not being overlooked. For example, most of the 20 million tweets posted during Hurricane Sandy originated from Manhattan. While Seaside Heights and Midland Beach were much more affected than Manhattan, fewer tweets came from these areas due to power outages, uncharged phone batteries and lower concentration of Twitter users. If an analyst had falsely concluded – based on the number of tweets – that Manhattan suffered more damage from Sandy, supplies could have been sent to the non-priority areas (Bajoghli, Mantaro and Horowitz, 2015).

40 Experiences in this field so far have allowed the identification of several issues (e.g. how to structure the information flows, how to filter the large amount of messages, how to use Twitter messages lacking proper grammar, or using abbreviations and slang words, etc.) but also come up with some effective solutions, such as coordination among actors, structuration of processes, training for civil protection/emergency response operators , establishing feedback mechanisms between volunteers and people on the ground, and others (for an example, see **Box 13**).

Box 13 — Managing information flows: some lessons learned

Both the strength and weakness of crowdsourced information management derives from its participatory openness. Making sense of received text messages and categorizing information appropriately has been a consistent challenge.

The importance of filtering and verifying text messages or crowdsourced information in general is among the lessons learned from the Haiti experience. Most of the criticism of crowdsourced crisis-mapping as was conducted in Haiti targets the overflow of information and lack of coordination with humanitarian agencies for immediate action.

Such criticism, however, comes at a time when the active online community has already progressed substantially.

The Standby Task Force, an online volunteer community, has incorporated lessons learned and improved processes through simulations and training for deployments with a much more structured framework and a comprehensive, modular approach to the various steps of crisis-mapping”

(Bott and Young, 2012).

Box 13 — Managing information flows: some lessons learned *(continued)*

Moreover, many tools are available to address the task of organizing and analysing the multitude of available data. For example, Artificial Intelligence for Disaster Response (AIDR — aidr.qcri.org/) is a free and open-source platform that identifies relevant and actionable content in real time. It identifies Tweets related to natural disasters, tags them and "trains" the system to identify relevant posts.

(Bajoghli, Mantaro and Horowitz, 2015)

Many organizations have expressed an interest in using this platform, including the International Committee of the Red Cross, the American Red Cross, Federal Emergency Management Agency (FEMA), New York City's Office for Emergency Management and its counterpart in the San Francisco.

3.3 Difficulties in forecasting events

41 A major limitation of crowdsourcing applied to crisis-mapping is its limited (for now) ability to forecast events. If, on the one hand, crowdsourcing is effective in managing crisis situations as they occur, or immediately afterwards, this is not the case with regard to forecasting and preventing.

42 It has been noted that, while some observatories created to provide information about a crisis are used to provide information about the impacts caused by floods and their victims, they do not provide information to prevent or minimize the impacts of those events. In addition, these observatories do not have any kind of integration with spatial data infrastructures as they are employed only to obtain volunteered information (Castro Degrossi et al., 2014).

43 It is clear that, at this level, a major effort is needed on the side of theoretical and methodological research.

3.4 IT infrastructure accessibility

44 A further limitation of crowdsourcing applied to crisis-mapping is related to the digital divide and consists in that, despite the increasing popularity of mobile phones and the Internet around the world, there are, in any case, large segments of the population (especially among the poorest) that do not have access, or who have limited and intermittent access, to these resources, or through others.

45 Closely related to this problem is the unequal distribution of skills (i.e. between the young and the elderly) necessary to use the new tools of information and communication. All this can be addressed and solved only through appropriate strategies of development and democratization on a global, national and local scale (see **Box 14**). For example, in areas with limited or no telephone network/no Internet access, disaster information must be given mainly through other means, which could include – depending on the local context – siren alarms, warning flags, information meetings, door-to-door messengers, etc.

Box 14 — Inequality in accessing proper information and communication tools

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

(Adapted from Zook et al., 2010)

3.5 Privacy, security and ethical concerns

46 Another important critical aspect to be considered, not only in environmental crises, but also in political ones, is that of privacy and the security of the people involved in gathering information in the field. Facebook and Twitter employ the practice of "notice and consent" to obtain their customers' permission to share personal information with third-party companies. This practice is unfairly in the provider's favour because it offers complex and non-negotiable terms that the user must evaluate within a few seconds.

47 Other smartphone applications which many people use regularly, such as Instagram, Tumblr and Snapchat, allow individuals' locations and other information to be sent and identified by one simple swipe of the geotag filter. Hence, the question is how this information can be used to enhance disaster relief in times of crisis, while maintaining the individuals' privacy and well-being (BajoghliR., Mantaro and Horowitz 2015).

48 Furthermore, in the case of situations where crowdsourcing comes from individuals and groups of people with a critical attitude towards the government or where human rights violations are reported, it is important to ensure the protection of sources (see **Box 15**).

Box 15 — The safety of sources

In politically sensitive environments, building a set of trusted information sources may involve major security issues. It can seriously compromise the safety of the people who originally published information on social media. The crisis-mapping community is currently developing general standards and the ethical, privacy and security issues that need to be carefully addressed in each case where crowdsourced crisis-mapping is deployed. To protect and maintain the ability of human-rights activists to operate in this digital space, a renewed framework or "relational law", is required, that can bring technology, networked governance and legal protection together.

(Adapted from Poblet and Casanovas, 2012)

49 This issue, therefore, has also a specific ethical relevance. It is important to ensure the protection of persons putting sensitive data online. In addition, with the exponential growth of data, it is important to determine more accurately the statutory liability of the bodies governing the collection, organization and dissemination thereof.

3.6 Integration with other information collection systems

50 Another important open issue for crisis-mapping today is the integration of new information and communication tools, used by crowdsourcing operators, into other "traditional" information collection systems, such as sensors and other surveillance systems (see **Box 16**).

Box 16 — Social media and conventional information collection systems

During the sudden catastrophic events that have occurred in this last decade, social media have proven their importance in the creation and management of ad hoc crisis communities. These platforms are increasingly used as complementary support tools for conventional crisis management teams. During recent disasters (e.g. Haiti, Australia, Japan, Mexico) they "have demonstrated their real potential in providing support to emergency operations for crisis management. However, several questions remain unanswered regarding the efficiency of their usage and, especially, their integration into the conventional information collection systems (technological sensors, cameras, SMS, etc.) usually used for crisis-mapping.

Birregah, 2012

51 In this regard, it is important to carry out specific studies and experiments which take into account both new developments of crowdsourcing in crisis-mapping and the latest developments in the field of surveillance systems. The latter include new forms of "smart surveillance", i.e. the use of automatic analysis technologies in surveillance applications. Smart surveillance may be understood as using technology to collect raw data via interlinked multisensory receptors (including video, audio, etc.) and their automated processing, assessment, analysis and (semi-) automated decision-making upon the gathered data (more information on smart surveillance is available at www.smartsurveillance.eu/).

4 SOME TOOLS AND THEIR USERS

52 To conclude this chapter, a rapid overview is provided of some popular crisis-mapping networks and platforms, to show readers a wide range of opportunities and instruments that could be included in their use. At the same time, we give some information on the actors and networks that have developed and advanced these technological solutions.

4.1 Ushahidi

53 The Ushahidi Web platform is developed by a non-profit, open-source software company. Ushahidi allows people in any part of the world to disseminate and collect information about a crisis. Information can be submitted by users via text message, e-mail or Web postings, and the data are aggregated and organized into a map or timeline. In addition to its crisis-mapping software, the company has also launched a product called Swift River to extract and organize accurate information about a particular crisis event from e-mails, text messages, blog posts and tweets that can seem overwhelming in the first days of a crisis, using machine learning algorithms.

54 The company recently launched a cloud-based version of its basic mapping platform that can be deployed quickly and easily and is hosted on Ushahidi's servers. The basic service is free but plug-ins and upgrades might imply a cost.

4.2 The projects of the International Network of Crisis Mappers

55 The International Network of Crisis Mappers is the world's premier humanitarian technology forum and is presented in **Box 16**.

Box 17 — The International Network of Crisis Mappers

The International Network of Crisis Mappers (Crisis Mappers Net) is the largest and most active international community of experts, practitioners, policymakers, technologists, researchers, journalists, scholars, hackers and skilled volunteers engaged at the intersection of humanitarian crises, new technology, crowd-sourcing, and crisis-mapping. Crisis Mappers Net was launched at the first International Conference on Crisis-mapping (ICCM) in 2009.

Crisis Mappers Net engages more than 8 000 members in more than 160 countries, who are affiliated with over 3 000 institutions, including at least 400 universities, 50 United Nations bodies, first responders operating in both the civilian and military sectors, dozens of leading technology companies, several volunteer and technical community networks and global, national and local humanitarian and disaster response and recovery organizations. Crisis Mappers Net has members with different skill sets and experience in the use of tools covering crowdsourcing, mapping, use of aerial and satellite imagery, geospatial platforms, advanced visualization and computational and statistical models.

This is acknowledged by sources such as the United Nations Office for Outer Space Affairs, UNOCHA ReliefWeb (this network operates at the "intersection of humanitarian crises, technology, crowd-sourcing and crisis-mapping")8 and the Digital Humanitarian Network (DHN).

Crisis Mappers Net works with data from diverse sources leverage mobile and Web-based applications, participatory maps and crowdsourced event data, aerial and satellite imagery, geospatial platforms, advanced visualization, live simulation and computational and statistical models that are used to power effective early warning for rapid response to complex humanitarian emergencies.

Crisis Mappers Net is not an organization or institution. Engaged people have very different goals, aims, strengths, interests, and backgrounds. Therefore, as a network, Crisis Mappers offers a neutral space for conversation and information sharing.

Crisis Mappers Net hosts a biennial conference event, the ICCM. This event showcases best practices and most recent contributions, innovations, and deployments from the global community. Crisis Mappers Net is a member of DHN, the Sahana Software Foundation, Help Earth Foundation, Connected Development and Humanitarian OpenStreet MapTeam.

(Ziemke, 2012)

4.3 Sahana

56 According to its promoters, the Sahana Software Foundation is "dedicated to the mission of saving lives by providing information management solutions that enable organizations and communities to better prepare for, and respond to, disasters." Humanitarian Affairs (OCHA).) (sahanafoundation.org/). *"Sahana"* means *"relief"* in Sinhalese, one of the national languages of Sri Lanka.

57 Sahana was created in Sri Lanka by members of the Sri Lankan IT community who wanted to find a way to apply their talents towards helping their country recover in the immediate aftermath of the 2004 Indian Ocean earthquake and tsunami. The community includes experts in emergency and disaster management as full partners in the software development process. This free and open source software project is supported by hundreds of volunteer contributors from dozens of countries, national and local authorities and relief agencies in their response to numerous large-scale and sudden-onset disasters.

58 It provides services that help solve concrete problems and bring efficiencies to disaster response coordination between governments, aid organizations, civil society and the survivors themselves, such as:

– Reuniting separated families through registering missing and found persons;
– Tracking and managing requests for help from individuals and organizations;
– Tracking organizations and programmes responding to the disaster, including the coverage and balance in the distribution of aid, providing transparency in the response effort;
– Enabling relevant sharing of information across organizations, connecting donors, volunteers, NGOs and government organizations, enabling them to operate as one.

Sahana's three main products:

59 **Eden** is a flexible humanitarian platform which has been built to help in disaster management. It has a rich feature set which is highly configurable to adapt to a wide variety of different contexts integrate with existing systems to provide effective solutions for critical humanitarian needs management either prior to or during a crisis. More information at sahanafoundation.org/products/eden/ and www.slideshare.net/SahanaFOSS/sahana-eden-brochure-10577413.

60 **Vesuvius** is focused on the disaster preparedness and response needs of the medical community, contributing to family reunification and assisting with hospital triage. It also provides client and staff registration capabilities for temporary sheltering and other emergency operations. More information at sahanafoundation.org/products/vesuvius/.

61 **Legacy products**: There are several other versions of Sahana software that are no longer under active development, but remain a rich part of the project's history. These systems were used in response to many disasters and adopted by government agencies and humanitarian organizations for disaster preparedness programmes – many of which are still active today. The most notable of the legacy products is Krakatoa, the direct descendant of the original Sahana code base developed following the 2004 Indian Ocean tsunami.

4.4 Google Crisis Response

62 Google Crisis Response is a team within Google.org that "seeks to make critical information more accessible around natural disasters and humanitarian crises". Google's responses might include: updating satellite imagery of the disaster area, creating a resource page with emergency information and tools, hosting a crisis map with authoritative and crowd-sourced geographic information, charitable donations to organizations on the ground, and engineering products and information services, such as Google Person Finder and Landing Pages, designed to organize and coordinate critical response information (www.google.org/crisisresponse/about/faq.html).

63 The Google Crisis Response Team has responded in the past to many disasters, including the 2013 Alberta flooding (Canada), the 2013 Jakarta flooding (Indonesia), the 2012 Typhoon Pablo (Philippines), the 2011 Christchurch earthquake (New Zealand), the 2011 Tohoku earthquake and

tsunami (Japan), the 2010 Haiti earthquake, 2010 Pakistan floods and 2010/2011 Queensland floods (Australia) (www.google.org/crisisresponse/about/response.html).

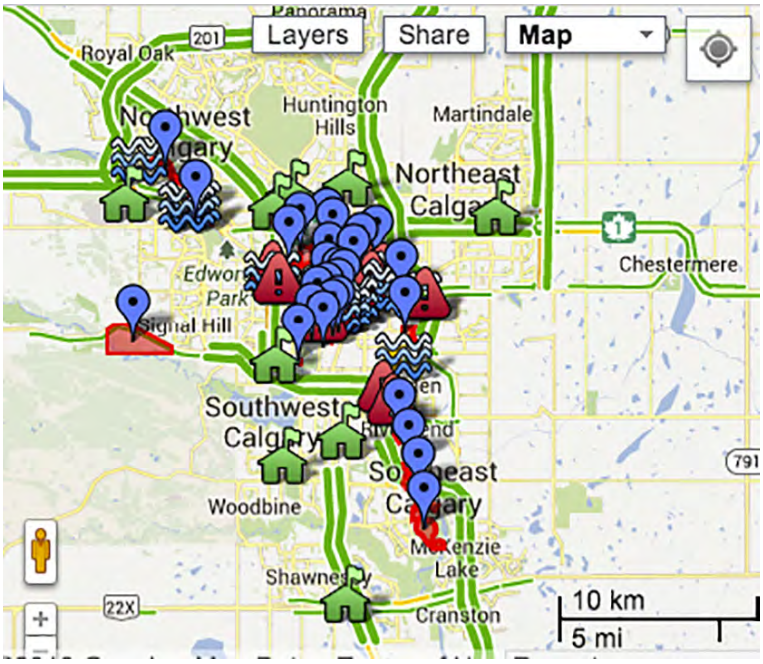

Figure 2 — Google Crisis Map for the 2013 Alberta (Canada) floods with emergency-related information such as evacuation zones, emergency shelter locations, public alerts and traffic conditions (Ng, 2013)

64 Google Crisis Response organizes emergency alerts and news updates relating to a crisis and publishes the information on its Web properties or dedicated landing pages. It also provides opportunities for donations in collaboration with agencies such as the United Nations Children's Fund, Save the Children, International Medical Corps, and local relief-providing bodies. Google also builds and provides tools to help crisis responders and affected people communicate and stay informed, such as Google Person Finder, Google Crisis Map, Alerts Google, Google Earth, Google Fusion Tables, Google Docs, and Google Sites.

4.5 International Charter on Space and Major Disasters

65 The International Charter is an organization aiming at "providing a unified system of space data acquisition and delivery to those affected by natural or man-made disasters through Authorized Users. Each agency member has committed resources to support the provisions of the Charter and thus is helping to mitigate the effects of disasters on human life and property".[5]

66 The organization provides for the charitable and humanitarian re-tasked acquisition of and transmission of space satellite data to relief organizations in the event of major disasters. Initiated by the European Space Agency and the French space agency CNES after the UNISPACE III conference held in Vienna, Austria, in July 1999, it officially came into operation on 1 November 2000 after the Canadian Space Agency signed the charter on 20 October 2000. Their space assets were then ERS and ENVISAT, SPOT and Formosa, and RADARSAT, respectively. The

5 www.disasterscharter.org/web/guest/home;jsessionid=12B23E856B22F87716FF346670083F3E.intlcharter-prod4040

assorted satellite assets of various private, national, and international space agencies provide for humanitarian coverage, which is wide, albeit contingent. First activated for floods in north-eastern France in December 2001, the charter has since brought space assets into play for numerous floods (Argentina, Charter activated on 28 December 2015), earthquakes (Nepal and India, 25 April 2015), oil spills (Vung Tau, Viet Nam, 12 March 2015), forest fires (New South Wales, Australia, 17 October 2013), tsunamis (Chile, 2 April 2014), major snowfall (China, 4 January 2010), volcanic eruptions (Calbuco Volcano, Chile, 23 April 2015), hurricanes (Joachin in Bahamas, 6 October 2015) and landslides (Antioquia Province, Colombia, 20 May 2015) and, furthermore, for the search for Malaysia Airlines Flight 370 and the 2014 West Africa Ebola outbreak.[6]

Box 18 — Space Charter

The International Charter on Space and Major Disasters (Space Charter, www.disasterscharter.org/) was signed in 2000 to promote "cooperation between space agencies and space system operators in the use of space facilities as a contribution to the management of crises arising from natural or technological disasters. It seeks to pursue the following objectives:

– Supply during periods of crisis, to States or communities whose population, activities or property are exposed to an imminent risk, or are already victims of, natural or technological disasters, data providing a basis for critical information for the anticipation and management of potential crises;

– Participation, by means of this data and of the information and services resulting from the exploitation of space facilities, in the organization of emergency assistance or reconstruction and subsequent operations.

The types of situations for which the Space Charter can be accessed include disasters caused by a natural phenomenon, such as a cyclone, tornado, earthquake, volcanic eruption, flood or forest fire, or by a technological accident, such as pollution by hydrocarbons, toxic or radioactive substances.

National disaster management authorities have benefited from access to the Space Charter since 2001 and have activated it several times in support of major disasters.

In 2010, for example, the Space Charter was implemented 53 times in order to support different emergency activities with Earth observations of floods, hurricanes, typhoons, volcano activity, debris flow, earthquakes, landslides, forest fires and tsunami.

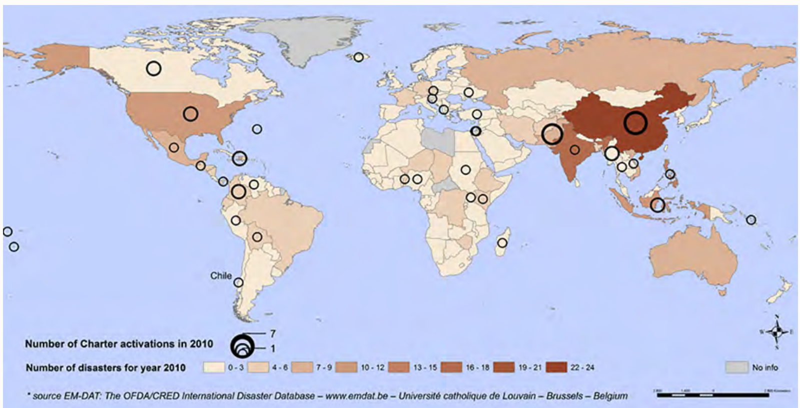

Figure 3 — Number of disasters and Space Charter activations in 2010

6 www.disasterscharter.org/web/guest/activations/charter-activations

Box 18 — Space Charter *(continued)*

Following a major disaster, the Space Charter is triggered by a user sending a fax to the On-Duty Operator. This 24/7 operator confirms the information required by the user and transmits the information to the Emergency on-Call Officer (ECO), also a 24/7 function, who in turn verifies the request and identifies the best satellite resources in support of the specific event. The ECO tasks the appropriate space agency and submits requests for new, as well as archived, images.

All relevant information is gathered in a dossier, which is then submitted to the Project Manager, especially identified by the Executive Secretariat of the Space Charter to ensure data are sent to the end user. When required, the PM coordinates the delivery of value-added products (maps, analyses, GIS data) and information. She/he is also responsible for submitting a report to the Executive Secretariat.

In the United Nations context, the United Nations Institute for Training and Research (UNITAR) Operational Satellite Applications Programme (UNOSAT), implemented in cooperation with the European Organization for Nuclear Research (CERN) has frequently operated as Project Manager and routinely distributes value-added products to United Nations users of the Space Charter.

Most United Nations activations have been requested by UNOCHA, with the World Food Programme as the second-most frequent requestor. UNOSAT has been active in all United Nations Space Charter calls and works closely with applicants and the space agency members of the Space Charter to ensure that user requirements are met for each situation.

Space Charter members are: the European Space Agency, the French National Centre of Space Studies (Centre national d'études spatiales (CNES)), the Canadian Space Agency (CSA), the Indian Space Research Organisation (ISRO), the United States National Oceanic and Atmospheric Administration, the Argentine Comisión Nacional de Actividades Espaciales, the Japan Aerospace Exploration Agency, the United States Geological Survey (USGS), the United Kingdom Space Agency and the Earth Observations Disaster Monitoring Constellation (DMC) International Imaging (DMCii), the China National Space Administration, the German Aerospace Centre, the Korea Aerospace Research Institute, the National Institute for Space Research of Brazil, the European Organisation for the Exploitation of Meteorological Satellites and the Russian State Space Corporation.

4.6 Humanitarian Open Street Map Team

67 Launched in January 2009 and established in August 2010 as a US non-profit organization, the Humanitarian OpenStreet Map Team (HOT) provides "free, up-to-date maps" as a "critical resource when relief organizations are responding to disasters or political crises" (hotosm.org). It aims "to apply the principles and activities of open-source and open-data sharing to humanitarian response and economic development and support the growth of the OpenStreet Map project".

68 The Humanitarian OpenStreet Map Team coordinates the creation, production and distribution of free mapping resources to support humanitarian relief efforts in many places around the world. It is considered by UNOCHA as one of the most active DHN-affiliated organizations (UNOCHA, 2015).

69 The services of HOT are:

- Collaborative maps for humanitarian aid. When major disaster strikes anywhere in the world, HOT rallies a huge network of volunteers to create, online, the maps that enable responders to reach those in need. For example, after the 7.0 earthquake hit Haiti on January 2010, more than 600 people contributed information to the OpenStreetMap within the first month. It became the default base map for many emergency organizations, such as search and rescue teams, humanitarian mapping NGOs such as MapAction and iMMAP, the United Nations and the World Bank. Collaborative mapping is particularly necessary to humanitarian work in areas where base map data are often scarce and out of date;

- Partnerships. HOT assists international organizations, as well as governments and first responders, with mapping needs during a disaster. Additionally, HOT participates in various long-term projects with its partners;
- Technical projects. HOT develops several open-source programs and applications to leverage collaborative mapping and the use of new technologies in the field of geographic information for humanitarian aid;
- Community development. HOT supports community mapping projects around the world and assists people to create their own maps for economic development and disaster preparedness. These local capacities enable people to take control of their own development.

4.7 Water Detective application[7]

70 Water Detective is a generic cross mobile application (app) used by citizens and professionals alike to report on all kinds of water-related problems. A user can select categories (such as flooding, dyke issue, etc.), helping the government become aware of (possibly) high-impact situations.

71 Through Water Detective, citizens and professionals become "social sensors" for local authorities and create a better and more detailed overview of the local water environment. This mobile tool makes it possible to identify problems at an earlier stage and to prevent serious events from occurring.

72 The Water Detective app is not only a simple reporting tool, it also creates a community feeling. One example are the reports on the screen of the users' area, showcasing a local map with other submitted reports. Users can check the other reports and are able to add or subtract a point on the ranking. Ranking can be used as a sort of data validation. Users with many "good reviews" are placed higher in the Water Detective ranking and will probably be sending a large number of serious and detailed reports.

73 Authorities can see Water Detective data on a Web platform for professionals called HydroNET. This platform enables the local authorities to see all the reports, add additional points for good reports and send feedback to a user (e.g. tell a user that a maintenance crew will be sent to the reported location of disturbance).

74 Water Detective is one of the tools that help citizens and authorities create a better view of the local water environment using a future proof sensor – the crowd – as social sensor.

75 Many key applications exist and provide users with different kinds of services for water-related data acquisition and delivery: CityFlood (provides online flood modelling and mapping for cities, www.hydronet.com/); HydroAlert (offers to define alarm levels and rules to automatically receive SMS messages or e-mail alerts, www.hydronet.com/); FloodReadyQ (geo-locates the user and provides him/her with real-time flood warning information and shows flood extent in relation to his/her

7 More information at www.pearl-fp7.eu/wpcontent/uploads/2015/11/IAWW_KB_November_2015_Final_2.pdf

current location and saved "favourite locations", including home, business, kindergarten or school, home of elderly relatives, etc.; www.hydronet.com/default.aspx?page=4); WOTs Up (collects citizens' observations of the water system in real-time via smartphone or browser; www.hydronet.com/).

76 The App can be downloaded by searching for "PearlDetective" in the Play Store or from: https://play.google.com/store/apps/details?id=com.hydrologic.pearldetective

PART II

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CRISIS-MAPPING AND CROWDSOURCING IN FLOOD MANAGEMENT

77 In the previous chapters it was seen how crowdsourcing is a useful approach – even more so today, thanks to the wide spread of information and communication technology (ICT), especially mobile phones – and also in developing countries) for facilitating crisis-mapping. Of course, "popular" (or volunteered geographic) information coming from citizens/societal actors in the field should be filtered and merged with technical information coming from other sources (GIS, etc.).

78 This tends to be true for any kind of social and environmental risk and is true in flood management because, all over the world, people want to assist those suffering from flooding and other natural disasters. Most private bodies are organized and communicate via the Internet (Pyka, 2013). This chapter therefore deals with the use of crisis-mapping and crowdsourcing in flood management, suggesting their usefulness in all steps of the process.

79 We shall start by describing the possible contributions of crisis-mapping and crowdsourcing, phase by phase in the management of floods, then the actual and potential roles of the various actors involved, paying attention not only to their individual tasks, but also to their interaction and the best way to cooperate. On this basis (among others), and taking into account also how these issues have been dealt with in the previous chapter, we shall try to identify which, on the one hand, are the main benefits and potentialities of crisis-mapping and crowdsourcing in flood management and, on the other, the limits and related possible solutions. This will take us to an account of the main challenges emerging from the combination of current practice and future potential functions of this approach.

5 POSSIBLE USE OF CRISIS-MAPPING AND CROWDSOURCING IN FLOOD MANAGEMENT: A CYCLE APPROACH

80 For better understanding of the effectiveness of crisis-mapping and crowdsourcing in flood management, what happens in this regard in the four phases of the cycle approach of risk management should be singled out. These are:

- Prevention (before a flood);
- Preparedness (before a flood);
- Response (during a flood);
- Recovery (after a flood).

81 We shall demonstrate that working on lessons learned to build resilience after flooding helps to increase preparedness before the next flooding event (cycle approach).

5.1 Before a flood

82 "Before a flood" means in phase of prevention and preparedness without any chronological meaning. In fact, chronologically, it is rare to be "before a flood" since, in each territorial area subject to this hazard, at least one flood has already occurred. Thus, chronologically, we are always in an "after flood" situation. It is not a play on words and it is an important aspect, as we shall see below.

83 Time "before" a disaster should be devoted to "disaster risk reduction", which focuses on the identification, assessment and reduction of disaster risks – i.e. to mitigation – which are

measures pursued for the purpose of avoiding or reducing disaster-related damage[8]. Mitigation comes in the form of structural measures (e.g. elevating homes for flood protection, and moving neighbourhoods or communities to less hazard-prone locations) and non-structural measures (e.g. enforcement of building codes and land-use regulations). It also implies that, while it is possible that some disaster effects can be prevented, other effects will persist but can be controlled or reduced through appropriate action (Carter, 2008).

84 The prevention and preparedness phase(s) entail(s) many principles, activities and tools beyond the scope of this publication. Instead, we are more interested in underlining that effort must be placed on acquiring the best available knowledge and on enhancing peoples' capacities/aptitudes to provide knowledge when a flood occurs.

5.1.1 Early warning systems:

85 Early warning systems play a significant role in the preparedness phase of the flood-management cycle. Despite different flood-forecasting initiatives being available from academia and research centres, what is often missing is the connection between timely hazard detection and community response to warnings. In order to bridge the gap between science and decision-makers, United Nations agencies play an important role in the dissemination of the information and provision of capacity-building to local governments. A reliable global early warning system in the United Nations would improve existing in-house capacities for humanitarian response and disaster risk reduction.

86 UNITAR-UNOSAT has therefore developed with its partners (CIMA Foundation, USGS and CERN) a global system which is able to increase the capacity of the existing framework for flood preparedness, mitigation and emergency response. Called Flood-FINDER, this system consists in the early identification of potential areas that can be flooded through country-level, modelled scenarios and detailed satellite-based assessment with the use of high-resolution imagery. It is a flood early warning and early action system, integrating ground observations, crowdsourcing data, modelling and remote-sensing assessments for improved preparedness and resilience among vulnerable communities (Arcorace et al., 2016).

87 In particular, Flood-FINDER comprises an operational service for flood preparedness and emergency response that is subdivided into the following tools and geographic information technologies solutions:

- Flood forecasting and monitoring module;
- Satellite service activation module;
- Crowdsourcing and observed data module.

8 It has to be remembered, however, that, in contrast to other natural hazards, floods are not only a potential disaster, but also an opportunity (APFM, 2009).

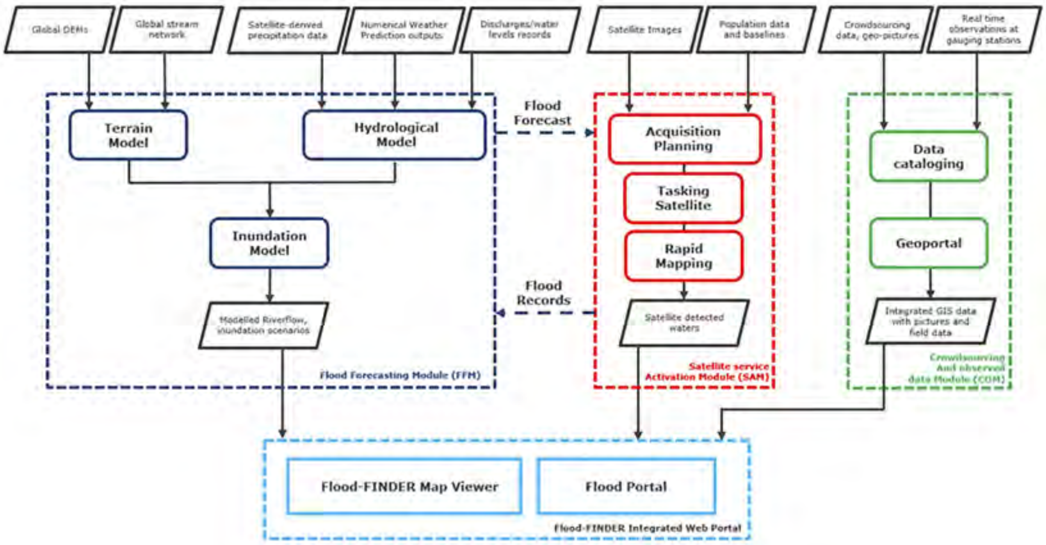

Figure 4 — Flood-FINDER system
UNITAR-UNOSAT (http://www.unitar.org/unosat/climate-service)

88 Each module provides modelled outputs, satellite-based analysis and processed observations from the field. These in turn are integrated into a Web GIS interface. The objective of the Flood-FINDER integrated Web platform is to share flood alerts with end users, including impact assessment forecasts and situation updates through a comprehensive and intuitive way of displaying the information, including the use of social media.

5.1.2 Updating/establishing maps

89 As some disaster responders have argued, the period before a disaster would be the ideal time to produce disaster-related information in the form of maps or otherwise (Farthing et al., 2010). Crowdsourcing could help these efforts through complementing existing information or through the provision of otherwise inexistent preparedness-related information. Whereas, in the past, natural hazards were mostly studied by experts and institutions with specialized technologies, crowdsourcing has the capability of complementing the identification of hazards from those who experience it first-hand. Even when official information sources abound, volunteered information can sometimes provide a different idea of what is taking place (e.g. crowdsourcing can expose disparities of which official sources might not be aware). Moreover, crowdsourcing offers a great opportunity to present traditional knowledge.

90 For example (Banuelos and Huntley, 2013), the city of Boulder, Colorado, USA, launched in September 2013 a Community Flood Assessment crowdsourcing map to capture flood data and stories from Boulder residents and businesses (more information at boulderflood2013b.crowdmap.com/).

91 Boulder citizens were empowered to contribute to shared experiences and to the documentation of the September 2013 flood event. On community submittals (called reports), citizens shared data/information and attached photos or videos to enhance their story (how they lived the event). Geo-located pins associated with specific date-and-time categories (such as flooding, road damage, path damage, property damage, debris and overflows) allowed the creation of easy-to-use maps. Once posted, all data, photos and videos were in the public domain and

could be used by all site users, including the city of Boulder[9]. Thus, this information on place-and-time flooding activities helped the city in assessing the entire flood event and helped – continues to help – to inform future planning efforts.

92 Residents were asked to backdate reports, so that all users could have a better understanding of what happened and when (i.e. post data when it actually happened, not with the date and time of the reporting)[10].

93 As this example shows, flood-mapping, constructed also thanks to crowdsourcing during the phases of prevention and preparedness, is also based on what happened in the "previous" flood events in the same area. This operation has to be fully implemented only in areas which have previously been information-scarce. In other cases, already existing maps should be updated (especially when a long time has passed since the last flood), taking into account that not only floods in the strict sense of the term have to be mapped but also infrastructure and settlements that could be affected, as well as information on available resources such as hospitals and emergency centres, public services, etc. Moreover, the emphasis can be put on submitting information that pertains to the needs of a given area or community.

5.1.3 Monitoring floods: Flood Citizen Observatory

94 Since the main objective of the prevention phase is to reduce the residual risk through early warning systems and measures that can be taken to minimize flood impacts, the constant monitoring of the risks and the assessment of the danger, arising from recent information, is required (Mendiondo, 2005).

95 Different information is used in the development of model-based prediction for flood warning systems. In this context, local and up-to-date data are essential for supporting decision-making. A crucial challenge is the availability of data at all points considered strategic. In this context, volunteer information, as well as sensor data, can be entered in the model for forecasting, since volunteers can act as human sensors (Goodchild, 2007), providing information about the environment, such as water level and flooded areas (Fava et al., 2013).

96 It is thus possible to use these citizens' data with monitoring data from traditional sources to develop predictive methods correlating the information available. Furthermore, volunteers may provide information about important parameters of local conditions on the verge of a flood. This information can help to provide a more effective and immediate response.

97 The Flood Citizen Observatory (FCO) (Castro Degrossi et al., 2014) is a crowdsourcing-based approach that enables the collection of volunteer information and has been used in a research project about flood-risk management called AGORA[11].Its main objective is to obtain useful volunteer information related to flood risk management, especially about flooded areas and water level in the river bed, in order to provide this information for decision-making. As the city of Boulder's

9 bouldercolorado.gov/newsroom/sept-27-2013-city-launches-crowdsourcing-map-to-capture-boulderflood-data-and-stories

10 The mapping application, called Crowdmap (powered by Ushahidi), was originally designed and built to crowdsource crisis information. The mapping application can be used on a desktop computer and is also smartphone-enabled with apps for both iPhone and android devices. Residents are encouraged to read the Crowdmap Terms of Use and Privacy Notice.

11 www.agora.icmc.usp.br/enchente/

crowdsourcing map, FCO is provided by the Ushahidi crowdsourcing platform (see **Section 4.1** and Ushahidi, 2014).

98 In FCO, citizens-volunteers are considered as "human sensors", since they can observe important parameters of flood-risk management in a local environment. In order to facilitate the information provision about flood risk in FCO, the interpretation mechanisms are represented by different categories, whereas the tags for each mechanism are represented by subcategories. Thus, the volunteer can identify more easily the category that best represents the observed scenario. To send a report, volunteers can use both a mobile application and a website (Castro Degrossi et al., 2014).

99 Sending a report requires that volunteers provide the following mandatory information:

– Title: represents the subject addressed in the report.
– Description: represents the observation performed by the volunteer; for example, the water level or flooded area.
– Category: represents the mechanism used to interpret the environmental variable, which provides information about the water level in the riverbed.
– Place name: represents the place from where the volunteer is sending the report.

100 Due to the uncertain credibility of this information, reports are checked by the emergency agencies involved in flood-risk management before they are made available online. The purpose of this verification is to reduce the number of false or inaccurate information disseminated to the public and emergency agencies.

101 Four mechanisms (Castro Degrossi et al., 2014) can be proposed which aim at supporting volunteers to better interpret the environmental variables they collect. These mechanisms were jointly designed by an interdisciplinary team composed of computer scientists and hydrologists. Three different scenarios were considered so the volunteer can interpret environmental variables in various situations, which are described as follows:

– The first scenario corresponds to a controlled point, i.e. a point where there is an interpretation resource that enables the volunteer to perform the measurement more accurately. In this scenario, there is a water-level ruler laid down in the riverbed which supports the measurement of the water level at that point.

  In Brazil, for instance (in the frame of the AGORA project), rulers were installed at 14 points in the five most relevant water streams of the urban area of São Carlos (São Paulo). Each has at least two points, one in the upstream and one in the downstream, before confluence with other streams;

– The second scenario corresponds to a semi-controlled point, i.e. a point where there is an interpretation resource for determining the value of the water level in the riverbed in a less precise way. In this scenario, there are two types of interpretation resources: a form similar to the human figure and multi-colour bands (green, yellow, orange and red). The colour bands correspond to the hazard index, i.e. the danger to which the population is exposed, the risk of human instability.

  This risk represents the forces exercised on an individual in water currents, i.e. the individual's vulnerability level exposed to floods. In addition, a human form was proposed to assist the volunteers to determine the water level more easily. Thus, the volunteer can use it as a visual resource to determine the water level, because it is painted on the riverbed in some points of the streams or as an imaginary resource, helping to determine the water level at points where no resources are available. In the human form case, water level measurement is carried out according to pre-defined tags: ankle, knee, waist, neck and above the head (the whole body);

– Finally, the third scenario corresponds to an uncontrolled point, i.e. there is no recourse in the riverbed which could help the volunteers to interpret the water level. For this mechanism, tags (low, normal, high and overflowing) were adopted that were of simple determination and approach to popular knowledge.

These tags are sometimes cited in the media to report the water level of a river (e.g. in Brazil, in the frame of the AGORA project) or the Zouave's statue on the Alma Bridge in Paris **(Figure 5)**. Thus, it is expected that the volunteers can interpret this environmental variable more easily.

102 This crowdsourcing-based approach for obtaining useful volunteer information in flood-risk prevention has been experimentally validated in the above mentioned Brazil example. It has been found that this proposed platform is effective in obtaining useful and accurate volunteer information, since volunteers can easily provide information about the water level in the riverbed through the platform categories. This is an important step, since, in certain regions of Brazil, there are no water gauges to perform such measurements in real time.

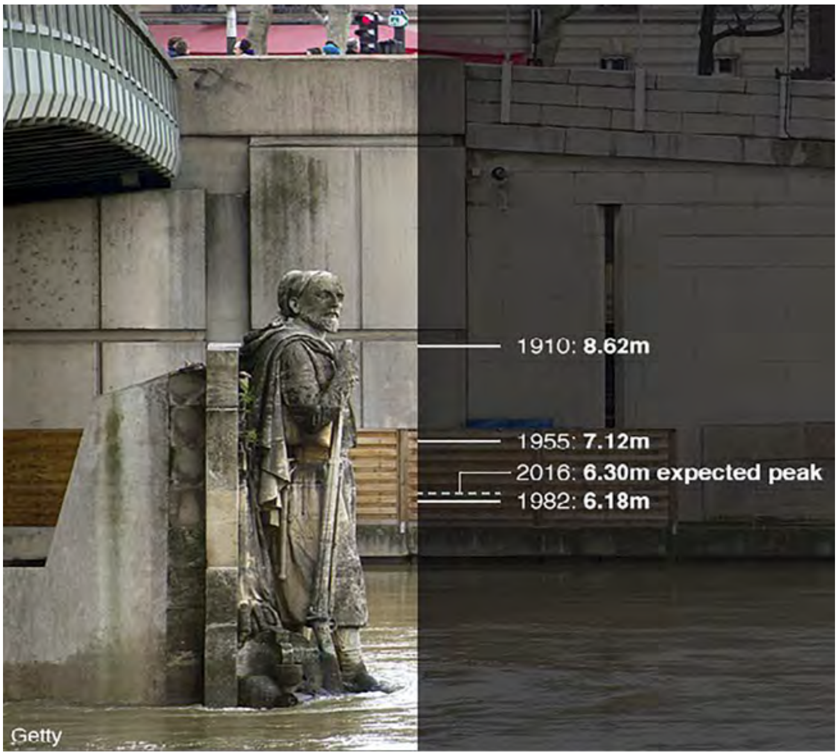

Figure 5 — The statue of the Zouave on the Alma Bridge, Paris, as a flood gauge (Travel France)

103 Furthermore, the use of FCO as a crowdsourcing platform was able to mitigate the variability in the structure of volunteered observations, since the platform provides some standards for

information provision. Thus, recurring problems, such as little or no structure of volunteered information, can be attenuated.

104 The structure of volunteered information is the first step towards integrating this type of information with data from other sources, such as sensors and raingauges. Although the experiment was effective, improvements should be carried out in this context. Volunteers had problems with the mobile application interface. Some, for example, had difficulty in interpreting certain report fields in time to submit an observation. Another challenge is related to the quality of VGI (De Brito Moreira et al., 2015), as already mentioned.

105 The METAGRI Project implemented by WMO in collaboration with the National Meteorological Services of Benin, Burkina Faso, Cape Verde, Chad, Côte d´Ivoire, Gambia, Ghana, Guinea, Guinea-Bissau, Liberia, Mali, Mauritania, Niger, Nigeria, Senegal, Sierra Leone and Togo in West Africa provides another example of citizen observatory. Developed in a region affected by both extremes of droughts and floods, this project aims at increasing the self-reliance of rural farmers by raising their awareness about effective weather and climate risk management and the sustainable use of weather and climate information and services for agricultural production. Between 2012 and 2015, 12 499 persons (mostly subsistence farmers) were trained, through roving seminars, by multidisciplinary teams (including National Meteorological and Hydrological Service (NMHS) staff) in how to access and use weather and climate information to maximize yields and minimize risks (WMO, 2015).

106 In this project, farmers became key partners in collecting and managing climate information. National Meteorological and Hydrological Services involved in the project distributed 3 095 raingauges to farmers who were trained in their use in conjunction with sowing calendars, which indicate suitable planting dates and appropriate crop varieties in the different locations, depending on the rainfall measurements obtained. The objective is also to increase interaction between NMHSs, other institutional partners and farmers whose livelihoods depend on weather and climate. The project team is currently working on the improvement of communication channels which would enable farmers to directly transmit field data to NMHSs (SMS, mobile application, etc.). Benefits would include increased availability and relevance of climate information and a better understanding by NMHSs of the needs of the farmers (see **Figure 6**).

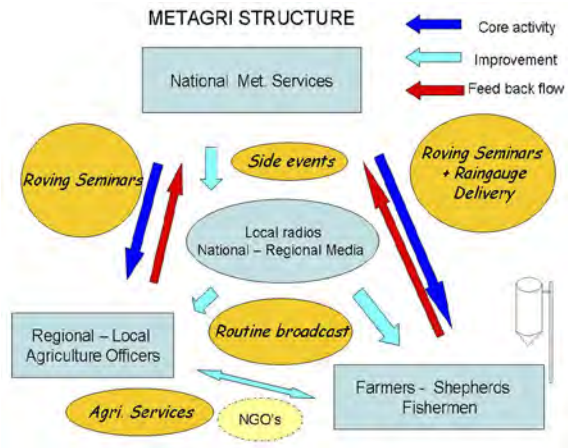

Figure 6 — Structure of the METAGRI project

107 Based on what is called "citizen science", the innovating technologies for the monitoring, modelling and managing water **(IMoMo)** approach has been developed under the leadership of a consortium of international partners[12] since 2012, funded by the Swiss Agency for Development and Cooperation **(SDC)** and WMO and achieved proof of concept in both the United Republic of Tanzania and Central Asia. Part of this approach – the IMoMo discharge mobile application – enables local stakeholders (especially farmers) to collect and transmit water-related information. Through this application – using a camera-based runoff measurement – operators can measure water level, surface velocity and discharge. As shown in **Figure 7**, users need to establish geo-localized benchmarks, then take a short video which incorporates these benchmarks.

Figure 7 — Geo-localized benchmarks (in white on the left and on the right) used to measure water level, surface velocity and discharge in the Themi River Basin, United Republic of Tanzania

108 The app processes measurement and results can be shared via SMS and USSD[13] **(Figure 8)**.

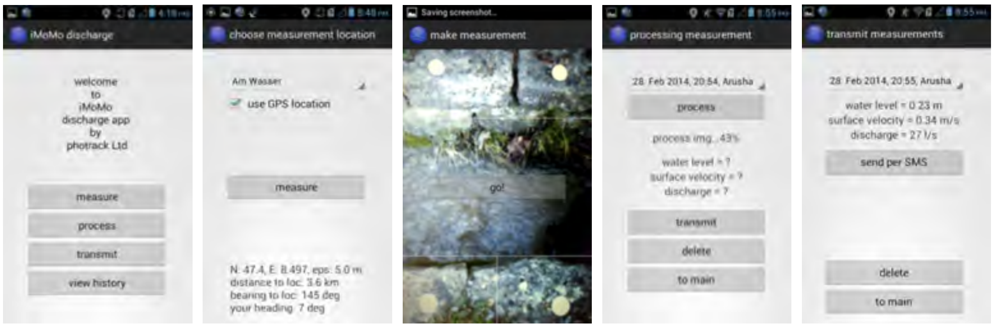

Figure 8 — Different steps for collecting and sharing data relating to water level, surface velocity and discharge via the IMoMo discharge application

109 This information can be useful in areas where there is a lack of data for flood forecasting systems **(FFSs)**. As for the METAGRI Project previously mentioned, the objective of this application is to increase water-related data production and sharing between local people and NMHSs to ensure availability and relevance of climate information and a better understanding by NMHSs of the needs of the local people.

110 For all the initiatives we have detailed so far, however, citizen's observations must be completed (whenever possible) with other data sources (i.e. provided by NMHSs, regional and local media, etc.) to strengthen water-related knowledge.

12 Partners are: Hydrosolutions Ltd , Haute Ecole Arc - HE-Arc , Photrack AG , International Office for Water (France), Ministry of Water (United Republic of Tanzania), Zurich University of Arts - ZHdK , Institute of Environmental Engineering - IfU Zurich , Swiss Development Cooperation - SDC , BGW Management Advisory Group , University of Zurich Department of Geography and the Centre for Development and Environment - CDE in Bern .

13 More information at www.imomohub.org/?id=1-1027-1093-1107

5.1.4 Capacity-building

111 Capacity-building is a core issue in the preparedness phase with many audiences to deal with. On one level, it is concerned with emergency responders, and elected officials and public administrators, who do not necessarily have a role in emergencies. On another level, it is also concerned with citizens. The purpose of training is to guide the audience to effectively execute the agreed emergency protocols. Here, we are interested in training focused on the specificity of crowdsourcing for crisis-mapping.

112 Capacity building is important for valorizing the crowdsourcing approach "before flood". Citizens involved as "human sensors" in relation to a FCO can contribute better if they go through training. In Brazil, this training addresses three points: the mechanisms used to interpret environmental variables (see the three scenarios mentioned above); the crowdsourcing platform used to obtain volunteered information; and instructions about how to insert a report in the platform.

113 Capacity-building, to be implemented "before a flood" can be important also for valorizing the crowdsourcing for crisis-mapping "during a flood". For contributing (as citizens/volunteers) to crisis-mapping that redraws or updates online maps of disaster-stricken areas, little or no technical expertise is needed to participate (therefore no specific training is needed). However, citizens can also cooperate in the development of software platforms that contribute voluntary information. In this case, technical expertise is required that should be acquired "before flood". This can be done at the local level (mainly on the basis of tools developed during previous floods) and also at upper levels. Networks such as the International Network of Crisis Mappers (see **Part I, Section 4.2**) or Humanitarian OpenStreet Map Team (see **Part I, Section 4.6**), as well as international programmes such as APFM, play an important role at this regard through webinars, help desks, online forums, Google groups, specific training courses (e.g. training of amateurs – i.e. students – to use mapping tools such as GPS) and international conferences.

114 More generally, capacity-building actions "before" flood creates/enhances a broader network of individuals and institutions seeing the use of crowdsourcing for flood mapping in a more proactive manner.

5.1.5 Resilience increase

115 Resilience is the ability of a system to absorb disturbance and still retain its basic function and structure (Walker and Salt, 2005). Resilience should not be confused as the opposite of vulnerability, as it refers to the principles or actions of stakeholders – both relief organizations and communities – that allow the promotion of better anticipation, response and recovery to the impacts of hazards. Promotion of resilience is fundamental for strengthening the capacities of people to effectively manage risks on the basis of the available resources (Blaikie et al., 1994).

116 Crowdsourcing can offer insights and analyses to improve resilience in the face of threats such as floods at least in two ways:

- First, crowdsourcing makes use of ICT and the willingness of volunteers to share content to collectively produce information that could serve as solutions to different problems and contribute to increasing a people culture of constant preparation, anticipation and, more importantly, decisive action – not just by response.

Crowdsourcing "before", "during" and "after floods" generates a proactive attitude among citizens/volunteers that improves resilience (also thanks to enhanced cooperation among actors). This proactive approach, enabled by necessity but also by the accessibility of current forms of ICT, has produced remarkable results.

"Our [crowdsourcing] projects provide an outlet and an avenue for advocacy around the issues. It helps people who volunteer to know that they're not alone, that they're part of a much larger problem in society than what they experienced that day" (Godchaux, 2012).

– Second, also thanks to crowdsourcing, interactive maps are developed (e.g. by Google) to provide localized support information, including risk zones. In addition to emergency information, the map traces subway, rail track and tunnel flooding, along with bridge and commute information.

5.2 During a flood

117 Crowdsourcing is particularly important during flood for crisis-mapping. Crowdsourcing, can provide real-time data enabling quick responses during flooding, or other natural disasters (Tierney, 2014). Moreover, during flood, crowdsourcing is important not only for crisis-mapping. It is also useful in coordinating help, shelter, health care and food for affected people (all these issues are beyond the scope of this publication, however).

5.2.1 Production of geographic information

118 Crowdsourcing for disaster response through the production of geographic information during a disaster, is inherently a reactive activity, meaning that it only takes place when a disaster has already taken place. This is also the worst time to produce information, since responders may already be facing severe pressure while the information for them to work with may not be ready for days or weeks later or might not say enough about human geography or needs (Schuyler, 2010).

119 Crowdsourcing efforts can contribute to emergency mapping in two different ways:

– Citizen development of software platforms that contribute voluntary information regarding response needs and activities, although this effort requires technical expertise;

– Crisis-mapping that redraws or updates online maps of disaster-stricken areas.

120 In a certain sense, crowdsourcing is more important in crisis-mapping during floods than before. Before floods, during the prevention and preparedness phase(s), there is time to collect, interpret and exploit all kinds of existing information (sometimes abundant) and, as we have already stated, crowdsourcing plays a "complementary" role (valorizing first-hand experience and traditional knowledge, providing a different idea of what is taking place). During floods, on the one hand, there is no time and, on the other, the situation can change quickly. The role of citizens as human sensors providing information is therefore central.

121 How does it work? As a first example (many others will be reported in Chapter 3), in December 2015, the heaviest rains in Chennai, India, in over 100 years provoked vast flooding. For residents and responders, this meant that reliable data on which streets were flooded, and which areas were inundated, were crucial in determining how best to react, but these data did not exist

(and data on similar events in the past were not adequate, especially when taking into account the intensity of this event compared to others in the recent past).

122 A rapid response project has utilized OpenStreet Map to fill these data gaps. Individuals report areas that were flooded by zooming in on the map, and clicking on the relevant area. Water-logged points, subways, tunnels and flyovers have been marked. Once reported, flooded areas turn pink, allowing citizens and responders to plan accordingly. Arun Ganesh (one of the leaders of this project) wrote: "In the last 24 hours, over 2 500 streets have been reported as flooded by the citizens of Chennai using the tool.

123 Although not individually verified, these contributions show patterns in the city and residential zones built around large water bodies and wetlands that are vulnerable during the monsoon. It is completely crowdsourced where people can map their own neighbourhoods … people can highlight roads that are flooded. We use data sources from NASA and ISRO on elevation profiles of the city and put all of this together in one place" (Ganesh, 2015). In two days, over 4 000 roads were reported as inundated. Further, after requests from people, the flood relief centres were also been marked (Varier, 2015).

124 Of course, data coming from this exercise were merged with other sources of information:

- UNITAR and UNOSAT satellite-detected inundated areas and probable floodwaters, derived from comparisons of imagery collected on 12 November 2015, 1 September 2015 and 14 October 2015;
- Geographic data representing low-lying and flood-prone areas from India's National Remote Sensing Centre's ISRO Cartodem3 and the USGS Earth Explorer;
- Google Maps data compiled by The Wire indicating waterlogged roads.

125 **Figure 9** shows a result of this work implemented in Chennai.

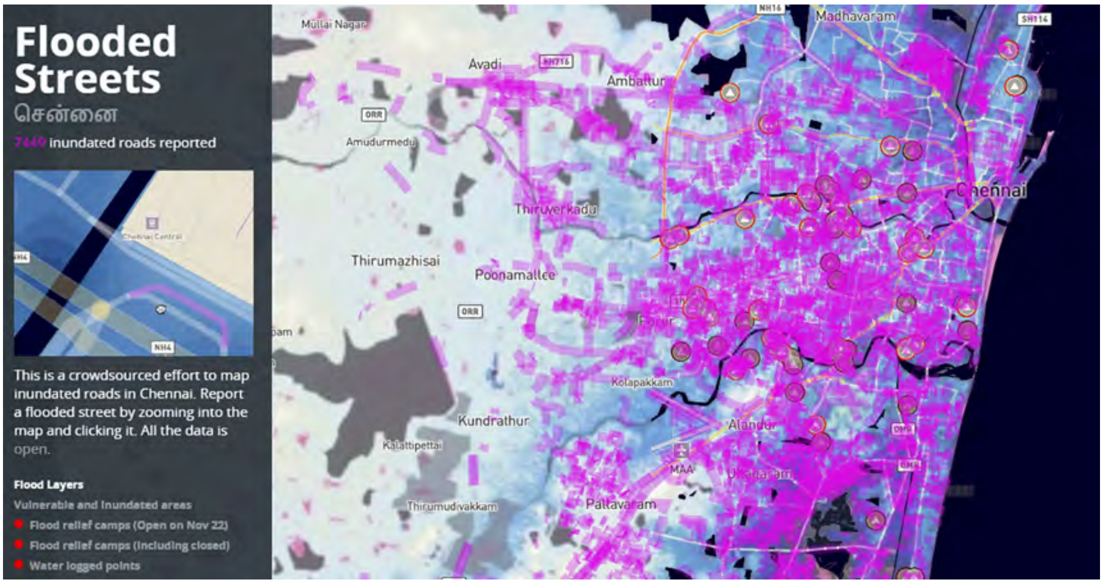

Figure 9 — Open Street Map. Crowd-sourced map showing flooded areas (in pink) in Chennai, India, after the heavy rainfall of November/December 2015 (Data Driven Journalism, 2015)

126 A second example is related to the Thai Crisis Planner & Reporter system, aimed at encouraging people to supply real-time flood information from their areas. The concept, in that case, was to integrate the flood-report system of the ICT Ministry (see www.floodthailand.net) and the GIS developed by Chulalongkorn University to allow people to report flood information from their locations into the system.

> *"This integration of the ICT Ministry's and Chulalongkorn University's flood-report systems is aimed at providing real-time flood information, developed by people, for the people. The joining of hands and the integration of the systems will help people to keep in touch with real-time flood information from any area. It offers both official information from the authorities and non-official news developed by people from around Bangkok who are in the location of floods. People who access it would be allowed to post info such as flood levels and water flow trends. The system also allows people to post photos of the flood situation. Moreover, people can access the system via the website through a browser via personal computer or mobile phone, and can also access via an application called Flood Rest. The system has two subsystems – Crisis Reporter and Crisis Planner. Crisis Reporter provides flood information while Crisis Planner allows people to check the water level in their location"*
> (Pornwasin, 2011).

127 Like most crowdsourcing (see **Part I, Section 4**), the means of capturing volunteered information comes from widely available technologies. Very briefly (and without any claim to be exhaustive), the following ones can be mentioned:

- Ushahidi platform (Ushahidi, 2014). As one of the leading platforms for crowdsourcing, several institutions have adopted it for their own purposes and localities.
- Short Message Service (SMS). SMS has been a cheap and reliable way of both receiving and broadcasting crowdsourced information. The free software Frontline SMS has been used extensively by institutions in receiving and managing messages.
- Fixed telephony (landline). Standard landline phones are still used to make calls to call centres operated by humanitarian institutions.
- Global Positioning System (GPS). GPS has been used (notably by the Humanitarian OpenStreet Map Team) in producing location information for infrastructure important for preparedness functions.

128 Generally speaking, pictures are worth a thousand words and can improve the context (Bielski and Zeug, 2015).

129 Crowdsourcing geo-referenced photos derived from GPS devices are also useful information in order to understand more about the evolution of a flood event. In this regard, during the 2011 Thailand floods, a crowdsourcing solution, called UN-ASIGN, was used by UNOSAT in order to assess the extent of the flooding in urban environments detected from radar satellite images.

130 Thanks to the integration of some 1 000 crowdsourced photos from the affected areas, UNOSAT's GIS analysts were able to undertake in situ verification of satellite data and to provide more reliable analysis to the humanitarian actors in the field. UN-ASIGN is a free mobile application (available at www.unitar.org/unosat/un-asign-crowd-source-photos-mobile-app) specifically designed to work over low bandwidth for crowdsourcing geo-referenced photos and text. The photos are automatically mapped, thus helping towards overall situational awareness from

areas affected by larger humanitarian disasters. The app allows the user to acquire photos easily with accurate satellite time and geo-tagging.

131 Geopictures can be allocated to a GeoRSS feed or integrated with Web maps, together with satellite-based analysis and GIS data (see below).

Figure 10 — Example of a geo-picture sent through the UN-Asign crowdsourcing photo mobile application

132 Not all social media messages however, are created equal. For example, during the days of the Zaragoza flood at the end of February 2015 (see **Chapter 8 in Part III**), it was possible to capture almost 15 000 tweets that used tags relating to the event. Of those tweets, only a small proportion provided relevant information applicable to the service. Of those messages deemed applicable, many still required special attention before they could be integrated into the service (Bielski and Zeug, 2015). For emergency response organizations, social media provide opportunities but also challenges, because a large amount of data must be filtered in order to extract the relevant and actionable information.

133 Thus, popular knowledge (or VGI) can be characterized by a lack of reliability and, more generally, its quality can be poor (as already stated, in general, in **Chapter 1**). This is especially true for information/data collected during a flood, and thus in an emergency situation, and quickly. Therefore, data/information from people on the ground should be "translated" (as far as possible) into reliable information (grabbed, filtered, sorted) and mapped. During this process some (or much) information is omitted. Nevertheless, a great deal of information is sufficiently reliable and, above all, provided early (often before information coming from other sources).

134 This "translation", sometimes, is carried out through procedures sui generis. In the Thailand case, initially there was no system to monitor and approve information posted by people. It was honour-based to emit real flood information with, in addition, a "vote" system: information with many "no" votes is considered not qualified and is deleted. The system is therefore, based on social checking. Its advantage is to have a wide range of information from people (Pornwasin, 2011).

135 This is a way not for just filtering information provided by the crowd, but to take the crowd into the filter itself. Something similar happened in the case of SwiftRiver (see **Section 4.1**) where the platform tracks user behaviour to determine the accuracy of incoming content with applications that allow the users to create a baseline of what they consider to be trusted information (Garber, 2011).

136 Authorities alone cannot cover the wide range of flood information in detail. As already underlined, popular knowledge (or VGI) is particularly important during floods since they are dynamic and the presence/level of water in any location can change quickly.

137 Looking to the (near) future, we can end this section as follows:

> *"Could crowdsourcing reports from social media ever replace traditional flood monitoring techniques? The results from a pilot survey implemented in Jakarta (one of the world cities where people tweet most, as well as, a city affected by annual flooding that forces thousands to abandon their homes and takes many lives) show that crowdsourcing data currently work best (as we have seen also in the Indian example above) as a complement to existing data-collection methods: there aren't yet enough people reporting floods on Twitter to create a comprehensive flood map of the city. This may change in the future, however: there is a commitment (from BPBD, i.e. the Jakarta Emergency Management Agency) to integrating, developing and promoting the utilized platform"*
> (Saunders, 2015).

5.2.2 Distribution of information (dispersed people, relief camps, medical centres, shelters, infrastructure)

138 Crowdsourcing plays an important role during floods, not only in the production of information (as we have seen above), but also in its distribution. The August 2012 floods in Manila, Philippines, displaced more than 80 000 residents and caused dozens of deaths.

Figure 11 — The University of Santo Tomas campus in Manila, Philippines, was heavily affected by the monsoon of August 2012.

139 In the midst of widespread flooding, a digital lifeline emerged to disseminate information (using Twitter and Facebook) as people pleaded for rescuers to retrieve them from the rooftops of their homes. About half the population uses social networks – something that government rescue workers, volunteers and media outlets used to their advantage by creating unified hashtags to spread information more efficiently. Specific hashtags were created such as #RescuePH for rescue calls; #ReliefPH for relief aid, #FloodsPH for breaking news, and #PHalert for official government alerts. Social media users also created a relief centre map on Google maps. Consolidated hashtags and online coordination make a noticeable difference in flood response (Consunji, 2012).

5.3 After a flood

140 "After a flood" means in the phase of recovery. As already underlined (taking into account also, the high frequency of flood events in the same territorial area); "recovery" corresponds, in a certain sense, to enhance prevention capacities and the preparedness of a community against a probable future event.

5.3.1 Crowdsourcing mapping for disaster recovery

141 There are also many cases of crowdsourcing mapping for disaster recovery that, of course, take place "after flooding".

142 Process and techniques are the same described above and the results are rich. They are based on the map(s) prepared during flooding, which inform two-way community discussions on situation strategies and priorities guiding their recovery efforts, enhancing, after the emergency, the mapping exercise. This has to combine technical sources of information and local knowledge (about the location of debris, temporary shelters, drinking water and much more) to engage local communities in the reconstruction process.

143 An example is the crowdsourcing initiative launched by the Australian Broadcasting Corporation (ABC) – the ABC QLD Floods Crisis Map – to plot the effects of the Queensland floods (2011). It was a mapping initiative designed to act as a prototype for mapping any potential disasters (Ross and Potts, 2011). People were asked to send information (to submit reports) regarding the floods for this mapping initiative on items, such as:

- Property damage;
- Roads affected;
- Electricity outages;
- Hazards, including debris in the water;
- Sewage and contaminated drinking water.

144 Reports were simple text-based messages or included photos and videos. Almost 1 000 reports were submitted. Reports were verified and the map that was built displayed evacuation centres and aid services including relief centres, emergency accommodation, hospitals and the police. The initiative used the Ushahidi platform.

145 The software used allowed audience reports to be aggregated from a range of sources, including SMS, twitter, e-mail and online news into a one-map-based interface. Its power lay in the ability of people to contribute using basic mobile phones. The learning process was rapid.

5.3.2 Crowdfunding for disaster response

146 The crowdsourcing approach, as already stated, goes largely beyond crisis-mapping (in relation to floods and also all other hazards) and these issues are beyond the scope of this publication. We shall, however, allude briefly to the use of crowdsourcing to collect funds for recovery and reconstruction in the case of flooding.

147 Crowdfunding is the practice of funding a project or venture by raising monetary contributions from a large number of people, often performed today via Internet-mediated registries, but the concept can also be executed through mail-order subscriptions, benefit events, and other methods. Crowdfunding is a form of alternative finance which has emerged outside the traditional financial system and is becoming an ever more popular way to raise start-up costs for businesses and projects all over the world. In this frame, crowdfunding is used for disaster responses not just in the developed world, but also in less developed countries.

148 One example of crowdfunding platforms for disaster response related to flood is the Alberta Arts Flood Rebuild campaign. The 2013 flooding was devastating for thousands of Albertans and many communities faced total rebuilding. The platform raised more than 125 000 Canadian dollars in about a week and 268 000 Canadian dollars altogether. The platform promoters underlined a further added value: "In addition to financial contributions, crowdfunding campaigns of this nature also generate significant exposure to those affected by the flood through social media channels that were kept updated in real-time through social media streams and saw the devastation firsthand" (in short, crowdfunding initiatives facilitate communication and awareness-building) (Shao, 2013).

149 A second example is related to flooding in Malaysia in December 2014 (one of the worst floods in a decade, with as many a quarter of a million people displaced from their homes and 21 people killed). Countries, corporations and organizations provided funds to aid those affected by the disaster. The platform FundedByMe asked people to provide help to the victims of the flooding by collecting funds. It was an international effort with Stockholm-based FundedByMe joining forces with the Republic of Korea messaging app Between and the online publication Vulcan Post joining to promote the campaign

6 ACTORS

6.1 Crisis mappers

150 As we have already stated in **Chapter 1**, crisis mappers are experts, practitioners, policymakers, technologists, researchers, journalists, scholars, hackers and skilled volunteers engaged at the intersection of humanitarian crises, new technology, crowdsourcing, and crisis-mapping.

151 Crisis Mappers leverage mobile and Web-based applications, participatory maps and crowdsourced event data, aerial and satellite imagery, geospatial platforms, advanced visualization, live simulation, and computational and statistical models to power effective early warning for rapid response to complex humanitarian emergencies. As information scientists, they also attempt to extract meaning from mass volumes of data downloaded in real time..

152 An international network of crisis mappers (Crisis Mappers Net, www.crisismappers.net/) (see also **Section 4.2**) was established in 2009. Crisis mappers play an important role in mapping any hazard valorizing a crowdsourcing approach (also through training, awareness-building, translation/filtering of popular knowledge, etc.).

6.2 Flood managers

153 Flood managers are professionals involved in floods, floodplain management and related topics. Flood managers work in any area prone to floods, mainly within public administrations, such as civil defence, water authorities, etc. Their attitude related to crowdsourcing in crisis-mapping (as well as the one of the other technicians/managers working on natural hazards) is ambivalent.

154 The contribution of crowdsourcing to crisis-mapping is often viewed by flood managers as a criticism of their capacities and the related data/information are/is considered as not "scientific" and, therefore, not sufficiently reliable.

155 In many other cases, however (mostly, but not only, if public systems are weaker), there is greater openness, interest and availability. For instance in Jakarta (Saunders, 2015), PetaJakarta – meaning map of Jakarta" in Bahasa Indonesian – was developed by researchers at Australia's University of Wollongong and the Jakarta Emergency Management Agency (BPBD) to take advantage of the significant use of Twitter in the city.

156 If someone in Jakarta tweeted the word "flood", the system would upload the location of the tweet to create a real-time, crowdsourced map of flooding in the city. Citizens' activity to report the scales/locations (users sharing pictures of floods and allowing Twitter access to the GPS coordinates of mobile devices) of flood events was also utilized by governmental agencies in February 2015, when the Ebro River in the Zaragoza area of Spain flooded twice within a single month (Bielski and Zeug, 2015).

6.3 Civil society and citizens

157 Volunteers/citizens who participate in crowdsourcing initiatives (for flood-mapping, but also in general) are, of course, very different people and do not share a common background. Moreover, their participation depends on specific contexts (who are the people who live in their area; their involvement in previous events; their level of education; the level of presence of civil society organizations, etc.). This is not to say that volunteers need to come from a specific background so that they could contribute information.

158 The following categories, in a nutshell, could be considered as volunteers, apart from the public at large (Narvaez, 2012):

- Entrepreneurs and farmers;
- Students;
- Doctors;
- GIS enthusiasts;
- NGO and international organization staff.

159 In terms of motivation, the majority of volunteers are motivated to share information or participate in mapping efforts for altruistic reasons, either because of the wish to proactively avert disasters or because of a broader desire to do good. Some are encouraged to join efforts through contests with prizes (students). Others join efforts because their livelihoods depend on the information they share (entrepreneurs and farmers).

160 Citizens'/volunteers' involvement level can vary widely: although there may be a large number of volunteers who originally sign up and participate only a little, the bulk of work is done by a small cohort of "super volunteers", who achieve a significantly larger amount of work than anyone else. They tend to be committed to the medium or long term and appreciate that it is a learning experience which gives them purpose and is personally rewarding. These volunteers often talk of becoming addicted to the activities and the amount of work undertaken often exceeds expectations. Digital volunteers' motivations are passion for a worthy cause, giving back to the community, helping to achieve a group goal, discovering new information (Terra, 2016).

161 These volunteers represent the leaders as well as the "key informants" among the citizens. Often they are "skilled volunteers", becoming, also, crisis mappers.

6.4 Media

162 As mentioned above, social networks are at the core of crowdsourcing for crisis-mapping (Twitter, Facebook, etc.). They have already been cited and will be mentioned many times in the examples in **Part III**, as well as in many other cases (and are important both in crisis-mapping and in all the crisis-management phases).

163 "Traditional" media can also play an important role. The reader is invited to consider the IFM Tool on Role of the Media in Flood Management (WMO, 2015).

6.5 Multilateral partnerships

164 The participatory process has been recognized as an essential element of community-based risk management that builds a culture of safety and ensures sustainable development. It addresses specific local needs of vulnerable communities by realizing the full potential of local resources and capacities. It seeks the active engagement of local people in all stages of flood-risk management activities (identification, analysis, planning, preparedness, response, recovery, monitoring and evaluation). Community-based activities for flood management should be organized strategically based on necessary actions for each target group: policymakers, disaster managers, trainers and community workers.

165 This is also true for crisis-mapping and crowdsourcing. Beyond all that has been said so far, it is an approach that enhances the participatory process. Thousands of citizens now participate in the management of flood through crowdsourcing. It is both a bottom-up participation (citizens voluntarily send data and information) and a top-down participation (citizens are solicited to do so).

166 As seen in the previous section, despite the embedded physiological inertia to change in institutions and authorities, there is a willingness to cooperate not only during floods, but also before and after. Sometimes, however, authorities (flood managers and others) address people as victims who can also play a pro-active role and not as partners in reporting. While being aware of each other's skills (taking into account that more and more volunteers are skilled or highly skilled, thanks to improvements in education, ICT diffusion, etc.), citizens' subjectivity should be more widely recognized as a resource as it already is in some cases (e.g. the Thailand case mentioned above).

7 FURTHER CHALLENGES

7.1 Institutionalization of the use of crisis-mapping and crowdsourcing in flood management

> *"There is nothing more difficult to take in hand, more perilous to conduct, or more uncertain in its success, than to take the lead in the introduction of a new order of things."*
> The Prince, 1532 (Chapter VI), Niccolò Machiavelli, Italian historian, philosopher, humanist and writer

167 One of the barriers that prevents the crowdsourcing potential from being fully realized can be identified in the lack of its acceptance in more institutionalized settings (Dawson et al., 2011).

168 As we have already seen, there is a wide consensus among those who make use of crowdsourcing that it is a viable and strong tool for the purposes of information collection and that most of the tools that could make it work already exist. Those who currently make use of crowdsourcing, however, do so mostly thanks to individuals promoting it who have confidence in it.

169 The hard part is to mainstream crowdsourcing as a standard tool that organizations such as the United Nations, NGOs, and all levels of a State – local, regional and national authorities – could work with (Narvaez, 2012).

170 This is a common problem met in many innovation processes and frequent in relation to ICT innovations. A context far from floods but with similar dynamics is the case of some judges in the judiciary system who invoke the inconsistency of electronic evidences in judicial proceedings. In the past, it has also been the case in the use of telemedicine by doctors. Similarly, some flood managers are reluctant to use crowdsourcing in crisis-mapping in flood management.

171 Some "gate-keepers", because of the difficulties they encounter in the management of innovative tools, (often due to their lack of personal skills and their resistance to acquiring new skills) can oppose their use – implicitly or latently.

172 This attitude, of course, is also justified by the limits of crowdsourcing that we have dealt with in **Chapter 3** (mainly those related to data validity and quality). However, the gate-keepers, instead of helping to overcome these limitations (cooperating in the innovation process), sometimes exploit them (almost pretentiously) to oppose to the crowdsourcing valorization in crisis-mapping .

173 These gate-keepers are present in organizations that take crowdsourcing into account[14].Thus, among the traditional actors managing natural hazards (local authorities, NGOs, international organizations, etc.), they are mainly present in the ones which are strong and do not perceive the usefulness of "new" sources of information (see **Section 6.2**).

174 More particularly, some public authorities/disaster managers sometimes have difficulty in appreciating the contribution of citizens. Some consider crowdsourcing products as competing with information coming from traditional communication channels that they are used to process, manage and share. Crowdsourcing map activities can be considered as problematic because they cannot be fully managed by the relevant authorities, especially during a crisis. For many reasons, including the lack of institutionalization, the high quantity, speed and diversity of sources, crowdsourced data are still not sufficiently cross-checked with information coming from traditional sources and integrated into conventional information collection systems (also because the formats differ widely from these systems), which affects further its credibility.

175 This lack of recognition of crowdsourced data by disaster managers (authorities, NGOs, emergency services, etc.) can have several negative consequences: development of dual information, loss of key information (e.g. from people experiencing a disaster or whose expertise is valuable in disaster management/recovery). Moreover, the lack of coordination between crowdsourcing activities and disaster managers can contribute to the spread of crowdsourced data that has not been validated and/or should not be disseminated in real time (e.g. during some security operations; although information must remain confidential at first, some leaks through social media can affect the smooth execution of operations).

7.2 Recognize the broader base

176 Likewise, the possibilities derived from crowdsourcing exist for the greater public. Crowdsourcing exists in the first place because there is enough public interest – more and more each day – about the extent to which an important event or cause is occurring.

177 However, this is not fully recognized (as we have just seen above) by some actors among flood planners, public authorities, etc. (this aspect will be further underlined in **Part III)**. On the other hand, a stronger recognition of this "broader base" could, in the opinion of the author of this Tool, facilitate its further enlargement and a better valorization of crowdsourcing in flood management. A larger public contributes and can contribute to crisis-mapping. "Broader base" means also valorization of all the societal actors, according to their knowledge and potentialities.

14 "Any organization that adopts crowdsourcing approaches needs to be prepared for internal resistance. Some of this may be a response to change in general, however there can be specific concerns about the introduction of crowdbased work" (Dawson et al., 2011).

178 For example, knowledge and past experience of elderly people about floods in their area must be valorized within crowdsourcing, likewise those who are usually marginalized people (women, minorities, the handicapped, etc.) who might have vivid experience and coping strategies to deal with floods and could take the crowdsourcing opportunities to have their voices heard. On the other hand, skilled people (and more generally "stakeholders") – also in sectors other than flood management – should also be valorized because they often hold and know how to provide useful information. Crowdsourcing should not be used only by specialists and experts: the aim of this approach is to give a voice to a larger public.

7.3 Role of humanitarian communities

179 Another challenge (strongly related to the previous one) can be the actual or apparent low awareness of crowdsourcing within the part of the humanitarian community that intervenes during flood (as well as in relation to other natural hazards), along with low knowledge of, and capacity to use, the crowdsourced information.

180 This could negatively impact the level of awareness among groups of users/potential users initially less familiar with crowdsourcing and its platforms (such as Ushahidi). Interviews among humanitarian communities also reveal some general "suspicion of the crowd" and related questions about the representativeness and quality of the data (Morrow et al., 2011).

7.4 Sustainability of volunteer efforts

181 Since most crowdsourcing is built around voluntary networks and contributions, sustainability is a core issue.

182 Volunteers have duties/obligations beyond their involvement in crowdsourcing activities (job, family duties, etc.). Therefore, there is a need to manage the commitment of volunteers, according to their availability. Their willingness (and their ability, too) – which entails giving them just the right amount of things to accomplish – especially those who do more than just submit information.

183 Another important issue is how to keep volunteers motivated in the long run – volunteers are often easy to come by but they are hard to keep. Since volunteers participate with some kind of reward in mind, the right incentives should be put in place so that they continue to be interested in volunteering. This can take several forms, such as providing visibility on how they are helping or offering opportunities for further learning (Narvaez, 2012).

184 Moreover, we need to develop more and more capacity-building tools for volunteer and community-based organizations, as well as citizen responders, including sensitization to issues such as protection vis-à-vis natural hazards (flood in our case). For capacity-building, it could be useful to consider partnering with small firms already working in developing countries or other vulnerable places that have experience consulting for the international community and government using GIS and mapping for development or recovery activities.

185 Sensitization contributes to the awareness and, therefore, to the empowerment of citizens/communities – capacity-building even more. The result may be stronger communities, improving the sustainability of the crisis-mapping community.

186 The sustainability of the crisis-mapping community is also enhanced by the strong links that platforms such as Ushahidi and Crisis Mappers Net have established with the scientific community. As underlined in an evaluation of the Ushahidi platform it should also be noted that a Standby Volunteer Task Force was launched at the International Conference on Crisis-mapping (ICCM) in 2010, precisely to aid in sustainability and preparedness (Morrow et al., 2011).

7.5 Opening two-way communication channels

187 Crowdsourcing is mostly used at this point as a one-way communication channel where information for crisis-mapping is provided by volunteers (according to the inputs coming from other actors) with few feedbacks of elaborated information (e.g. merged with scientific data) to volunteers. Of course, as we have seen, there are some efforts to transform information flows by making crowdsourcing a two-way communication channel by giving back the information that is received.

188 Nevertheless, the efforts to make crowdsourcing a tool for two-way communications still have a long way to go. Substantial progress can be made in terms of how crowdsourced information can be repackaged and presented in a way that complements official information. Moreover, progress can also be made in terms of making use of crowdsourcing as a tool to automatically trigger certain actions (e.g. where to find resources –human, technical and financial– and coordinate preparedness efforts). These issues, however, are beyond the scope of this Tool (Narvaez, 2012).

PART III — EXAMPLES

8 PAKISTAN FLOOD (2010)

189 In late summer 2010, the people and territory of Pakistan were deluged by monsoon rainfall that triggered widespread flooding. This flooding affected more than 20 million people, many of whom could be reached only by aircraft.

190 Floodwaters inundated and destroyed much of Pakistan's vast wheat crop – the nation's largest home grown food source – creating a food crisis across the country.

8.1 UNOSAT response

191 The Pakistan floods of 2010 resulted in the destruction of property, livelihood and infrastructure across the Indus river basin. Meteorologists indicated that the meteorological conditions in Pakistan during the period of July and August were unique in terms of spatial coverage, duration and intensity compared with historical events.

192 The percentage increase in rainfall from July to September 2010 from what happens normally in the same period of the year ranges from 2% to 412% (Pakistan Agricultural Research Council, 2010).

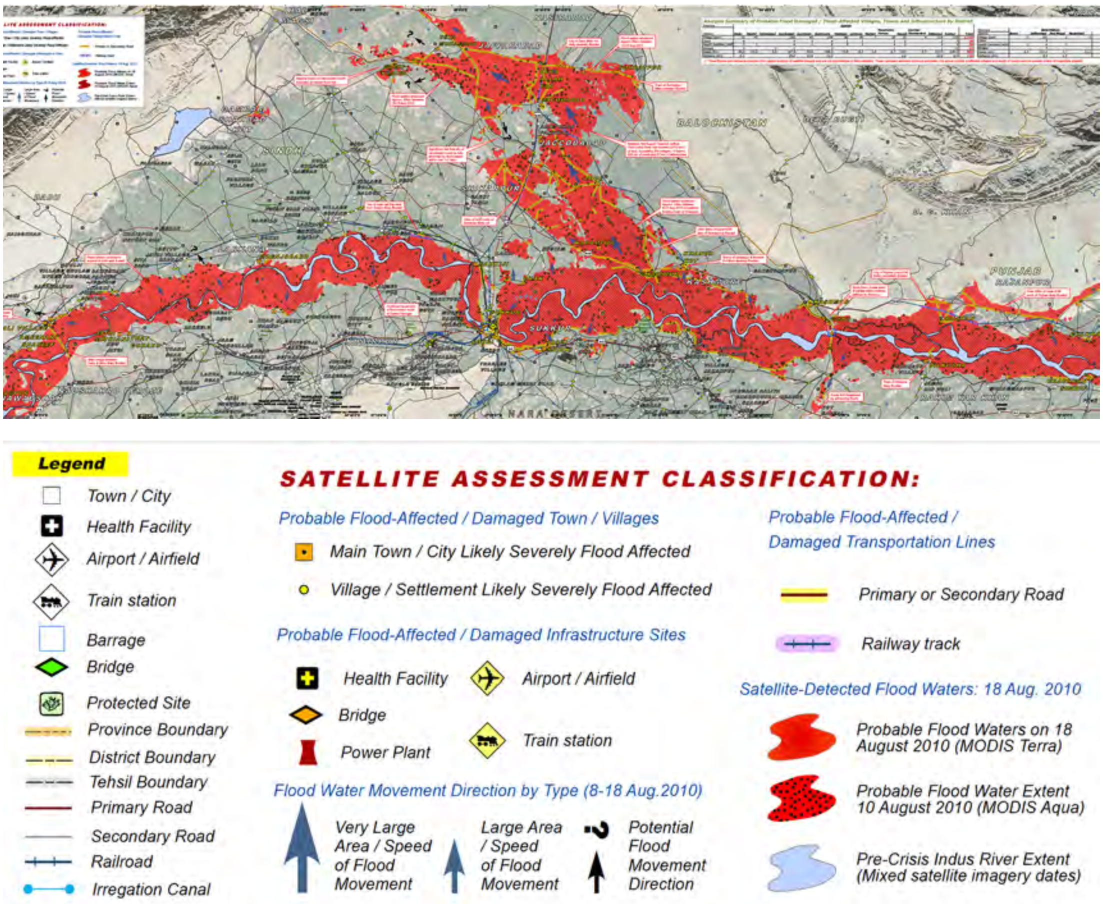

Figure 12 — Map of analysis of probable flood-affected villages, towns and infrastructure along the Indus River in Sindh and Balochistan provinces[15]

193 Throughout the course of this catastrophic disaster from 28 July to 7 September 2010, UNOSAT[16] provided emergency response maps to the humanitarian community with the support of the International Charter on Space and Major Disasters in collaboration with several partners. A total of 23 analytical reports and maps were produced by UNOSAT across the affected provinces in Pakistan as detected by a constellation of satellite sensors.

194 The estimated total surface area of all satellite-detected floodwater during this event was 37 280 km2 based on cumulative analysis from 28 July to 16 September 2010. Based on these results, it is estimated that approximately 4.5% of the surface area of Pakistan was directly flooded during the course of this event.

195 UNOSAT analysis of satellite imagery of flood-affected areas was improved by detailed geographic data about population, transportation and infrastructure from Google (Google MapMaker). With reference to those baseline data, spatial analysis conducted with satellite-derived flood data provided a preliminary estimate of the potential number of villages, towns and infrastructure sites, as well as the length of roads and railway tracks directly affected.

15 unosat-maps.web.cern.ch/unosat-maps/PK/FL20100802PAK/UNOSAT_PAK_MOD_Sindh-Damage-Analysis-18August2010_HR_v2.pdf

16 www.unitar.org/unosat/maps/PAK

196 In particular, it has been estimated by UNOSAT that over 7 490 villages, 135 towns/cities and 190 health facilities were identified as potentially directly affected by the floodwaters, the majority of villages being completely inundated or surrounded by flood waters without overland evacuation routes. Over 5 000 km of primary or secondary roads were likely to be submerged along with 400 km of railway tracks and 400 bridges.

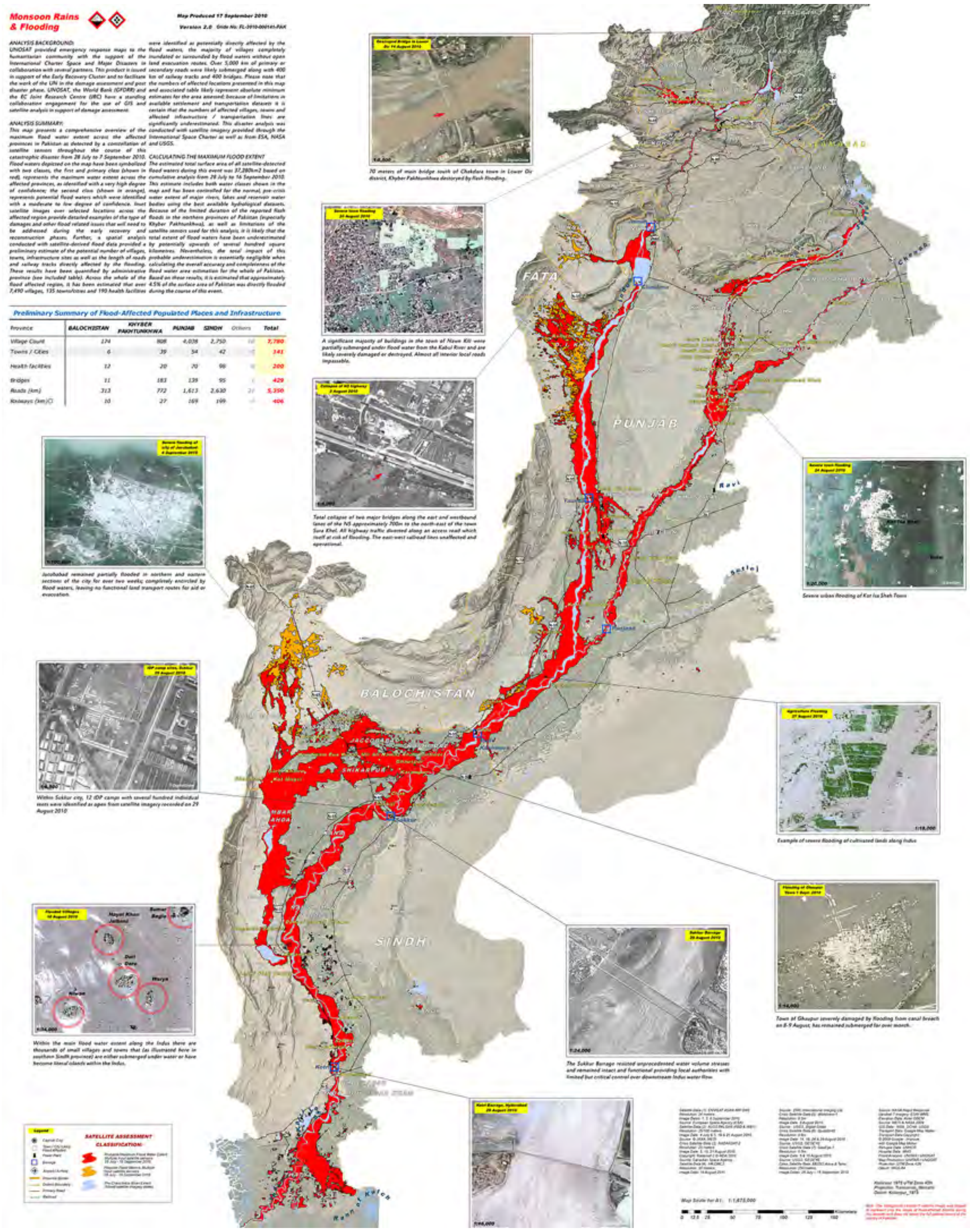

Figure 13 — Composite figure from satellite derived products for the Pakistan floods of 2010[17]

[17] unosat-maps.web.cern.ch/unosatmaps/PK/FL20100802PAK/UNOSAT_PAK_FL2010_EarlyRecoveryOverview_v2_LR.pdf

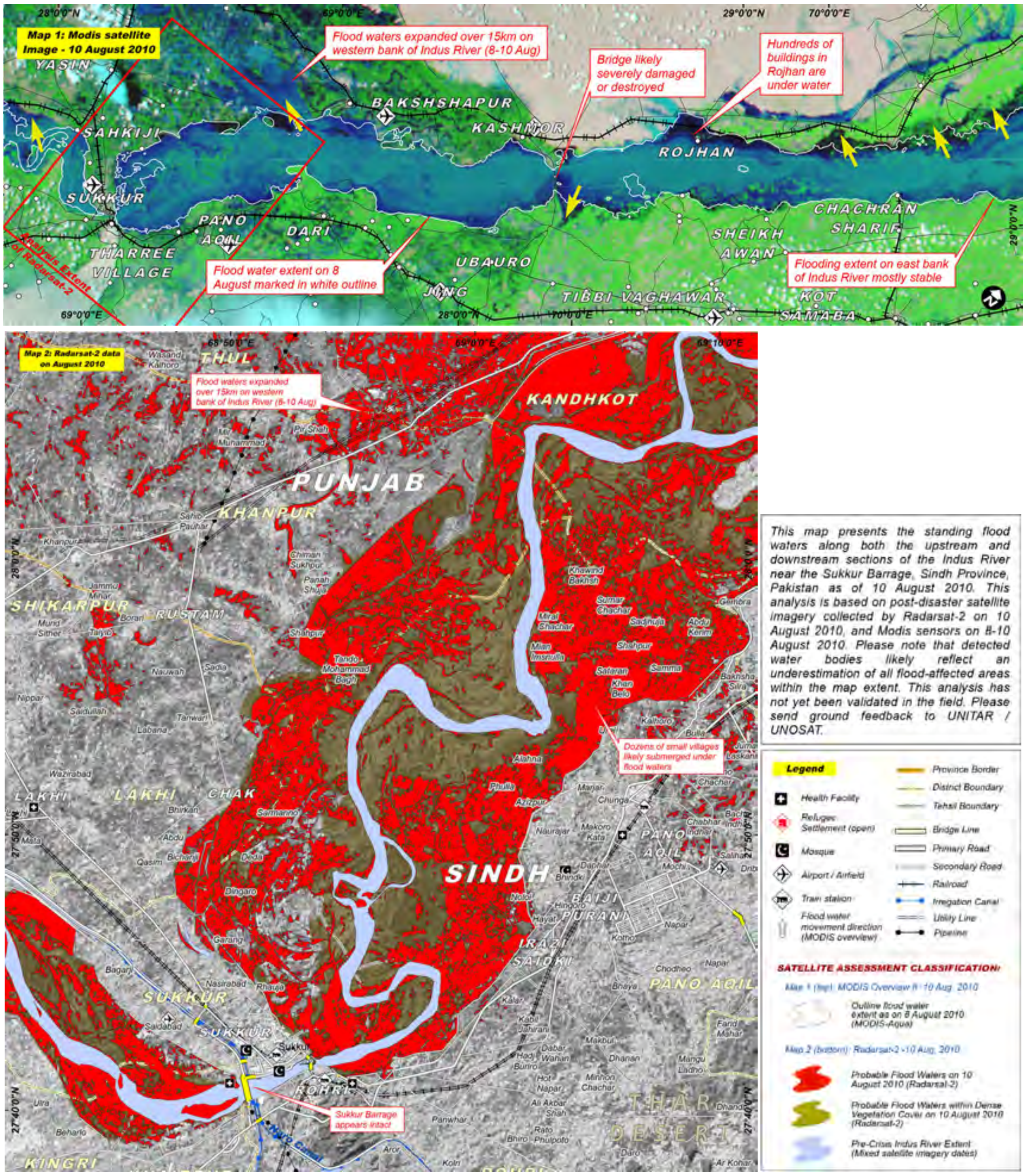

Figure 14 — Composite figure from satellite derived products for the Pakistan floods of 2010[18]

197 The UNOSAT flood analyses were validated in the field by Pakistani officials. The sharing of those accurate flood analyses was immensely appreciated by the user community (United Nations, NGOs and government officials).

8.2 Pakistan report and CrowdFlower

198 Pakreport (pakreport.org/flood2010/) is also an initiative conceived and implemented in response to the Pakistan floods in the summer of 2010. Pakreport is based on ICT and brought together crowdsourcing companies, crisis-mapping organizations, relief agencies and engineers in a

18 unosat-maps.web.cern.ch/unosat-maps/PK/FL20100802PAK/UNOSAT_PAK_FL2010_RS2-SindhBarrage-10August2010_v1_LR.pdf

common disaster management effort. Pakreport has been developed through crowdsourcing, utilizing Ushahidi software (Meier, 2010) in two ways:

- The use of people to provide reports from the ground; and
- The use of people around the world to translate, categorize and geolocate incoming messages.

199 This collected information was processed and then displayed on pakreport.org in an online map that people can see (Woolworth, 2012). The idea is that an undefined public from around the world can spontaneously come together to help a foreign community in its time of need. During the 2010 floods in Pakistan, flood information was launched involving volunteers to help with disaster-relief efforts in Pakistan. The information was reported and a team of dedicated people at PakReport mapped real-time data from Pakistan by collecting information from aid agencies and the media, as well as direct reports by e-mail and SMS.

200 The CrowdFlower project (Meier, 2013) helped PakReport to geolocate and translate reports from the ground (massive waves of unstructured information emerging from crisis-affected regions) in response to the floods in Pakistan. Messages from people on the ground (from Twitter via TweetDeck, among others) were grabbed, filtered, sorted and mapped and instructions transmitted to the emergency services. The first SMS reports started on 29 July 2010, when the service was enabled. Twitter-filtering (TweetDeck) was applied rapidly in comparison with other sites designed to aggregate information.

201 As Robert Munro reported in 2010 in his blog post: *"We are working to support a team … in Pakistan who are mapping the flood and post-flood conditions there, collecting reports from the general public and aid organizations via SMS, media monitoring and direct reports (www.pakreport.org). The potential scale of this information is extremely large, and therefore so is the potential bottleneck"* (Seybold, 2010). CrowdFlower was used for this reason. Urdu-, Pashto- and English-speaking volunteers around the world could come online to the CrowdFlower task (pakreport.crowdflower.com), read one message at a time and then complete a form to add geographic coordinates, categories and translations.

Figure 15 — Instructions on how to map SMS messages from the crisis in Pakistan through CrowdFlower (McLary, 2010)

9 QUEENSLAND AND VICTORIA FLOOD (AUSTRALIA, 2010/2011)

202 During the Queensland floods in 2010 and 2011, social media emerged as an effective method of disseminating information, complementing the traditional methods of television and radio. Social media played a vital role in providing real-time information and helping people communicate and stay connected to their family, friends and communities throughout the disaster.

203 Facebook pages appeared almost simultaneously with the floodwaters; for example, Rockhampton and CQ Floods 2010 was created on 29 December 2010 and by 3 February 2011 had 8 635 "likes". The group Toowoomba & Darling Downs Flood Photos & Info was created on 10 January 2011, just a few hours after the disaster began, and within a month had 37 700 "likes". This means that 37 700 people looked at the site and "liked" what they saw or used the "like" function to demonstrate support for the victims. In addition, it is likely that many more people used the site for obtaining or distributing information (Bird et al., 2011).

204 In the days during and following the Queensland floods, Risk Frontiers conducted a survey of people who were members of a number of Facebook pages, in an attempt to discover how people found out about the existence of the pages, what they were hoping to learn and what they did with the information. Preliminary results of the survey found that, of the 381 respondents, 61% used the pages to gain information about their own community. Many users relied on these pages for flood-related information during the worst stage of the disaster. Other people were using the pages to gain information about the communities of their family (45%) and friends (38%), often then communicating this knowledge directly back to their loved ones. Risk Frontiers asked the respondents to rate the information provided by community, government and media in terms of accuracy, timeliness, usefulness and trustworthiness. The results revealed that the community Facebook pages were accurate, up to date, useful and trustworthy and, in most cases, ranked higher than government and media websites.

205 Moreover, in response to the impending threat of Cyclone Yasi, administrators from various Queensland flood community Facebook groups joined together to develop and manage a new community group page entitled Cyclone Yasi Update.

206 Another study analysed the community of Twitter users who disseminated information during the crisis caused by the Australian floods in 2010/2011 (Meier, 2013(b)). The authors analysed 7 500 flood-related tweets to understand which users did the tweeting and re-tweeting. This was done to create nodes and links for social network analysis, which was able to identify influential members of the online communities that emerged during the Queensland, North South Wales (NSW) and Victorian floods, as well as identify important resources being referred to. The most active community was in Queensland, possibly influenced by the fact that the floods were orders of magnitude greater than in NSW and Victoria.

207 An active role was taken by local authorities, namely Queensland Police, government officials and volunteers, on social media. However, as far as the online resources suggested by users are concerned, no sensible conclusion could be drawn, as important ones identified were more of a general nature rather than critical information and there was an insufficient number of tweets that could be downloaded to be able to generalize the findings (Cheong and Cheong, 2011).

10 JAKARTA FLOODS (INDONESIA)

208 Jakarta, the Indonesian capital, is a megacity of around 10 million people, with over 28 million in the wider metropolitan region. As a result, the city faces a huge range of challenges, from the world's most congested roads to annual flooding that force thousands to abandon their homes and takes many lives. For example, the 2007 flooding affected more than half a million inhabitants and caused more than US$ 900 million worth of damage and losses (Speed, 2014).

10.1 Using participatory mapping for disaster preparedness in Jakarta

209 As part of the PetaJakarta pilot project (mentioned below) in Jakarta, high-resolution data were collected to inform flood preparedness and contingency planning led by the Province of Jakarta's Disaster Management Agency (BPBD-DKI Jakarta). The data, available to the community and the general public, were used in the 2011/2012 Jakarta contingency emergency planning exercise. The online and open-source platform Open Street Map, was utilized.

210 The Jakarta Open Street Map project is led by the Province of Jakarta's Disaster Management Agency (BPBD-DKI Jakarta) with support from the Indonesian National Disaster Management Agency (BNPB), Australian Aid Agency (AusAID), Australia-Indonesia Facility for Disaster Reduction (AIFDR), the Humanitarian Open Street Map Team and the World Bank/GFDRR.

211 The work is part of a collaboration with the Open Data for Resilience Initiative (OpenDRI), led by the World Bank and GFDRR, which aims to reduce the impact of disasters by empowering stakeholders from the public sector and civil society with robust risk information and analytical tools to support decision-making (Gunawan, GFDRR-World Bank, 2013).

212 The OpenStreetMap exercise in Jakarta relied on community participation and stakeholder engagement to collect detailed information about local infrastructure. A unique element of the initiative was that it brought together different stakeholders from the public, private and civil sectors. Participants included students from Jakarta universities, facilitators from villages in Jakarta province, heads of villages, government officials, the Humanitarian Open Street Map Team, donors and partner organizations.

213 The local community was trained in basic GIS and OSM tools. To allow for wider use of the tools, the software and training materials were translated into Bahasa, the local language. Social media channels (Facebook, Twitter, Blogs) were used to build an online mapping community (Gunawan, 2013).

214 The data collected through participatory mapping provided high-resolution baseline information for Jakarta Province used to assess, communicate and manage risk. Moreover, this approach enhanced knowledge transfer and capacity building within communities and between different stakeholders, raising collective awareness of disaster risk.

215 Key highlights included:

- Detailed data collected for 6 000 buildings and critical infrastructure, including schools, hospitals, places of worship, and all 2 668 neighbourhood boundaries within the Province of Jakarta, including the affected areas which had been affected by flooding in the past;
- Over 500 representatives from Jakarta's 267 communities participated in workshops and 70 students from the University of Indonesia trained in the use of OSM and basic GIS skills;
- Training materials were provided in the local language and risk information was disseminated on large-scale map printouts;
- The high-resolution data were used to reveal the buildings and communities most likely to be affected by a flood disaster. This analysis informed the 2011/2012 disaster-management agencies' contingency plan, which specified actions required by disaster-management entities at the province and district levels and listed available emergency response equipment and the exact locations of evacuation sites needed in case of a flood emergency (Gunawan, 2013).

216 The high-resolution data are freely available for practitioners and the general public for understanding disaster risk planning, development and poverty-reduction projects.

10.2 PetaJakarta.org project: Crowdsourcing Flood Maps in Jakarta

217 The PetaJakarta.org project, set up by researchers at Australia's University of Wollongong and the Jakarta Emergency Management Agency (BPBD) and Twitter Inc. was operationally active from December 2014 to March 2015. During this time, the project enabled Jakarta's citizens to report the locations of flood events using the social media network Twitter, thereby contributing to a publicly accessible real-time map of flood conditions at PetaJakarta.org (Saunders, 2015).

218 These data were used by BPBD DKI Jakarta to cross-validate formal reports of flooding from traditional data sources, supporting the creation of information for flood assessment, response and management in real time. During the pilot phase of the project, when anyone in Jakarta

tweeted the word "flood", the system would upload the location of the tweet and create a real-time, crowdsourced map of flooding in the city. Accuracy is always a concern with crowdsourced data, so another innovative feature of the platform is its partnership with Twitter. Residents of Jakarta who tweeted the word "flood" during the pilot received a message asking them to confirm that they were trying to report a flood. Only once they had done this did the report appear on a crowdsourced map.

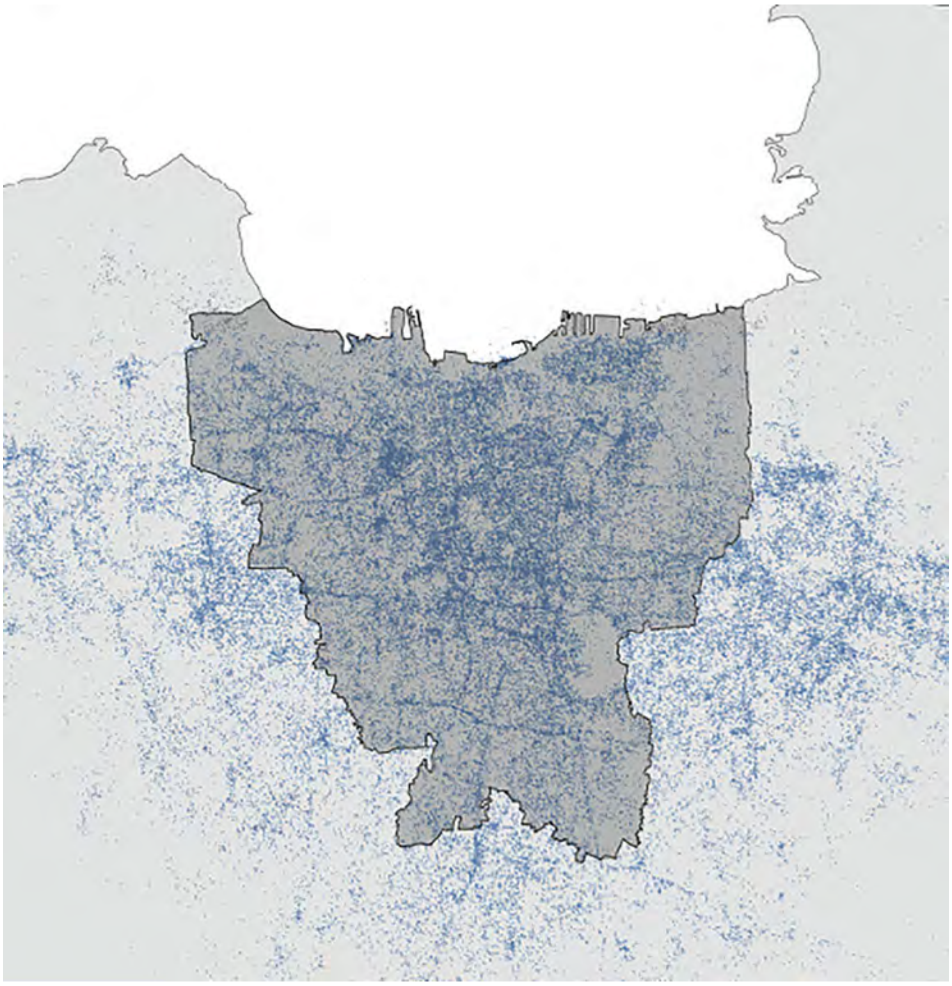

Figure 16 — Geolocated tweets related to flooding in Jakarta during the 2013/2014 monsoon season (petajakarta.org/banjir/en/research/)

219 The community-participation aspect of the project was communicated in a concise, action-oriented form in all the media produced for the public. *"See a flood? Tell us."* has been the basic message used to indicate how the public should best engage with the project. The large crowdsourcing element of the project was also highlighted in language and visuals (the more people use Peta Jakarta, the better the map will be), indicating a user-centric incentive that also encouraged users to share information about the project with their own social media network by retweeting messages from the @petajkt account.

220 However, there were not (according to the PetaJakarta project promoters) enough people reporting floods on Twitter to create a comprehensive flood map of the city. Crowdsourcing data were therefore used as a complement to existing data-collection methods.

221 Through its integration in Jakarta's official, existing disaster risk management information system (BPBD DKI), the PetaJakarta.org project has proved the value and utility of social media as a mega-city methodology for crowdsourcing relevant situational information to aid in decision-making and response coordination during extreme weather events. PetaJakarta.org is a promising evolution within the disaster-risk management information system because it leverages both the inherent capabilities within ubiquitous mobile devices (Global Navigation Satellite System-enabled messaging) and the network capabilities of social media through free and open source software to provide validated and actionable information for citizens and government agencies, thereby improving situational knowledge and increasing response times in disaster scenarios.

222 To maintain resilience within this information system, the study emphasizes the need for access to data via open application programming interfaces, which enable the integration of vulnerability information and potential hazard exposure to facilitate integrated risk evaluation and assessment. For residents of Jakarta, PetaJakarta.org enabled autonomous users to make independent decisions on safety and navigation in response to the flood in real time, thereby helping increase the resilience of the city's residents to flooding and its attendant difficulties. Critically, this outcome was achieved using the same data and map that were used by the Government; designing the platform to meet the needs of citizen-users and government agencies enable and promotes civic co-management.

11 UTTARAKHAND FLOOD (INDIA, 2013)

223 In June 2013, northern India experienced heavy rainfall that triggered devastating floods and landslides in the states of Uttarakhand, Uttar Pradesh and Himachal Pradesh. The early monsoon rains causing the floods were believed to be the heaviest in 80 years. On 17 June 2013, the state of Uttarakhand received more than 340 mm of rainfall, which was 375% above the normal benchmark of 65.9 mm during a normal monsoon. This cloudburst caused heavy floods in Uttarakhand as well as in the neighbouring state of Himachal Pradesh. In the city of Dehra Dun, capital of Uttarakhand, this was the wettest day during the month of June in over five decades. Heavy rainfall for four consecutive days, as well as melting snow during summer, aggravated the floods further. It was reported that the flooding caused the deaths of more than 600 people, with thousands missing and homeless. Damage to bridges and roads left almost 73 000 people trapped in various places.

224 UN-SPIDER's partner, the International Water Management Institute (IWMI) produced flood maps for the Yamuna, Ghaghara and Ganga rivers and for the states of Uttarakhand and Uttar Pradesh using data from the US National Aeronautics and Space Administration (NASA) Terra and Aqua satellites[19]. Swollen river width with an average of 15–20 km along the banks of the major Yamuna river as viewed by NASA's MODIS Terra/Aqua images explains the scale of flooding, particularly in the highly affected states of Uttarakhand and Uttar Pradesh. Major flood-affected districts included Haridwar in Uttarakhand and the districts of Meerut, Jyotiba Phule Nagar, Muzaffarnagar, Aligarh, Badaun, Lakhimpur Kheri, Bahraich and Ramnagar in Uttar Pradesh.

225 Furthermore, the crowdsource mapping community obtained information from the Internet and other communication channels, including official sources, blogs, social media, NGOs,

19 www.un-spider.org/advisory-support/emergency-support/6714/floods-india

public networks and the news media, aggregating it and making it more useful and actionable to help the Uttarakhand flood-relief effort (Ramachandran, 2013).

226 Situation reports were, therefore, generated and an online crisis map[20] set up by the Google Crisis Response team was also updated with vital information on rescued people, cleared areas, people stranded, relief camps, medical centres, road networks, etc. During this flood, Google also developed an example of its webapp, Person Finder, that enables users to provide and search information about missing persons (Ramachandran, 2013). According to the Uttarakhand State Council for Science and Technology, the role of crisis-mapping had been to bridge the gap that existed between information seekers and providers, particularly when it came to providing insights into the situation on the ground and the action that needed to be taken (Ramachandran, 2013).

20 google.org/crisismap/2013-uttrakhand-floods?gl=in

12 COLORADO FLOOD (USA, 2013)

12.1 Tomnod (Digital Globe)

227 Tomnod is run by a commercial satellite company called DigitalGlobe. On Tomnod, volunteers use satellite images to explore the Earth and solve real-world problems. The Tomnod team searches for all important locations in every new image and "tag" any important ones with the help of people (crowd).

228 DigitalGlobe activated its FirstLook satellite imagery service for emergency management during the widespread flooding in Colorado Springs near the Wyoming border in September 2013[21].

229 The flooding event that impacted a portion of Colorado's front range between the Colorado Springs area and the Wyoming border caused unprecedented evacuations and widespread damage. Once the flooding began, DigitalGlobe activated FirstLook, making before and after high-resolution satellite imagery of the affected areas available to first responders and government agencies (FEMA, Red Cross, National Guard, etc.) for the purpose of planning and maintaining awareness of the situation. FirstLook allows DigitalGlobe to provide much needed insight to those on the ground within a short amount of time. DigitalGlobe's high-resolution satellite images combined with its geospatial analysts' expertise provided actionable information for first responders in near-real time (Dinville, 2013).

230 Images of the event were collected as the floods occurred and delivered to disaster-relief agents for response efforts. They were accompanied with geospatial analysis to provide actionable information for first responders in near-real time. DigitalGlobe also helped organize a crowdsourcing campaign at Tomnod to enhance its maps and analysis of the damage.

21 www.satnews.com/story.php?number=530776406

231 In addition to DigitalGlobe's analysis, the team at Tomnod launched a crowdsourcing campaign to help map the damage. Tomnod's Facebook page indicated that the platform was used for crowdsourced disaster investigations several other times over the past few months, such as for flooding in Bolivia[22] and the United Kingdom[23].

12.2 Colorado Virtual Operations Support Team

232 The Colorado Virtual Operations Support Team (**COVOST**) is a resource (in the frame of the VOST concept) that can be activated at the request of any local, tribal, city, county or state entity with the approval of the strategic communication team within the Colorado division of the Homeland Security and Management Division (Department of Public Safety - Colorado) during their time of need.

233 COVOST aims to provide the state of Colorado (and, therefore, local communities in Colorado) with "a powerful and effective team of trusted agents, whose mission is to provide increased situational awareness through an innovatively, effective, efficient, elegant use of social media and other online or virtual tools".[24] COVOST partners trusted agents from Colorado, USA and the rest of the world (also for building relationships with other VOSTs for surge support on large activations; ties to other teams for mutual aid is one of the most important aspects of the VOST concept) and is training its agents via Webinars[25].COVOST agents do not have to be "experts" on these platforms. In this way, however, the agency (Department of Public Safety-Colorado in this case) determines the skill level and strengths of team members.

234 COVOST, as any other VOST, is a group of people who are interested and enthusiastic assembled ahead of time to listen and report in support of an agency/organization (Department of Public Safety- Colorado in the case of COVOST). People take account of what is being said on social media platforms and apps, stakeholder accounts, news article comments, and anywhere that public comments can be found about what is happening in relation specifically to emergencies – earthquakes, wildfires, floods, storms, public health emergencies, tornadoes, hurricanes and more. They can help find useful information, organize it, provide decision support, sentiment analysis, monitoring and reporting.

235 A well-trained VOST can also answer repetitive questions that are asked on social media, direct people to specific resources, correct known erroneous information, monitor social media accounts, respond to comments or questions, etc. This resource can be useful during a disaster, as the amount of information flowing on social media and the Internet can rapidly become overwhelming. Emergency managers need to know what is being shared on social media to gain real-time situational awareness, to respond to rumours, misinformation or old information, and to support the good information that is being shared (Reuter, 2016).

22 www.tomnod.com/campaign/boliviafloods2014/map/13tx4y7

23 www.tomnod.com/campaign/thamesfloods022014/map/136x1ky29

24 drive.google.com/file/d/0B2pPEZapFDm-djRDZjV5TlhmTE0/view

25 All the agents are identified with contact information and their username in all the social media platforms (personal platforms and the platforms of the agencies they belong), filling a specific form.

13 ELBE RIVER FLOOD (GERMANY, 2013)

236 One of the most severe floods ever recorded in Germany in the last 400 years was that of the River Elbe in June 2013. Flooding spread across a large area of central Europe (Germany, Hungary and the Czech Republic) following heavy rainfall over a few days.

Figure 17 — The city hall of Grimma, Germany, surrounded by floodwaters, on 3 June 2013 (AP Photo/dpa, Jens Wolf)

237 Relevant information was extracted from social media during this disaster, based on the hypothesis that "most flood-related tweets are posted by locals" and therefore contained local knowledge available only to people experiencing the floods firsthand (Meier, 2014).

238 Over 60 000 disaster-related tweets generated in Germany during this flooding event of the River Elbe were analysed. However, only 398 (0.7%) contained keywords related to the flooding. Major urban areas such as Munich and Hamburg were not the source of most flood-related tweets. Instead, the majority referring to the flooding were posted by locals closer to it (i.e. a considerable amount of flood-related tweets were geo-located in areas of major flooding). This means that mostly people in regions affected by the flooding or people close to these regions posted twitter messages referring to the flood. Therefore, the distance from flood phenomena is indeed a useful parameter to prioritize twitter messages towards improving situation awareness for Twitter. Whether this is also true of other social media platforms, such as Instagram and Flickr, remains to be seen.

239 Volunteer-related tweets closest to the flooding, yield greater situational awareness of its localization, intensity and impacts. Indeed, information about current flood levels is crucial for situation awareness and can complement existing water-level measurements, which are only available for determined geographical points where gauging stations are located. Since volunteer actions are increasingly organized via social media, this type of information is very valuable and completely missing from other sources.

14 EBRO RIVER FLOOD – ZARAGOZA (SPAIN, 2015)

240 Melodies (www.melodiesproject.eu) is a European Union project aiming to develop new, innovative and sustainable services, based upon open data, combining Earth Observation data with other data sources to produce new information for the benefit of scientists, industry, government decision-makers, public service providers and citizens.

241 In February 2015, the Ebro River in Spain flooded twice within a single month. This was due to the accumulated rainfall being 200% greater than the expected average (WMO, 2015). It affected the city of Zaragoza and surrounding areas. The Copernicus Emergency Management Service activated the Rapid Mapping service twice to support the disaster response. During this event, people affected by the flooding and those supporting the victims also described their situations and expressed their opinions on social media.

242 The Melodies project reports asked for information via Twitter to *@MelodiesProject*. The photograph in **Figure 18** (top) was tweeted on 1 March 2015 and showed the condition of the Ebro River, remarking that its level was totally unusual (Increíblecómoestá el #Ebro en Zaragoza). Melodies project staff commented that "this user provided some contextual information because he was amazed at the state of the river. While the outside world already knew that flooding was occurring in the area, local knowledge can improve information content. The picture that was shared with this particular tweet was also valuable information. From a disaster point of view, this is evidence of the scale of the event and provides visual confirmation about the extent of the inundation" (Bielski and Zeug, 2015).

243 Since the Twitter user allowed access to his mobile device's GPS coordinates, the location where this photo was taken was also available and it was possible to map it accurately (**Figure 18**, bottom) and thus quickly determine at which point the Ebro River overflowed.

Figure 18 — State of the Ebro River in Zaragoza on 1 March 2015 (top) and the coordinates provided by the mobile device when the picture was taken (bottom, red pin)

PART IV

PERSPECTIVES

244 Social media provide the means for creating new communities and re-energizing old communities. Events, such as the ones illustrated in **Part III** (among others), however, point to the creation of a new kind of quickly formulated, potentially powerful community – the ad hoc crisis community, which is made possible by new social media that supports "crowdsourcing" approaches to addressing complex problems (Howe, 2008). Ad hoc crisis communities form on the fly as existing social media communities, news organizations and users converge in social media spaces in response to sudden disasters.

245 Jeff Howe (2008) elucidates some of the critical rules for crowdsourcing that, according to him, are exactly in step with the needs of crisis-mapping. There must be someone in charge (even if it is a committee) to make critical decisions often about what not to do (or not create), rather than what to do (or create). In creating social media, this is probably one of the most important rules, then development of a benevolent "dictator" (e.g. a competent person with recognized authority, who takes a decision quickly), who understands the socio-technical behaviour of the social-media-using public (and is able to select and valorize it).

246 Socio-technical behaviour has changed from long-held patterns to take advantage of the new information flows offered by new technology (Goolsby, 2010). It describes new patterns of behaviour mediated by, and promoted through, advanced ICT (e.g. smart phones), software and server technologies. The new socio-technical behaviour pattern has news portals such as Digg or Huffington Post offering the most popular headlines drawn from across the country or the world. Without replacing traditional news sources (e.g. online newspapers) – rather, supplementing them – social media provide sourced and instantaneous information that is less achievable with traditional news sources. The next generation of community/crisis maps will reflect a community that runs at a fast pace and has a high information demand. Many of the posts will – or should be – short-lived.

247 We meet, of course (see the examples **Section 3.2** or on some reports related to FCOs in **Section 5.1**) the problem of spoofing (false reports). In this regard, past experience with social media suggests that bad data can be rapidly culled from the system by other reports (usual multiple reports) that the data are wrong, but this is still a social experiment. At the time of writing, people texting in will leave a trace (their phone number), which will help prevent inaccurate or bogus reports. If people block their identity, then that, too, is a red flag about its trustworthiness.

248 Thus, crisis-mapping through crowdsourcing can and should enhance the reliability and the validity of the data produced. This trend will be strengthening, taking into account that the use of crowdsourcing in crisis-mapping is a global phenomenon. Global because worldwide (as shown by the examples in **Part III**) and global because related to a huge quantity of very different phenomena (as seen in **Parts I** and **II**): from flood (that interests us in this Tool) to landslides to crises due to anthropogenic causes, etc. A "mutual learning process" is therefore going on (more each day), thanks also to platforms and networks (such as, for example, the e-lecture "The future of crisis-mapping for disaster response" by Patrick Meier[26]) that (through more or less formal/informal training) can "transform" volunteers who want to help and get involved in civic engagement around crisis into "sensors", recording important parameters for disaster management in a local environment.

249 Perhaps what could be most exciting about the recent use of crowdsourcing in crisis-mapping is not just its use for identifying problems, but also existing solutions; the idea is to combine crowdsourcing with crowdfeeding to create a crowdsourcing "market place" that matches needs with resources. The basic idea is to help others help themselves. Professional disaster responders may not always be there to help but the crowd is always there (Meier, 2011). This requires a new approach, which also includes a new way to network, manage data and train staff and stakeholders in the field.

250 This is not to say that professionals and technicians can stop carrying out their functions. Nor that we should use in crisis-mapping and solution identification only popular knowledge (volunteered geography). It is simply that this knowledge can be – and already is – increasingly valuable.

251 In this frame, the limits are not so much a lack of validity or reliability or even a lack of capacity in the management of large amounts of data (with differentiated and sometime unusable formats). Thanks to the spread of ICT, even in the most remote areas of the world, not even the lack of IT infrastructure accessibility is a problem. Together with privacy, security and ethical concerns, the main risk is to forget (or at least not remember enough) that crowdsourcing is a tool, not an end – and never will be. Challenges such as climate change (and the related increase of natural hazards) or the worsening of social exclusion (among many others) remain as they are and need specific and effective policies to be implemented and enhanced. They cannot be "solved" through tools, however beautiful and perfect.

26 www.youtube.com/watch?v=M_NguESRZ4g

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