Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

Crowdsourcing In The Humanitarian Network – An Analysis Of The Literature

Bachelor Thesis

by

Raphael Hörler

2014

Supervisors:

Dr. Dagmar Schröter

Dr. Christian Pohl

Department of environmental science (D-USYS)

ETH Zurich

25th August 2014, Zurich

Abstract

The recent explosion of Internet technology enabled the world to be more and more connected. With such a new network, the possibilities of crowdsourced volunteer efforts rise during disasters. People from around the world can act as an emergency responder by fulfilling simple tasks, which in the mass have proven to be a valuable support to humanitarian aid agencies. The crowd can also just act as a sensor or social computer, where their real-time online reports in social media can contain useful information during a crisis. International organizations such as the United Nations and the World Bank are increasingly joining crowdsourcing projects and seek support from upcoming Volunteer Technical Organizations (VTC), that perform crowdsourcing. Mostly the cost-efficiency and timeliness data delivery is fostering this new movement, which has its clear advantages over traditional efforts that generally need more time. A quick answer to a disaster is indispensable for emergency agencies. But for all that, challenges remain to be investigated. Accuracy, trust and security issues particularly hinder the adoption of crowdsourced data, although several solutions exist. This paper seeks to define the humanitarian aid crowdsourcing community, the associated projects and the challenges and chances that come with incorporating crowdsourced information in disaster response.

Acknowledgements

I would like to thank several people, who supported me during the time writing this thesis. At first, a big thank to my supervisors Dagmar Schröter and Christian Pohl, who always stood by my side with helpful advice. Their guidance gave me the confidence to carry on. Also I would like to thank Pablo Suarez for his effort in helping me to find an appropriate research question and who introduced me to experts in the field of humanitarian crowdsourcing. Your effort really was the spark to get the ball rolling. Lastly, I would also like to thank my family who, as always, had an open heart for me during the difficult steps in between this work.

Figures and Tables

1 Introduction

The anthropocene is connected online. The accelerating improvement of smartphones, tablets, laptops and global networks creates an increasingly connected world, where almost everyone can talk, write and share information with people, who are thousands of kilometers away. It is expected that global mobile phone subscriptions will reach almost 7 billion by the end of 2014. 78% of these subscriptions belong to the developing world, with Africa and Asia-Pacific showing the strongest growth in ownership of mobile-cellular phones. Also the number of global internet users will reach roughly 3 billion by the end of 2014 (International Telecommunication Union, 2014)[1].

Growth is a major driver of humanity, leading to very high population density in developing countries, increasing the number of cities around the world and the amount of wealth. Along with that, global warming is increasing, supporting the probability of extreme weather events. If a disaster strikes a city in this fast growing and dense world, the damage can be severe, such as when the devastating 7.0 magnitude earthquake stroke Haiti in January 2010. To help the affected people in such a crisis, information about the damage, planning the response and analyzing huge amount of data is needed. But the response was different this time. Haitians used social media like Twitter and Facebook to plea for help instead of calling emergency agencies. The pleas were recognized by thousands of ordinary volunteers who supported the disaster response by aggregating, translating, geo-tagging, and plotting the most important tweets and posts in a live crisis map (Harvard Humanitarian Initiative, 2011)[2]. Additionally, due to the half unfinished map by Google, concerned volunteer GIS-experts from all around the world created an entire map of the capital Port-au-Prince in a matter of days by analyzing satellite images provided by the World Bank and the open source software OpenStreetMap (Meier, 2012)[3].

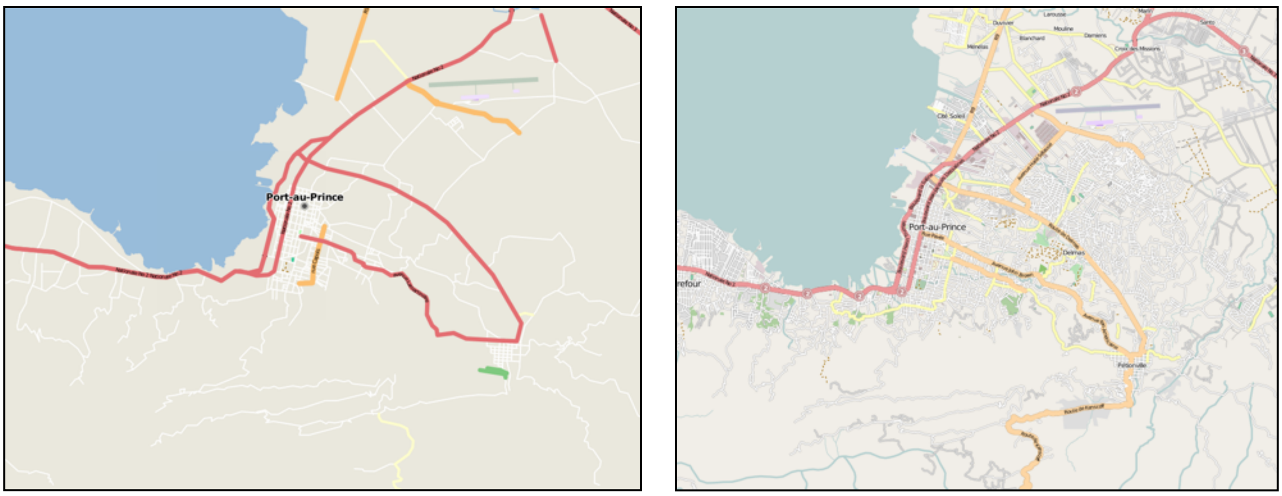

Figure 1 Map of Port-au-Prince before and after the volunteer mapping effort.

Crowdsourcing definition

In this era of technology, including the possibility to shunt out geographical distance, a new type of bottom-up concept for emergency response, called crowdsourcing, emerged.
The literature contains a vast number of different definitions on crowdsourcing. To summarize the most important aspects, I present the following three:

"Crowdsourcing is a type of outsourcing of a so far intra-corporate task to a volunteer, often big group, by an open call (Duden)[4]."

"Crowdsourcing is a type of participative online activity in which an individual, an institution, a non-profit organization, or company 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 (Estellés-Arolas & González-Ladrón-de-Guevara, 2012)[5]."

"Crowdsourcing can be used to solve problems and produce information by asking a distributed group of people, often volunteers, to perform certain tasks. In the case of humanitarian work, it has been used to refer to two distinct models: one in which information is sought directly from affected communities […] and another in which technical or information management tasks, such as mapping or geo-tagging, are outsourced to a "crowd" of volunteers that can live anywhere (UN Office for the Coordination of Humanitarian Affairs (OCHA), 2013)[6]."

While the first definition, found in a general encyclopaedia (ie. Duden), is very compact and easily understood, Estellés-Arolas and González-Ladrón-de-Guevara propose a more detailed explanation of crowdsourcing. They take into account what the crowd should do, what they receive in exchange and what the crowdsourcer initiator's benefit is. This helps understanding the context of this study. The third definition by OCHA emerges from the humanitarian sector and thus adds the most important aspects of crowdsourcing for this analysis.
Moreover, there subsist diverse types of crowdsourcing in the literature. To keep it simple, I stay with the generic term crowdsourcing and the definitions above.

Today, crowdsourcing is present in various sectors. One can find this method in academic fields, research and development, libraries and museums, private companies, in connection with the government, entertainment and also in social welfare projects. Crowdsourcing in the latter will be the topic of this study. The big diversity of applications can be explained due to the opportunities of crowdsourcing. The work can be spread among numerous volunteers and it is often done for free. This lowers the cost and the time needed for the project. The simple principle to propose a task to a volunteer group was strongly fostered by the rapid emerging global internet connection (Gupta & Sharma, 2013)[7].
As already mentioned, I'll focus on crowdsourcing in the humanitarian sector. It has been used for finding missing persons, validate information, translate texts, crises mapping and to gather other useful data for humanitarian decision makers (OCHA, 2013)[6].

Research questions

The leading research question for this study:
How is crowdsourcing integrated in the humanitarian aid network?
Out of this main question rise four other questions for a detailed analysis:

- Who are the players behind crowdsourcing in the field of humanitarian aid?
- How is crowdsourcing used to support the humanitarian aid sector?
- What are the opportunities and risks?
- Is there a place for complex analytical crowdsourcing tasks in emergency response?

The aim of this research is to raise awareness of the potential of crowdsourcing as a support in crisis situations, that it can save lives and give affected people a better standard of living. The current literature does not contain a comprehensive overview of humanitarian crowdsourcing projects, their players and distinctions.
To help me focus in this maze of existing studies and reports, I want to give an overview of the format, variety, challenges, possibilities and effectiveness, that come with the incorporation of crowdsourcing in the field of humanitarian support.

Usage of topic and placement of the research questions in the scientific discussion

The study targets a broad majority of the humanitarian sector. It aims at giving an overview of crowdsourcing possibilities, their reliability, effectiveness and major problems to emergency aid agencies, which could use this work as a resource for their own projects. It also provides a structured classification for crowdsourcing projects, which could be a tool to stay in focus.
In scientific terms this work shows, how much crowdsourcing is integrated in the humanitarian sector. Crowdsourcing is becoming more and more popular and its capabilities are still unclear and need further research. However this study gives an up to date summary

of what has been done, what can be done and what may come in the future of humanitarian crowdsourcing.

Structure

This thesis is split into four chapters with every one targeting one of the four research questions. The first chapter defines the leading actors in humanitarian crowdsourcing, divided into humanitarian organizations like the World Bank, United Nations or the International Federation of the Red Cross and the Volunteer and Technical Communities (VTC's). While the first section builds a solid overview of actors, the second chapter goes deeper into the matter and shows the relevance of crowdsourcing in humanitarian aid projects. Three forms of crowdsourcing classification, each divided into different technical media such as Twitter, Facebook or Flickr, and the third split into mapping and tagging, point out the most important methods used in crowdsourcing for emergency management. The next part discusses the major challenges and risks that come with the incorporation of crowdsourcing, as well as the possibilities to facilitate disaster relief. Lastly, the discussion turns to whether complex analytic crowdsourcing tasks could play a role in emergency response. The paper ends with a conclusion and a prospect into the future.

2 Method

2.1 Literature review and expert consultation

The articles analyzed in this study were found through the Web of Science database, Google Scholar and recommendations from experts. I used keywords like "Crowdsourced* AND solutions* / humanitarian work* AND crowdsourcing* / volunteer* AND technology* AND communities* / volunteer* AND crowdsourcing* AND disaster*. This list is not meant to be complete.

During the early stages of determining the topic of my bachelor thesis, my bachelor adviser Dagmar Schröter and I went in contact with Pablo Suarez, associate director for research and innovation in the Red Cross/Red Cresent Climate Centre. He gave me useful connecting factors to carry on with my study and introduced me to John Crowley. John Crowley works as an adviser to the Global Facility for Disaster Reduction and Recovery's Open Data for Resilience (GFDRR) Initiative at the World Bank, supervises the Camp Roberts humanitarian technology accelerator and is a researcher at the Harvard Humanitarian Initiative. He showed me several very valuable reports and studies to the thesis and encouraged me to track ISCRAM via the University of Tilberg (Prof. Bartel van der Walle) and University College of London (Prof. Muki Haklay). Bartel van der Walle advised me to check out the proceedings of the 2014 ISCRAM conference and later versions. Muki Haklay suggested looking out for the work of the Humanitarian OpenStreetMap Team (HOT) and Patrick Meier's blog at iRevolution.net. Patrick Meier is a pioneer in next generation humanitarian technologies, author of the forthcoming book "Digital Humanitarians: How Big Data is Changing the Face of Humanitarian Response" and the creator of iRevolution. The straightforward and up to date blogs really helped me in finding relevant information. Furthermore, Pablo Suarez introduced me to Pietro Michelucci who is the founding editor of the journal Human Computation and developed the Springer Handbook of Human Computation (2013). Again Pietro Michelucci recommended Patrick Meier's blog, as well as a search for papers from Leysia Palen. She is an Associate Professor of Computer Science at the University of Colorado Boulder, USA and directs the Project EPIC (Empowering the Public with Information during Crisis).

With all these recommendations from experts, I was able to find the relevant needed information to complete this research study.

2.2 Classifying the crowdsourcing system

Crowdsourcing can be used in very different ways. To give this work a clear view, I had to make a reasonable classification on how crowdsourcing could be laid out for humanitarian purpose. In the literature there already exist several classification methods. (Wechsler, 2014)[8] would categorise crowdsourcing into participation possibilities:

1. *Knowledge holders*
2. *Researchers*
3. *Involved citizens: concerned/responsible/competent participants*
4. *Interested citizens*
5. *Supporters*
6. *Examiners and evaluators*

(Narvaez, 2012)[9] defined two activities in his dissertation about crowdsourcing for disaster preparedness:

1. *Producing platforms for the contribution of voluntary information:*
   Volunteers and disaster-affected people can submit their needs and worries via different services like E-Mail, Short Message Service (SMS) or, most frequently, smart phone applications. This crowdsourced information can be put together in a map and in turn be shown to the public for verification and as a source of information for relief organisations.
2. *Crisis mapping:*
   Volunteer geographers with specific knowledge or the skills to use map-based platforms such as OpenStreetMap can create new maps, where the official maps are destroyed or lack relevant information, such as impassable streets, hospital locations or damaged buildings.

Finally I read about crowdsourcing roles in the paper from (Poblet, Garcia-Cuesta, & Casanovas, 2014)[10].
They build a triangle based on user's involvement and level of data processing.

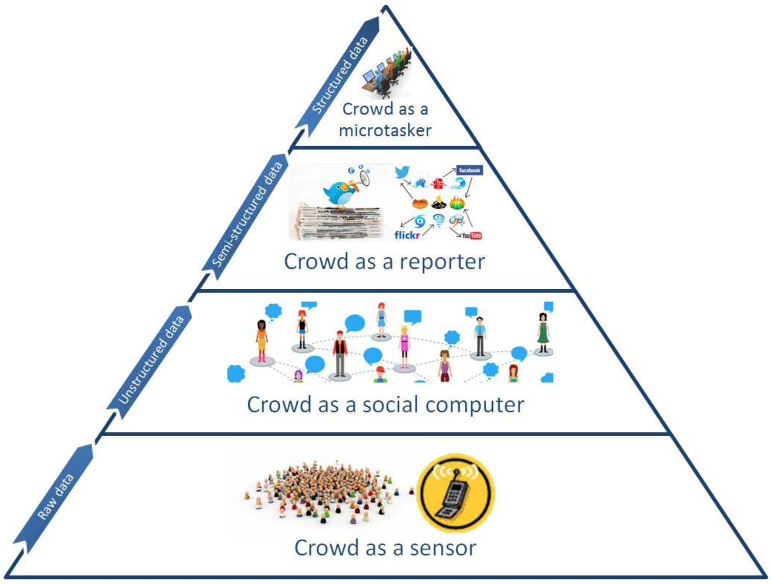

Figure 2 Classification pyramid by Marta Poblet et al.

In the lower tiers, the data is raw and unstructured, like for example in the use of mobile phones, tablets or occasionally social media. This means, that the crowd is not directly targeted to give a solution, they are roughly involved. The top two tiers however glean semi-structured and structured data, which makes the contributors more similar to employees. This could entail usage of a priori knowledge of the volunteers to attain a distinct goal.

I will briefly describe the four identified roles.

1. *Crowd as a sensor:*

   Is a passive form of crowdsourcing. Sensor enabled mobile devices create raw data by automatically run processes (e.g. GIS receivers). A known example is phone coordinates for positional triangulation.

2. *Crowd as a social computer:*

   States the crowd as a social computer. People communicate via social media (e.g. Facebook, Twitter, Instagramm etc.) for their own purpose and create unstructured data, which can later be used to leach out useful semantic information. This also does not require any form of participation in a crowdsourcing initiative by the crowd.

3. *Crowd as a reporter:*

   Gives the crowd a more active role. People specifically report disaster related data, such as landfall of a hurricane or local damage via Twitter and other social media platforms. These are real-time bits of information that have already valuable content.

4. *Crowd as a microtasker:*

   Is the most active form of crowdsourcing. The crowd generates high quality, structured and interpreted content by using specific tools. This could be image labelling, organising reports by categories, adding coordinates, translation work and much more. Yet microtasking may require special skills or certain training to fulfil the task (Poblet, Garcia-Cuesta, & Casanovas, 2014)[10].

I chose this classification from Marta Poblet and colleagues over the other two because it doesn't lack depth and is based on humanitarian crowdsourcing. Dietmar Wechsler, in the first classification introduced above, showed the great variety of different roles, with which the community can participate in a crowdsourcing task. However, he did not concentrate his work on humanitarian purpose, but took a holistic, transdiciplinary perspective on crowdsourcing. The classification by (Narvaez, 2012)[9], the second classification introduced above, can be directly used to categorize most of the crowdsourced cases I found during my research. Nevertheless, for the purpose to contribute to a better overview of crowdsourced project in the humanitarian sector, I wanted a more detailed differentiation. We further see that "crowd as a microtasker" already tends to go in the direction of crowd-analysis. This will be examined in the discussion part later.

3 Results

3.1 The humanitarian aid crowdsourcing community

In section 3.1.1 I will first describe the companies and institutions most frequently named to use crowdsourced data as support for their tasks. It is important to note, that these are not the crowdsourcing initiators. Section 3.1.2 identifies the institutions and platforms, that initiate crowdsourcing "on the ground" as a tool to get relevant information, which can in turn be used by the first group (e.g. disaster relief organisations, emergency agencies or governments). Yet some may represent both, initiator and end user in one. This chapter serves as an important overview and description of the main actors, who use crowdsourcing, which is indispensable for the further analysis of crowdsourcing projects.

3.1.1 (International) humanitarian organisations

United Nations (UN)

To prevent another conflict like the Second World War, the United Nations was created in 1945 by 51 countries. They all came together for developing friendly relations among each other, preserving international security, improving social progress, providing better standards of living and guaranteeing everybody their human rights. The UN is an intergovernmental organisation with currently 193 member states, which includes nearly all countries on the planet, since the total number of countries on earth by most accounts is 196 (United Nations)[11]. Its objectives include:

Figure 3 Emblem of the UN.

- To help every nation on the planet to work together to enhance and help to improve the everyday lives of poor people, to abolish world hunger, life threatening diseases, poor or non existent education and illiteracy, and to encourage respect for every citizen of the Earth's rights and liberties;
- To forge and develop friendly and useful relations among the world's nations;
- To keep peace amongst nations throughout the entire world;
- To be a global centre for reaching these goals by harmonizing each nations weaknesses and strengths.

United Nation's Office for the Coordination of Humanitarian Affairs (UN OCHA)

UN OCHA is the part of the United Nations, which coordinates humanitarian aid in emergencies. They build a framework, where the actors can contribute to the overall response effort.

Figure 4 Emblem of UN OCHA.

The four key missions are:

- Mobilize and coordinate effective and principled humanitarian action in partnership with national and international actors, in order to alleviate human suffering in disasters and emergencies.
- Advocate the rights of people in need.
- Promote preparedness and prevention.
- Facilitate sustainable solutions.

They are mostly present in Africa and Asia with some offices in the Middle East and the Americas (United Nations Office for the Coordination of Humanitarian Affairs)[12].

World Health Organization (WHO)

The WHO supervises and coordinates health issues within the United Nations scheme. It provides leadership in global health topics, contributes to health research, setting standards and norms, supports the countries in need with technical backup and monitors global health trends (World Health Organization)[13].

Figure 5 Emblem of the WHO.

Their roles in public health (Cross Border Directory)[14]:

- Leadership provision on health matters and engaging in partnerships where joint actions are required.
- It shapes the research agenda and stimulates the generation dissemination and translation of essential knowledge.
- It sets standards and norms, monitors and promotes their implementation.
- It articulates evidence based and ethical policy options.
- It provides required technical support, and builds sustainable institutional capacity.
- It monitors health situations and assesses health trends.

UN High Commissioner for Refugees (UNHCR)

The UNHCR was established by the United Nations General Assembly in 1950. It leads and coordinates international action to safeguard refugees and clear refugee problems worldwide. The main purpose is to protect the rights and well being of refugees. The UNHCR achieves this target by offering asylum support for everyone, including a safe refuge in a different state. It also fosters the possibility of refugees to return home voluntarily, integrate locally, or resettle in a third country. Additionally the UNHCR has a mandate to help stateless people (United Nations High Commissioner for Refugees)[15].

Figure 6 Emblem of the UNHCR.

As the United Nations web page states:

At its heart, UNHCR's work revolves around three very human goals that all of us can relate to -- saving lives, restoring hope to those who have lost everything, and helping people to find their way 'home' again -- even if it means building a new life in a new land. Everyone deserves a place to call home (United Nations)[16].

United States Agency for International Development (USAID)

Created by John F. Kennedy in 1961, USAID is a federally funded development agency of the United States. While focused on the approach of participatory development, sharing ideas, time and resources and generate decisions together with partners and customers, it also aims to advance the political and economic interests of the United States. Furthermore the agency facilitates the transition between conflict and long-term development by investing in agriculture, health systems and democratic institutions. Yet the most important task of the USAID is to prevent conflict in the first place (United States Agency for International Development)[17].

Figure 7 Emblem of the USAID.

USAID has the ambition to:

- Promote broadly shared economic prosperity.
- Strengthen democracy and good governance.
- Protect human rights.
- Improve global health.
- Advance food security and agriculture.
- Improve environmental sustainability.
- Further education.
- Help societies prevent and recover from conflicts.
- Provide humanitarian assistance in the wake of natural and man-made disasters.

Unite States Federal Emergency Management Association (FEMA)

Since its creation in 1979 and signing by President Jimmy Carter the purpose of FEMA, an organisation within the United Sates of America, stayed the same.

Figure 8 Emblem of the FEMA.

FEMA's mission is to support US citizens and first responders to ensure that as a Nation we work together to build, sustain, and improve our capability to prepare for, protect against, respond to, recover from, and mitigate all hazards (United States Federal Emergency Management Association)[18].

In 2003 FEMA has been incorporated into the Department of Homeland Security (DHS). It supports the federal government to prepare for, prevent, weaken the outcome of, respond to and recover from domestic disasters, either man-made or natural and terroristic acts (United States Federal Emergency Management Association)[18].

International Federation of the Red Cross and Red Crescent (IFRC)

After the First World War the need for a close cooperation of Red Cross societies was necessary. That's when the IFRC was founded in Paris 1919. Today it's the world's largest humanitarian network that reaches 150 million people in 189 National Societies through the work of over 13 million volunteers.

Figure 9 Emblem of the IFRC.

The IFRC aids victims in disasters and fosters the capacities of its member national Societies to act in an emergency without discrimination as to nationality, race, religious beliefs, class or political opinions.

The IFRC describes their vision as follows:

To inspire, encourage, facilitate and promote at all times all forms of humanitarian activities by National Societies, with a view to preventing and alleviating human suffering, and thereby contributing to the maintenance and promotion of human dignity and peace in the world (International Federation of Red Cross and Red Cresent Societies)[19].

World Bank

The World Bank is a United Nations international financial institution and a component of the umbrella organisation World Bank Group. Established in 1944, the World Bank Group has over 120 offices around the world. It's a partnership to ensure financial and technical assistance to developing countries around the globe. The World Bank Group as a whole is not a bank in the ordinary sense, but it consists of five institutions, of which the International Bank for Reconstruction and Development (IBRD) and The International Development Association (IDA) together make up the World Bank. They grant low-interest loans and interest-free credits to developing countries to support the investments in health, education, infrastructure and many more. Another offer from the World Bank to developing countries is the support through policy advises, technical assistance and research and analysis.

Figure 10 Emblem of the World Bank.

The stated goals by the World Bank Group for 2030 (The World Bank)[20]:

- End extreme poverty by decreasing the percentage of people living on less than $1.25 a day to no more than 3%
- Promote shared prosperity by fostering the income growth of the bottom 40% for every country

Global Facility for Disaster Reduction and Recovery (GFDRR)

The Global Facility for Disaster Reduction and Recovery is a partnership of 41 countries and 8 international organisations founded in 2006. GFDRR provides technical and financial assistance to developing countries to establish disaster risk reduction in national development strategies.

Figure 11 Emblem of the GFDRR.

Its main businesses are the 5 priorities by the Hyogo Framework for Action (HFA) (Global Facility for Disaster Reduction and Recovery)[21]. Namely:

- Ensure that disaster risk reduction is a national and a local priority with a strong institutional basis for implementation.
- Identify, assess, and monitor disaster risks and enhance early warning.
- Use knowledge, innovation, and education to build a culture of safety and resilience at all levels.
- Reduce the underlying risk factors.
- Strengthen disaster preparedness for effective response at all levels.

3.1.2 Volunteer and Technical Communities (VTCs)

3.1.2.1 Mapping associations

GIS Corps

Founded in 2003 GIS Corps is a collaboration of experts dedicated to help underprivileged communities with GIS services in short-term projects on a volunteer basis. They are affiliated with the Urban and Regional Information Systems Association (URISA), one of the central professional associations of GIS professionals in the United States. The community consists of roughly 2600 volunteer GIS professionals who already participated in over 45 countries (Resor, 2013)[22].

Figure 12 Emblem of GISCorps.

MapAction

MapAction is a non-governmental organisation that formed in 2004 during the huge Indian Ocean tsunami with a headquarter in the United Kingdom. They consist of volunteer GIS-experts specially trained in disaster response who can be deployed anywhere in the world in a matter of hours. MapAction deploys a team to the disaster zone, gathers data and updates situation maps to support local aid agencies (MapAction)[23].

Figure 13 Emblem of MapAction.

Google Map Maker

The idea behind the launch of Google Map Maker in May 2008 was to provide detailed digital maps in countries where they just did not exist. Users can add or edit roads, parks schools and much more. They can also mark places and add relevant information and edit contributions by other people. Millions of users worldwide contribute their local knowledge to the Google Maps and Google Earth. For emergency assistance, Google Map Maker was first used in June 2008 after the cyclone Nargis hit Myanmar where no maps of roads, hospitals and cities were publicly available for disaster response efforts (Blanchard & Chapman, 2012)[24].

Figure 14 Emblem of Google Map Maker.

OpenStreetMap (OSM)

OpenStreetMap was created in 2004 entirely by volunteers to give a free, easily accessible mapping platform and is also called “the Wikipedia of Maps”. In contrary to other platforms like Google Maps, OSM allows everyone to contribute his or her knowledge to the map by adding missing information, editing or correcting mistakes. Geographic data is often kept within governments, locked by commercial vendors or even just not existing. During a disaster OSM can fill this gap very effectively with its currently over 1 Million registered users and about 300’000 contributors.

Figure 15 Emblem of OpenStreetMap.

Out of OSM community emerged a collaboration between interested people, later called the Humanitarian OpenStreetMap Team (HOT) and was active during several disasters like the Earthquake in Haiti for instance (see section 3.5.1 for a more detailed account of OSM’s activity then) (Blanchard & Chapman, 2012)[24] (Chapman, Wibowo, & Nurwadjedi, 2013)[25].

CrisisMappers

The success of early volunteer mapping projects from GISCorps and MapAction led Patrick Meier and other convinced researchers and practitioners to launch CrisisMappers at the first International Conference on Crisis Mapping (ICCM 2009) in Cleveland, Ohio. Experts from the public and private sector, the United Nations and several governments joined CrisisMappers to find solutions to real problems and initiate projects that help to advance the new field of crisis mapping. CrisisMappers were active during multiple disasters: The Chile earthquake in February–March 2010, the Deepwater Horizon oil spill in April–May 2010, the Pakistan floods in July 2010, and the Haiti cholera outbreak in Oct 2010 (Crowley, 2013)[26] (Blanchard & Chapman, 2012)[24].

Figure 16 Emblem of CrisisMappers.

The Global Earth Observation -Catastrophe Assessment Network (GEO-CAN)

Is a network of scientists and other expert volunteers around the world created in 2010 in the wake of the disastrous Haiti earthquake. They analyze small image patches that are provided by ImageCat. By comparison of post- and pre-disaster satellite imagery GEO-CAN produced a building-by-building assessment of the damage in Haiti. They were also activated during the Christchurch earthquake in New Zealand in 2011 (Blanchard & Chapman, 2012)[24].

The Standby Task Force (SBTF)

After the volunteer mapping efforts in Haiti, Chile and Pakistan, Patrick Meier saw the potential of VTCs and wanted to create a more permanent volunteer online community. That's when he founded the Standby Task Force with many other experts and launched it at the 2010 International Conference of Crisis Mappers (ICCM 2010). The SBTF is organized into 11 individual teams. To name a few, the Media Monitoring Team supervises mainstream and social media origins for relevant information, the Geo-Location Team finds the coordinates of events reported by the Media Monitoring Team. In a next step the Verification Team tries to verify the validity and accuracy of the data being mapped, and the Analysis Team generates situation reports provided to emergency agencies, who requested help from the SBTF (Patrick, 2011)[27].

Figure 17 Emblem of the Standby Task Force.

Anyone can join the Task Force with all materials available online. The organisation wants to maintain a transparent and open-source model. They communicate via Skype, have training materials available on a Youtube channel and also provide downloadable power point presentations (Resor, 2013)[22].

The volunteer community of the SBTF has grown to more than 800 members in over 80 countries while the majority persists of professionals from the technical and humanitarian sector (Patrick, 2011)[27].

3.1.2.2 Tagging associations

MapMill

After hurricane Sandy hit the Northeastern United States in October 2012, the Civil Air Parol (CAP) shot thousands of geotagged high-resolution areal images. The damage was so big, that the incoming data lasted too long for a timely damage analysis. That is when the Humanitarian Open Street Map Team (HOT) modified the MapMill platform, simply to microtask the analysis of the thousand images. Jeff Warren originally created MapMill to quickly sort images from kites and balloons. HOT customized the platform in order that volunteers using MapMill could tag each picture as “OK” (no infrastructure damage), “Not OK” (some damage) or “Bad” (significant damage). With a single click, the user saw the next image and the three possible answers and so on. This volunteer based crowdsourcing system completed the analysis of a very large amount of images in a matter of days (Meier, Human Computation for Disaster Response, 2013)[28] (Chapman, Knight News Challenge, 2013)[29].

Tomnod

Meaning “Big Eye” in Mongolian Tomnod states its mission as follows: “The Tomnod mission is to utilize the power of crowdsourcing to identify objects and places in satellite images.” They use high-resolution satellite imagery from DigitalGlobe, slice them into small squares, where volunteers can tag one picture at a time. For validity, every picture is tagged by multiple volunteers, which allows Tomnod to identify the locations of maximum agreement between users with statistical algorithms. Things, that Tomnod makes available to the crowd for tagging, include tracks of refugees, missing airplanes, typhoon damage, and wildfires (Tomnod)[30].

Figure 18 Emblem of Tomnod.

MicroMappers

The origins of MircoMappers dates back at late 2012 after the Typhoon Pablo struck the Philippines. Over 20’000 tweets had to be sorted through, which led UNOCHA to search help from the STBF. STBF and Patrick Meier found the solution to sort through this huge mass of tweets in the free and open-source crowdsourcing platform PyBossa and crowdcrafting.org. With machine learning algorithms the tweets are filtered and then shown to the volunteers (World Science Festival, 2013)[31].

Figure 19 Emblem of MicroMappers.

Until now MicroMappers provides four different apps in which volunteers can simply participate by undertaking certain tasks. These apps are:

TweetClicker

This app asks volunteers to determine if a tweet shows relevant and useful information for emergency responders like the Red Cross or UN.

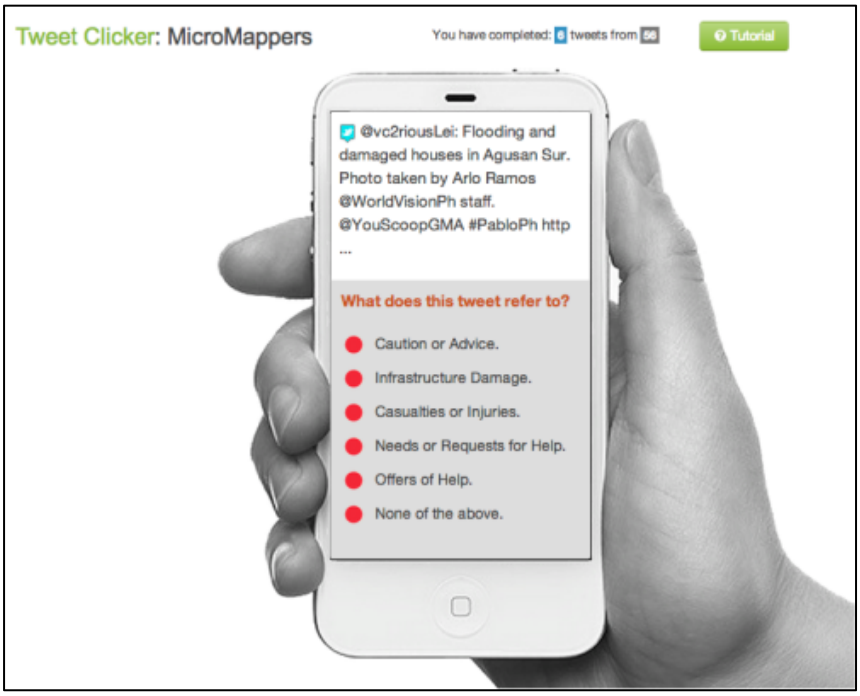

Figure 20 Interface of the TweetClicker app.

TweetGeoClicker

With this app, the volunteers can geo-tag tweets that come with no automatically integrated GPS locations. It also includes a simple tutorial, on how to find the GPS locations of the mentioned places in a tweet.

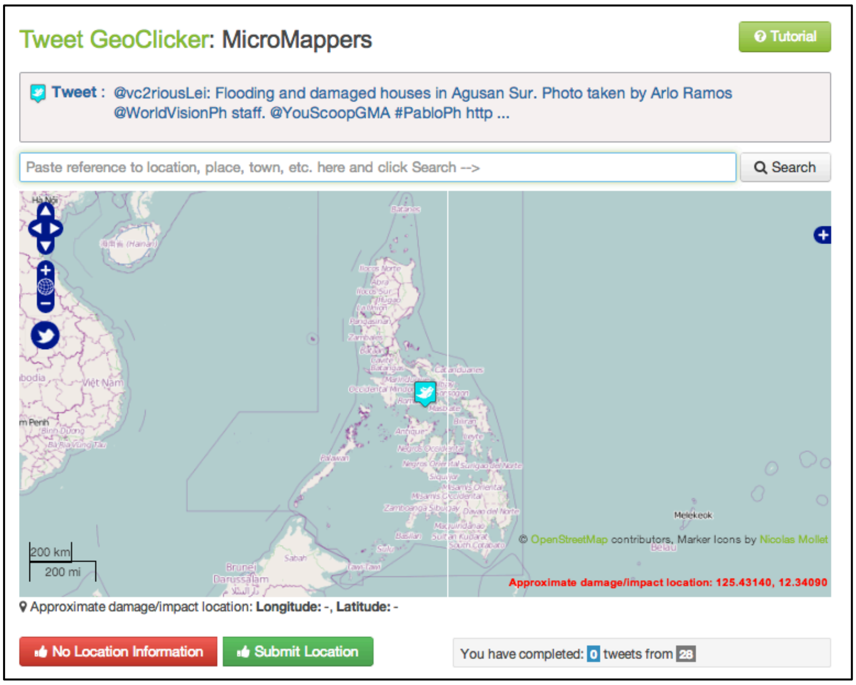

Figure 21 Interface of the TweetGeoClicker app showing a Tweet on top and the map to set the GPS location beneath.

ImageClicker

The function of this clicker is to asses the damage shown in a picture. The images are automatically taken out of twitter and uploaded to Imageclicker.

Figure 22 Interface of the ImageClicker app.

ImageGeoClicker

Like TweetGeoClicker, the purpose of this app is to geo-locate images that are not geo-tagged automatically. A tutorial also gives hints on how to do so.

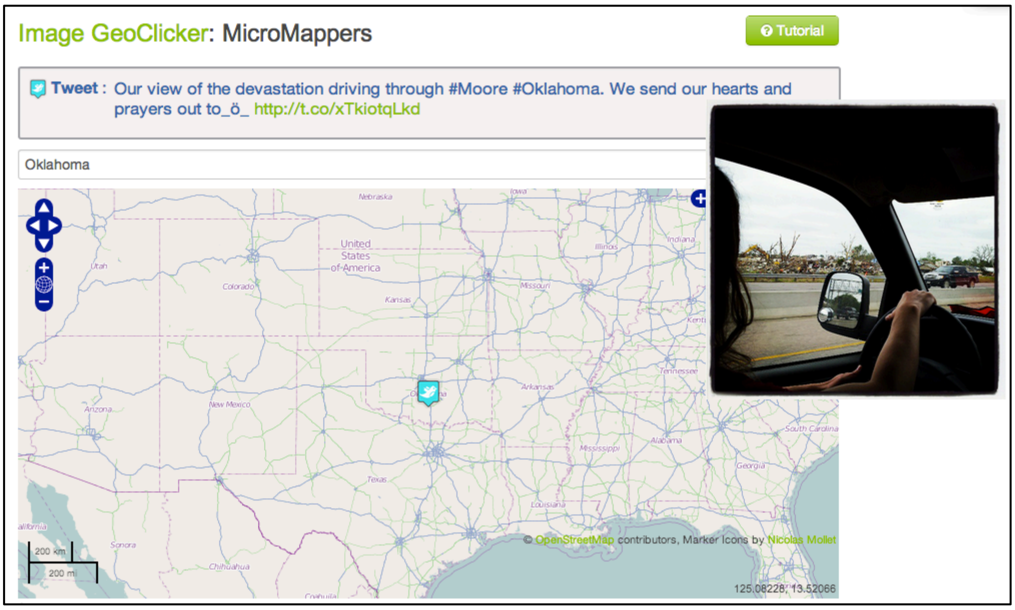

Figure 23 Interface of the ImageGeoClicker app also with the tweet on top and the map underneath.

To assure a high level of data quality every tweet and image is shown to three different volunteers till it is finally tagged (Meier, irevolution, 2013)[32].

3.1.2.3 Online crisis information platforms and collaborations

Ushahidi

The open-source crowdsourcing crisis information platform has its origins in the Kenyan post-election violence between 2007 and 2008. Created by volunteer citizen reporters and bloggers, the purpose of Ushahidi was, that ordinary Kenyans could report human right violations via email, voicemail, SMS, Twitter, web forms, YouTube, Flickr, Facebook, Skype, and other social media. The advantage of the time stamped and geo-tagged information lead to a live crisis map, where the public could receive early warnings before the mainstream media, covered by a greater geographic area and with no censorship (Heinzelman & Waters, 2010)[33]. Since then Ushahidi has grown into a global non-profit technology company registered in Florida, with origins and still many members in Kenya.

During the devastating earthquake of Haiti in 2010 Ushahidi gained more publicity due to its success. The U.S Marine Corps stated, that the Ushahidi Map helped them save hundreds of lives. FEMA also publicly noted, that this crisis map was the most comprehensive and up-to-date map available to the humanitarian community (Patrick, 2011)[27].

CrisisCommons

The CrisisCommons came into existence out of the first CrisisCamp in March 2009. The global community of technical volunteers, crisis response organisations, governments, and citizens want to improve the use of open data and volunteer technology communities to foster innovation in disaster management. Crisis response organisations are incorporated on a long-term basis. They also act as a connecter between VTC's and governmental agencies like the UN (Blanchard & Chapman, 2012)[24].

Figure 24 Emblem of CrisisCommons.

CrisisCommons has coordinated remote volunteers around the globe to provide social media and technology support for responses to disasters like the earthquakes in Haiti (2010), Chile (2010), and Japan (2011), and to the floods in Nashville, Tennessee (2010), Pakistan (2010), and Thailand (2011) (CNA, 2011)[34].

Random Hacks of Kindness (RHoK)

Random Hacks of Kindness is a collaboration between Google, Microsoft, NASA, Yahoo!, and the World Bank that established itself during the CrisisCamp in June 2009. They agreed to mobilize volunteer expert programmers to create open technology solutions to real world

Figure 25 Emblem of Random Hacks of Kindness.

problems, foster the chance for technologist to use their skill in humanitarian aid and build a technical framework of organisations and people who can identify and handle challenges for social impact (Random Hacks of Kindness)[35]. During a RHoK event expert developers sit together to brainstorm, program and find solutions that can have a tangible impact. One outcome of this is for example the mobile phone application, which allowed citizens to let their loved ones know, that they are ok by simply clicking a single button during the earthquake in Haiti 2010 (Blanchard & Chapman, 2012)[24].

Humanity Road

Humanity Road was founded in 2010 and is a volunteer based charity, that helps in online disaster response by monitoring social media in emerging events, such as floods, hurricanes, tornados or earthquakes. They also offer customized training for emergency responders on the use of social media and crisismapping (Humanity Road)[36].

Figure 26 Emblem of Humanity Road.

3.2 Crowd as a sensor

The recent years brought the phenomenon of sensors in smartphones, like cameras, GPS modules, a digital compass, an accelerometer, humidity sensors, gyroscopes and light sensors to name a few. These numerous sensors in a single smartphone, which is already ubiquitous in most countries, led to the development of sensing applications for collecting specific user experiences (Xiao, Simoens, Pillai, Ha, & Satyanarayanan, 2013)[37].

In this section, the crowd as a sensor for emergency management support is evaluated. While the crowd as a sensor is already used for traffic analysis (Pan, Zheng, Wilkie, & Cyrus, 2013)[38], particular matter exposure and emission measures (Mun, et al., 2009)[39], eldercare via GPS and microphone records (Goldman, et al., 2009)[40], it has only recently been used for emergency response.

A mobile app, designed by researchers at the University of Passau in Germany and the London School of Economics (LSE) to analyze crowd density in real-time, collects location data from people, who installed the app via GPS and send it to a database called CeonoSense, developed by ETH Zürich. There the data is processed into a real-time heat map, showing dense areas in red and clearer areas in blue (Evans-Pughe & Bodhani, 2013)[41]. This heat map can be used by local police stations during an event, and they can also send warning or informing messages back to the app owner directly or via Twitter. It was successfully tested in November 2011 at the Lord Mayor’s Show in London. The London police stated, that this app will help the police of London monitor crowds during big events and keep the people informed (London School of Economic (LSE), 2012)[42].

The same idea was used with a customized app during the Zürich Festival in Switzerland 2013. It was reported as a complete success. Hotspots were clearly visible and fitted to observations on site and generated pictures (Schmid, 2013)[43].

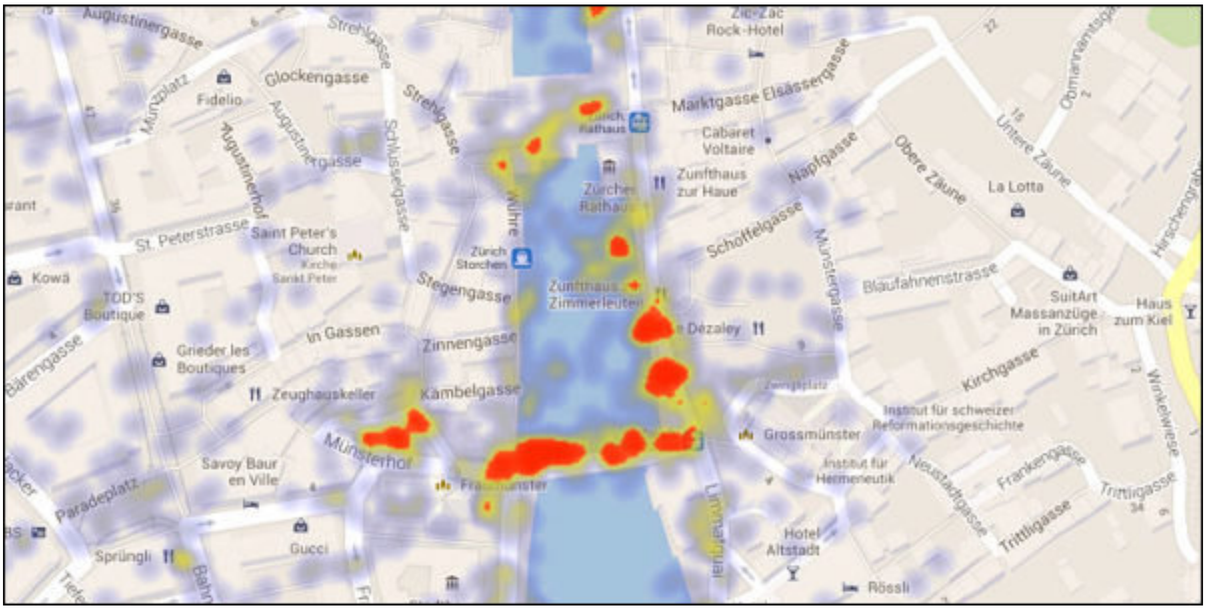

Figure 27 Friday at 19:15, a lot of people gathered at the fraumünsterbrücke to see a high wire act.

3.3 Crowd as a social computer

During and after a crisis the access to timely information is a main challenge of disaster responders. A clear picture of the situation could save many lives. To help gaining a better overview of the disaster, social networks can be an invaluable source, due to its real-time reactions and mass-information. This section explores the potential of these sources in the internet age.

3.3.1 Twitter

When a disaster occurs, people's first reaction nowadays is to go online and write or talk about it. Twitter is the most common micro blog network in the United States and has been used a lot for crisis analysis by researchers. To handle this new behaviour many researchers suggest different techniques to do so (Chae, Thom, Jang, Kim, Ertl, & Ebert, 2013)[44].
I will describe 7 example applications, which used Twitter for disaster analysis.

	Author	Date	Main goal	Method	Results
1.	MacEachren et al.[47]	October 2011	The primary task is to find and store tweets in a format that allows interactive analysis for emergency management.	They created a web-database called SensePlace2. It includes 5 core components: query panel, timeline display/control, tweet list, tweet map, and history view. At first they used the Twitter application programming interface (API), that serves as a gateway for easy programming, to search for tweets back- and forward-in-time by using keywords like "earthquake" or "hurricane". Then they use the most recent tweet ID, which can be found for a specific keyword to find the 1000 most recent tweets. After the tweets are loaded into the database several applications analyze tweets for coordinates, hashtags, names, URL's etc. Lastly the found locations are georeferenced using Geonames. The distribution of geolocated tweets between a specific time-span is shown in an interactive map, where one can select a tweet, which then is highlighted.	Example usage of SensePlace2 for the causes of the BP Oil Spill on birds. Starting with the keywords "oil, birds" a tweet link led to a video, where a scientist from Exxon spills cleanup stated, that the BP oil would mostly be consumed by bacteria and won't cause real problems. This tweet was countered by many other tweets, showing birds covered in oil, a Youtube video showing a shore full with oil in Pensacola and photos of oil on the beach. These information bits with tweets about oil position created situational awareness for breeding and migrating birds in just an hour.
2.	Starbird et al.[45]	April 2012	The purpose of this study is to identify on-the-ground Twitterers during mass disruptions, to identify new information coming from on-the-ground sources by a machine learning process. They examined the use of social media during the Occupy Wall Street (OWS) political protest in New York City in September 2011.	They used the Twitter API to search for keywords like "occupywallstreet". Then, to examine changes in the profile information (number of followers, friends, lists and location) over time, they neglected all who made only 1 tweet during the protest. After that a 10% sample was created and two groups formed, those who were on the ground and tweeting information from the ground, and those who were not on the ground or were not tweeting information about the protests from the ground by analyzing their keyword tweets and profiles. Now, they tried to find the same results with machine learning techniques by using a Support Vector Machine with asymmetric soft margin.	The model that was created, correctly classified on-the-ground twitterers with 67.9% accuracy. The classification technique is not meant to stand-alone. It should be integrated in textual content analysis combined with human judgment.
3.	Terpstra et al.[46]	April 2012	The study examines the possibilities of real-time and automated analysis of Twitter messages shortly before, during and after a storm hit the Pukkelpop festival 2011 in Belgium using the information extraction tool Twitcident.	The Twitcident system maintains a list of incidents happening in the Netherlands by real-time parsing public paging messages sent to emergency services and extracting references to an incident's location, start time and type of incident. Then it uses the Twitter API to search for tweets relating to a specific search query. The extracted tweets can then be filtered via keywords, topic of interest, type of tweets (i.e. retweet, reply, mention), tweets from trusted media or emergency agencies and date-time ranges. The tool comes with a statistic chart, tweet list, plotted tweets on a geographical map and a gallery of pictures and videos found in URL's. Terpstra et al. analyzed 96,957 tweets that were transmitted on August 18 between noon and midnight.	The analysis of tweet activity showed a drastic increase after the storm hit the festival, which indicates that the festivalgoers were largely taken by surprise. While tweets about damage could be verified by uploaded pictures and were retweeted a lot, the validity of tweets about casualties were questioned and not retweeted until they got confirmed by official news media. This result suggests, that social norms on Twitter prevent the propagation of unverified information about sensitive topics. Terpstra et al. also found that nearby citizens helped the festivalgoer by offering warm meals, shelter, hot shower etc., which suggests, that social media fosters community resilience that originates from nearby people, who sympathize with the victims.

4.	Imran et al.[48]	May 2013	The paper presents a system that automatically extracts information nuggets from microblogging messages during disasters, using machine learning techniques.	The dataset of this study consists of 206'764 tweets, posted during the tornado that struck Joplinin, Missouri in May 2011. At first Imran et al. classified the tweets into personal, informative and other. Only the informative tweets were used for the onward analysis. They were further split into four categories, which contribute to situational awareness: Caution and advice, casualties and damage, donations of money, goods or services and information source. Now, to automatically classify a tweet as informative and into one or more of the above categories, they used Naïve Bayesian classifiers and a number of binary, scalar, and text features. An example for binary features would be, whether the tweet contains unigrams, URL's, the @ symbol or numbers. A scalar feature assessed the tweet length. The text feature removed all non-words. Then for every four categories pre-human-trained language-specific classifiers extracted location references, time references, sources, and other specific information nuggets, such as advice or damage reports, by using the Stanford Named Entity Recognizer, the Stanford Part of Speech Tagger and the Wordnet classes.	The results from the automated classifier were compared to human workers who classified the tweets into the same categories with the same dataset. The percent of agreement between automatically extracted items and human judges for six categories were as follows: Sources 83%, Time 85%, Location 93%, Caution/Advice 71%, Casualties 79% and Damaged Objects 47%. The experiments show that indeed machine learning can be utilized to extract structured information nuggets from unstructured text-based microblogging messages with good precision.
5.	Chae et al.[44]	October 2013	To give responders an interactive visual spatiotemporal analysis and spatial decision support environment, that assists in evacuation planning and disaster management	At first they used the number of Twitter users, who generated geo-located tweets in Manhattan and New Jersey during hurricane Sandy in 2012 and generated a heat map. Then a comparison was made, during and after the hurricane passed the city. Additionally, the analyst can gain situational awareness with the temporal distribution of twitter users, using a bar chart, which shows the number of twitter users in 4h intervals. Furthermore, they integrated geo-locations and temporal distributions into a single map.	A significant reduction in twitter users was detectable after the hurricane passed New Jersey. This can indicate, which areas were highly damaged. The bar chart with temporal distribution for instance revealed a gathering in the supermarket after the evacuation order.

6.	Rogstadius et al.[49]	October 2013	This paper by Rogstadius et al. Presents the employment of CrisisTracker during the 2012 Syrian civil war.	As shown in the papers above, CrisisTracker extracts tweets using the Twitter API. It categorizes them into stories with similar content and provides a map with geotagged tweets, a search board for queries, the size of stories (number of unique users, who mention the story) and a filter for stories by time, location, report category and named entities. In an 8-day trial during the 2012 civil war in Syria, they selected 50 keywords in English and Arabic, which led to approximately 3.5 million tweets.	At first, 70% of the found tweets were discarded, because they didn't match the area of interest. Then CrisisTracker automatically clustered tweets into stories that have similar content. Volunteer experts for the 8-day trial added tags like location and categories to stories, to make it easier for analysis. Several important events (e.g. massacres, explosions, and gunfire) were discovered by CrisisTracker before they were reported by other sources. Specificity was also improved due to its timeliness and links to photos and videos. A fired missile in a video plus claimed time can lead to searches about the impact. Also a big value was the historical archive of all larger stories that can be analyzed back in time to find out about long-term trends.
7.	Dashti et al.[50]	May 2014	The paper illustrate, how tweets can be used to directly support geotechnical experts by helping to gain awareness of the damage by a natural disaster like the 2013 Colorado Floods.	The Project EPIC from the University of Colorado used a four-node Cassandra cluster to store tweets from Twitter's Streaming API in a secure and scalable way during 9 days, after the flood started. Analysts from EPIC identified important keywords, which described the disaster in the best way by reading news articles and monitoring the public Twitter stream. The found tweets this way counted to 212,672, whereof about 1% was geotagged. They searched the dataset for four attributes and combinations thereof namely: 1) geo-tagged tweets, 2) tweets that contain URL's to videos and pictures, 3) tweets with place names, and 4) tweets that come with structural conditions defined by geological experts. The geo-tagged tweets then were manually filtered to find the most important ones for the engineer team, mainly consisting of reported damage to lifelines like roads, walls, bridges and sewage lines. Afterwards, they overlaid this geo-tagged tweets on satellite-, hazard- and aerial maps.	The maps with geo-located tweets, which come with attached pictures, provide good situational awareness. The difference of water levels between photos of the same location, but different times, can be used to learn about the flood stage, basin hydrology and evaluate drainage over time. Furthermore, the tweets with attached photos can verify expected high risk flooding for roads and bridges in the flood plain areas.

3.4 Crowd as a reporter

Twitter is for delivering the news, Facebook is where we talk about the news, and the blog is where we provide the details (St. Denis, Palen, & Anderson, 2014, p. 5)[51].

As emergency agencies and responders increase their contact to people by turning more and more to social media, the crowd as a reporter gains huge interest. Eyewitness reports on the ground can contain invaluable information for disaster relief organisations and can be immediately shared via several communication forms. I present examples, which include Websites, Twitter and e-mail, Skype and mobile phones.

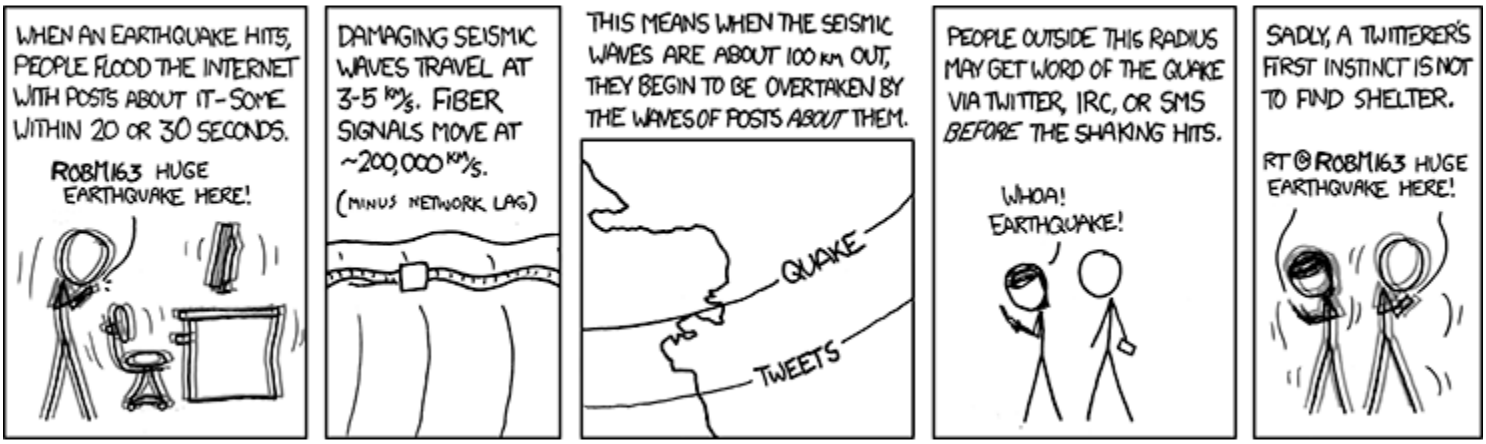

Figure 28 A comic by Randall Munroe indicating how fast social networks react to a disaster like an earthquake.

3.4.1 Website

One of the early successful applications, that introduced citizens into disaster response, was Did You Feel It? (DYFI) from the U.S. Geological Survey (USGS) Earthquake Hazards Program in the year 2000. The idea is, that citizens use the USGS website to report about earthquakes they have felt (or not) by filling out a multiple-choice questionnaire, developed by USGS. The questions are built to automatically measure the Modified Mercally Intensity (MMI) from 1 to 12. The numbers correlate to descriptions, how humans felt the earthquake. 1 is "not felt", 12 would be "complete destruction" and the question for 6 is "felt by all, windows, dishes, glassware broken, weak plaster cracked". Then the MMI values are averaged between all responders to provide an average measure (Atkinson & Wald, 2007)[52]. Additionally, the citizens are asked about their location and what they heard during the earthquake. DYFI received already more than 2'790'000 responses since its implementation and tends to correspond very closely to authoritative ShakeMaps, i.e. maps from the USGS, produced from traditional scientific sensors. DYFI is capable of detecting earthquakes of less then magnitude 2.0, which would be very difficult for traditional sensors. Furthermore, the time needed and costs can be held very low, compared to up-to-date sensors and trained seismologists, especially in remote regions (Young, Wald, Earle, & Shanley, 2013)[53].

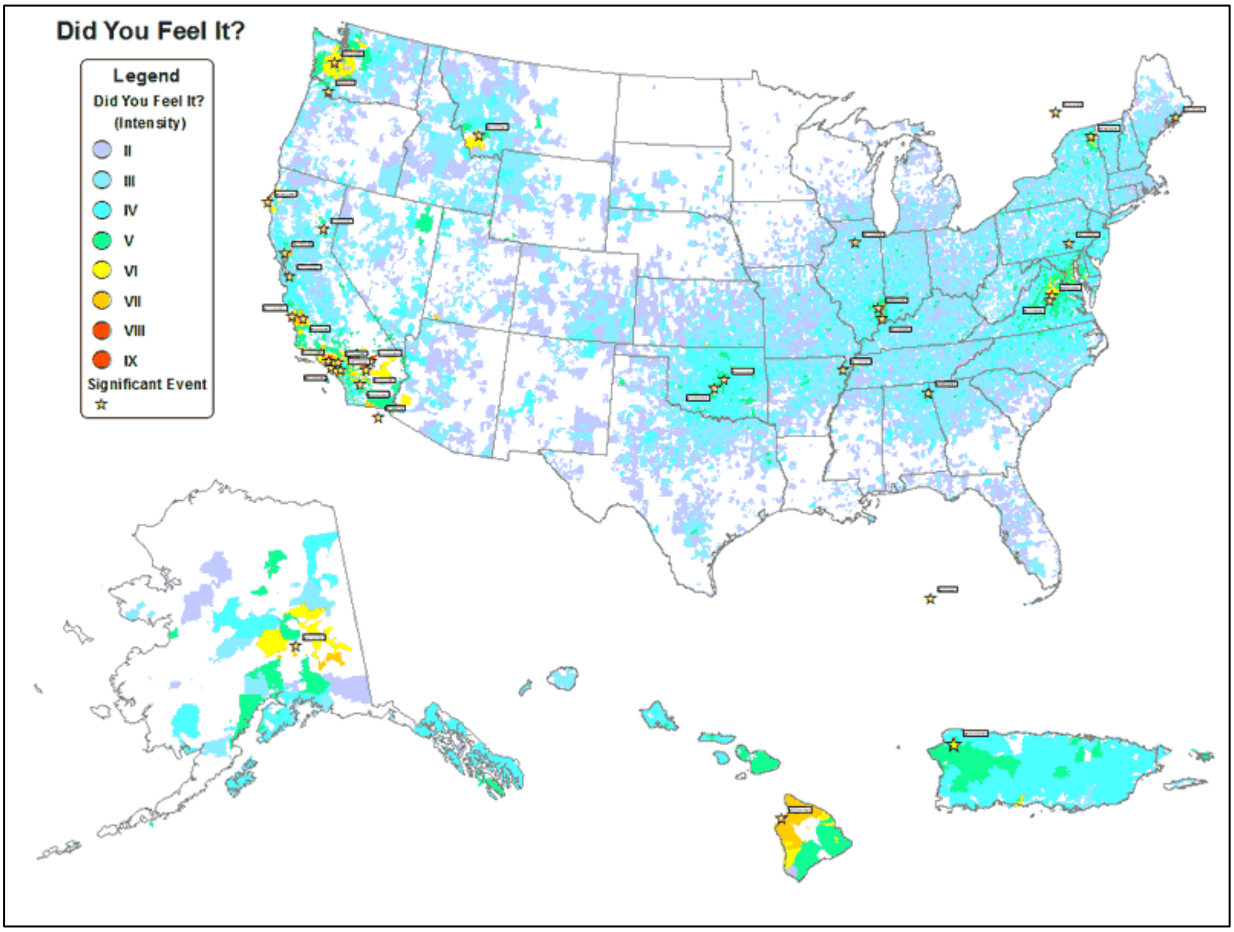

Figure 29 This figure shows the cumulative responses for 1993 till 2013 in the United States using DYFI?. The stars represent a significant event.

SeeClickFix (SCF) is another web-based model that encourages citizens to report certain problems to governments. SCF concentrates on local problems and issues in neighbourhoods, such as potholes, graffiti, broken roads or streetlights etc.

The platform was firstly launched in Connecticut (United States) 2008 by Ben Berkowitz, due to the lack of responsiveness of local governments, addressing a graffiti issue. The web interface of SCF shows a list of reported issues with current status and number of votes from other users, wanting to have the issue fixed. Users can also upload pictures to a Google map mash-up and highlight the geographic location. The reported issues get transmitted via e-mail to the local governments who can respond to individual complaints directly. SCF fosters the transparency between citizens and their government (Mergel, 2012)[54].

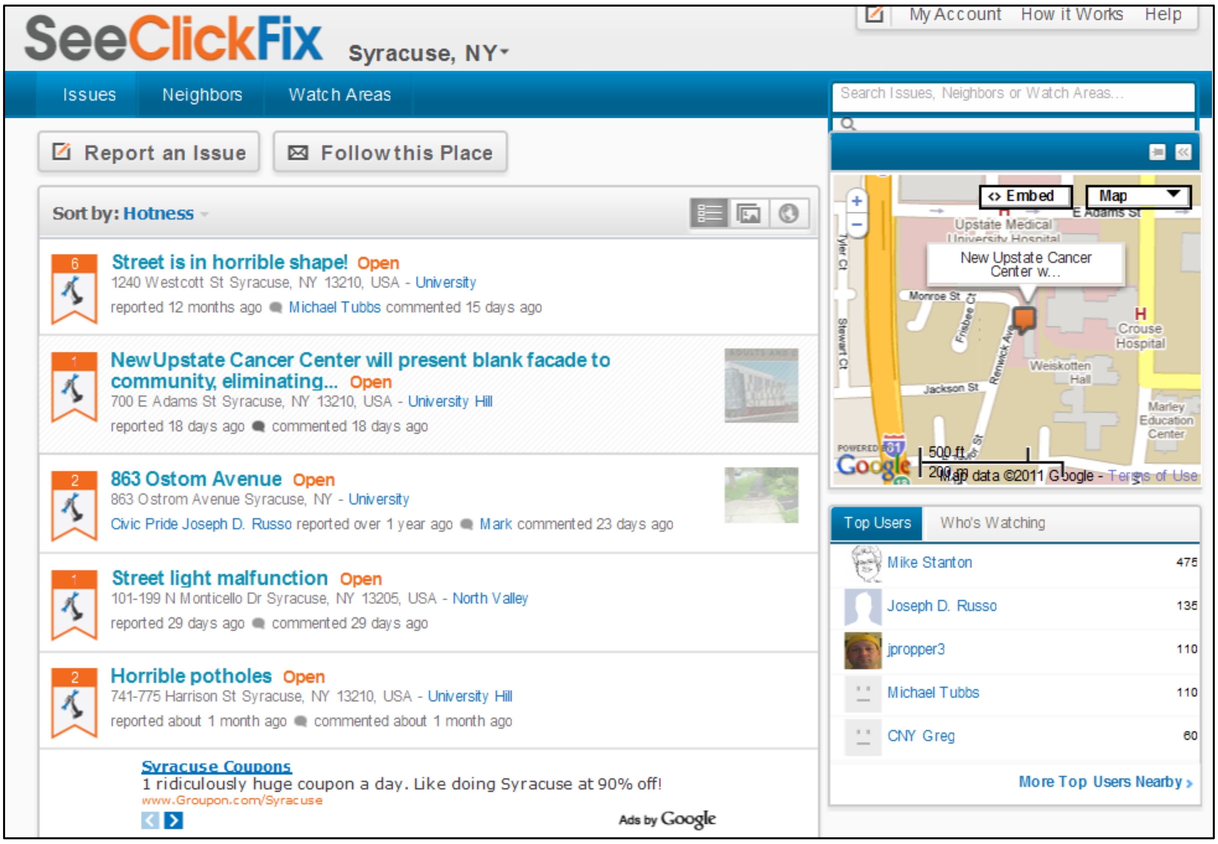

Figure 30 Interface of SeeClickFix with reported issues, the according map and the user list in the bottom left corner.

3.4.2 Twitter and E-mail

SyriaTracker is similar to CrisisTracker and is a part of the umbrella group, called HumanitarianTracker. It utilizes automated data mining tools by using the platform from Harvard University's HealthMap, which mines data for disease detection and customized it for their needs to automatically monitor human rights violations in Syria. Blog posts, news media, Facebook and twitter are analysed, but it integrates also on the ground eyewitness reports, that can be sent via Twitter or e-mail to SyriaTracker, which maps the results. The reports, that often contain videos and photos, can be held anonymous to ensure the security of reporters within Syria. The SyriaTracker website includes an instruction page for this issue. Then they increase the accuracy of the collected information by cross-referencing and triangulating the eyewitness reports with the information found in the news and social media (Meier, Human Computation for Disaster Response, 2013)[28]. Additionally the eyewitness reports come with a vote-up/vote-down feature to "score" the veracity. With this technique SyriaTracker could verify almost 90% of the documented killings on their map, and about 88% of the people killed by Syrian forces could be associated with specific names, since the uprising began (Meier, irevolution, 2012)[55].

From March 18, 2011 through Mai 18, 2014 about 106.755 deaths were documented (SyriaTracker, 2014)[56].

USAID and other agencies directly use SyriaTracker for their own official crisis map (Meier, Human Computation for Disaster Response, 2013)[28].

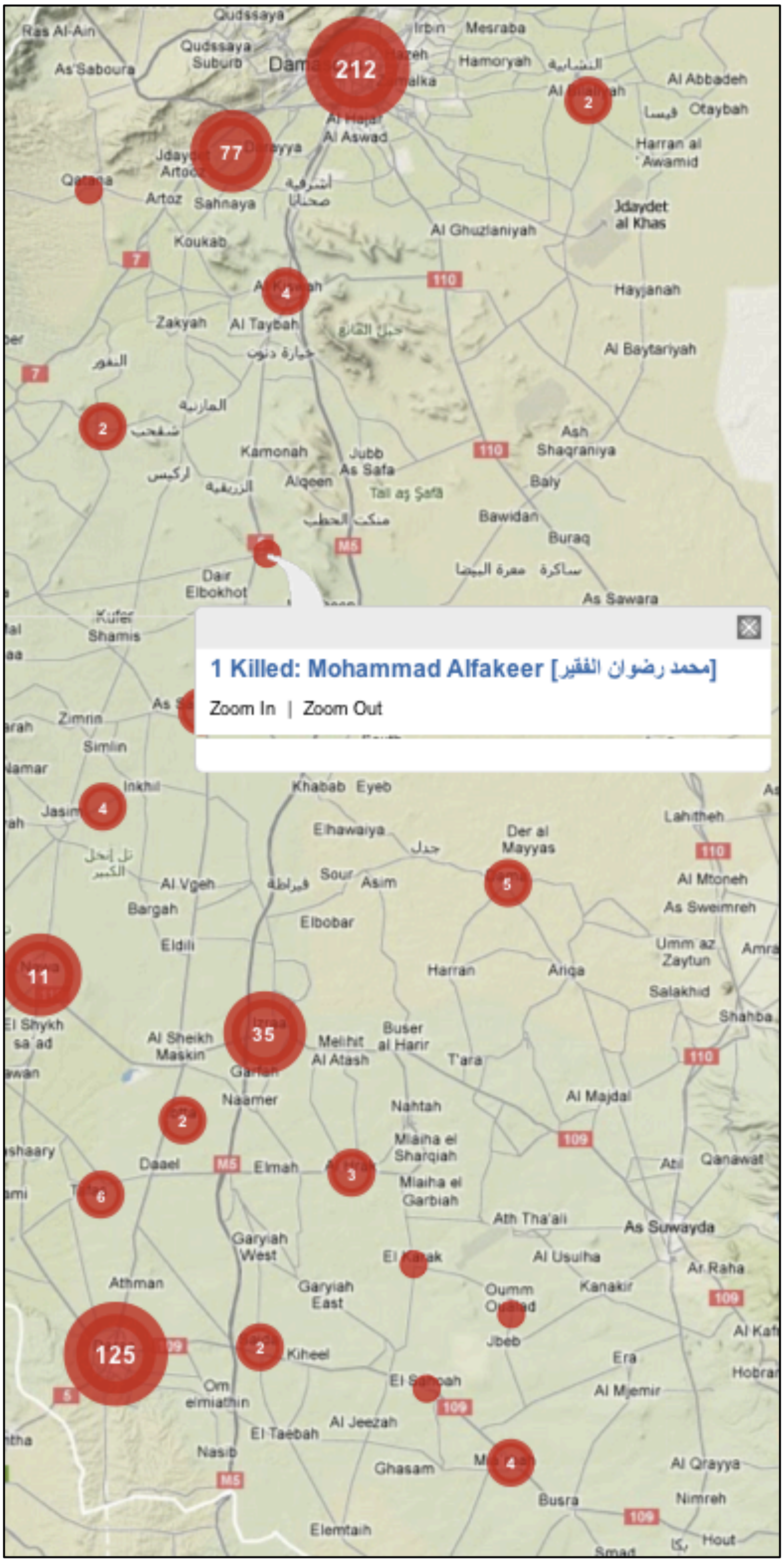

Figure 31 The Ushahidi map used by SyriaTracker shows the reported killings during the Syrian civil war in red dots.

Another application that uses Twitter for disaster assistance is Tweak the Tweet (TtT). Kate Starbid firstly presented TtT during the Random Hacks of Kindness barcamp in 2009. The idea is, to make crisis related tweets in Twitter machine-readable by using several hashtags. Data can then more efficiently be extracted and used by those communicating about disasters. She then deployed TtT the first time at the Haiti Earthquake in 2010, with help from many colleagues at the University of Colorado, project EPIC. An example would be:

#haiti #need supplies #name orphanage #loc Laboule #contact clairnise or alberte 509.3400.9797 #rescuemehaiti

The programme processes the tweet into:

orphanage in urgent need of supplies in Laboule: Clairnise or Alberte 509-3400-9797

The hashtags can be sorted and messages with specific tags directly linked to emergency responders. The response from volunteers using TtT in Haiti “on the ground” was not great, mainly because Haitians weren’t used to the social media platform Twitter. But the empirical examination of TtT revealed important features of self-organizing. Way more volunteers acted as remote “translators” by using the TtT hashtags to translate tweets in machine-readable format (Starbird, Muzny, & Palen, 2012)[45] (Starbird & Palen, "Voluntweeters": Self-Organizing by Digital Volunteers in Times of Crisis, 2011)[57].

3.4.3 Skype

During the widespread violence in Southern Kyrgyzstan in May and June of 2010, local groups faced diffused misinformation, such as rumors sent via SMS. For example, cross border attacks operated by a particular ethnic group. To check, if these rumors were real, volunteers turned to Skype and invited several friends they trusted to a chat group. Within two hours, 2000 people across the country joined the group. In this chat, rumors got examined and validated carefully. The volunteer Skype network was a success and proved to be effective for the early detection and response to rumors (Meier P. , 2011)[58].

3.4.4 Mobile phone

During the devastating Haiti Earthquake in 2010 mobile phones were a lifesaver. Within days the Ushahidi team collaborated with phone companies and the U.S. State Department to set up a free SMS short code number (McClendon & Robinson, 2012)[59]. About 70% of the cell phone towers in Port-au-Prince had been destroyed in the disaster, however, 85% of the

Haitians had access to mobile phones, because the towers were quickly repaired. Mobile phones were the most direct connection to disaster responders for Haitians and enabled volunteers to directly help and visualize the situation (Heinzelman & Waters, 2010)[33].

(Besaleva & Weaver, 2013)[60] present a mobile application, called CrowdHelp, that uses crowdsourced information for real time patient assessment, even before dispatching a response team to the disaster area. It was developed together with specialists, who had experience from the large earthquake in Haiti 2010. The purpose of the application that can be used in gadgets such as smartphones, tablets and computers is, to help emergency managers get a timely reaction to crisis and to give victims the possibility for a simple, secure and fast injury assessment. Users can download the app on their cellular phone and send information about the crisis, get information about their possible conditions and causes and shows a list of places, capable of treating the victim. To get the information about the condition and causes, they can simply click on body parts that are injured, using CrowdHelp's interfaced as shown in the image below. The app then shows a list of imagery, videos and emergency centers, which fit to the symptoms.

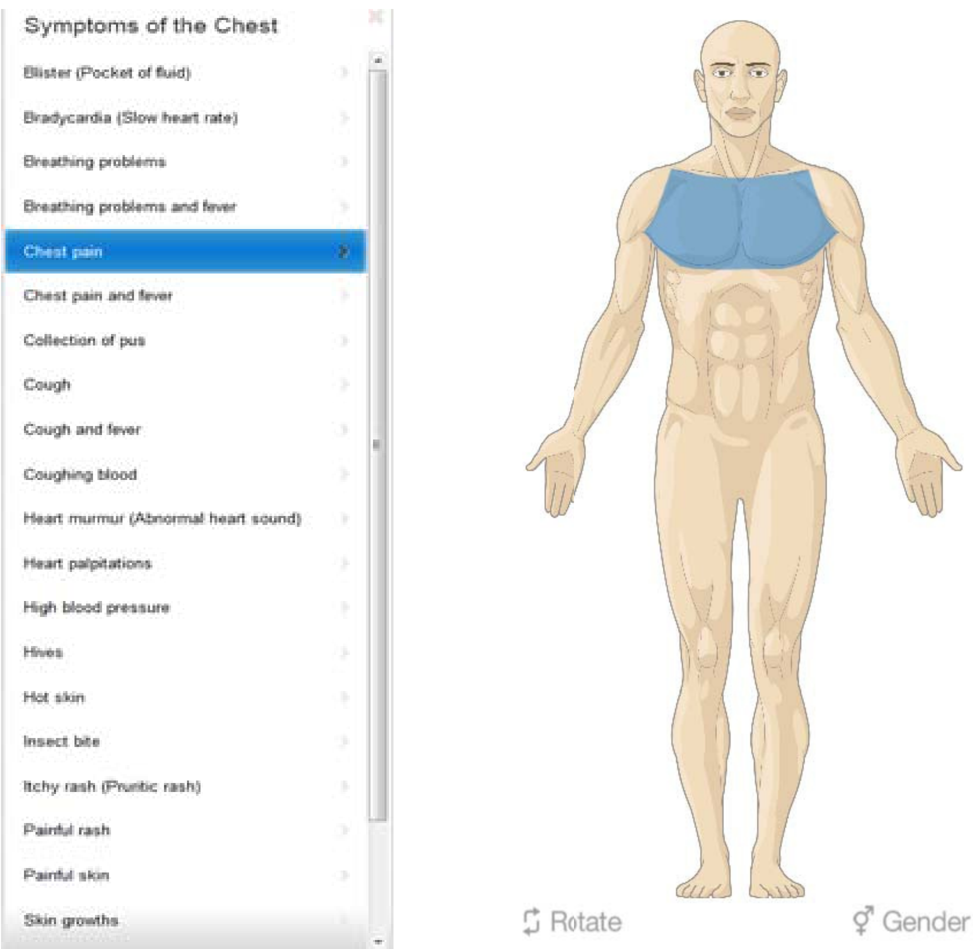

Figure 32 Interface of CrowdHelp's app with a list of symptoms on the left and the according body parts marked on the right.

Machine learning algorithms cluster and summarize all inputs into clear stories such as urgency, geographical location and physical proximity to dangerous events. The urgency and physical proximity to dangerous events are visualized by numbers, ranging from 0-5 and colours, ranging from red, yellow to green respectively. There doesn’t exist any result in the literature so far.

3.5 Crowd as a microtasker

We have to distinguish between volunteers situated in crisis-affected locations and volunteers outside of such locations, helping from their home on a computer. The past section described the first type of volunteers; this section will focus on the latter. The crowd as a microtasker has a very big potential in helping affected people in crisis, because it can handle tasks, that would cost enormous amount of time for emergency agencies at a fraction of that cost. Microtasking divides a large effort such as mapping, imagery observation, geo-locating objects and translating messages into small tasks that can be solved in minutes. With the help of hundreds of volunteers, the tasks can be completed in parallel and the group of volunteers acts like a supercomputer. Microtasking needs to have simple guidelines to enable accuracy and tracking instruments, so that the tasks are not performed in access (Harvard Humanitarian Initiative, 2011)[2].

3.5.1 Mapping

Probably the first successful implementation of volunteer crisis mapping was the Ushahidi live disaster map during the devastating Haiti Earthquake in 2010.
The collection of information in different social media and mapping of the geo-located messages were entirely done by volunteer students at Tufts University in Boston (Patrick, 2011)[27].
But the precise mapping of the incoming information turned out to be a major challenge, due to the lacking maps in Haiti, before and after the earthquake. That's when a volunteer community from OpenStreetMap (OSM) came into action. They began with tracing satellite images, provided by DigitalGlobe and then included post earthquake satellite imagery, donated by GeoEye and the World Bank. The volunteers were able to create the most detailed street map of the capital Port-au-Prince available. Within just a week, emergency responders used OSM and the Team at the Tufts University switched from Google Maps to the more detailed OSM and integrated it into the Ushahidi platform (Heinzelman & Waters, 2010)[33].

OSM can also be used to get important crisis-relevant data, before a disaster happens. A Humanitarian OpenStreetMap Team (HOT) project, launched in Indonesia in March 2011, mobilized volunteers, containing students, local government officials and civil citizens to map critical facilities in Jakarta, which are supposed to help building resilience against floods. They worked together with Indonesian agencies, the Australian Government, UNOCHA and the World Bank. Jakarta's flood risk is very high, due to its near proximity to rivers, low topography and high population of over 10 million people. The Team mapped critical infrastructures, such as health facilities, schools, fire and police stations, religious facilities and major roads. The data proved to be very valuable during 2013 and 2014 flood seasons (Humanitarian OpenStreetMap Team)[61].

Sugeng Triutomo, a deputy Chief for Prevention and Preparedness in the National Agency for Disaster Management (BNPB) of Indonesia stated: “The example of the National Capital Province of Jakarta is very encouraging, where using the OpenStreetMap online platform, detailed neighbourhood scale mapping of administrative boundary and disaster response assets such as shelters, logistic centres and evacuation route for flood preparedness can be mapped in only one week (The World Bank)[62].”

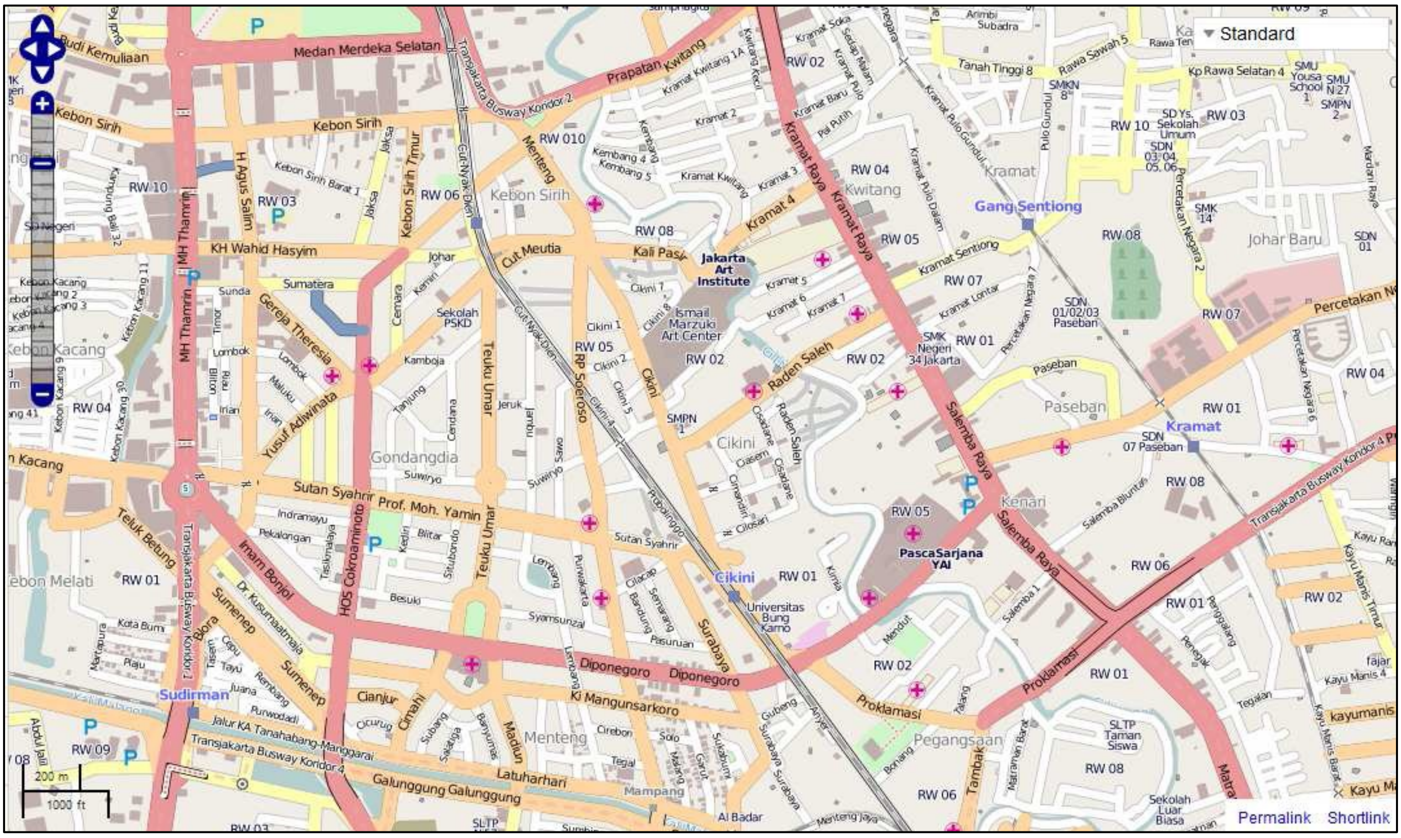

Figure 33 A very detailed map showing a fragment of Jakarta, Indonesia, especially indicating health care infrastructure with the red crosses.

Another example, in which the Ushahidi platform was used, is during the Russian wild fires in 2010. Volunteer Russian bloggers, who were inspired by the response during the earthquake in Haiti the same year, launched a live crisis map based on Ushahidi. What was new to the previous crisis maps is, that they included not only crowdsourced needs, but also crowdsourced help to their map. Often the less affected people seek to help others, but don’t know how (Patrick, 2011)[27].

The platform facilitated the coordination between individuals in need and volunteer helpers with specific categories like “What is needed” and “I wish to help” with complementary subcategories, such as “I need evacuation” and “I have transport” (iipdigital, 2011)[63].
The informal help, provided by the volunteers, was faster and more noticeable than that of the Russian government. Additionally, the mass media in Russia tried to reveal as little information as possible, while the “help map” from Ushahidi was both live and public (Patrick, 2011)[27].

Figure 34 The customized Ushahidi “help map” for crowdsourcing needs and help during the Russian fires in 2010.

In November 8, 2013 the category 5 typhoon Haiyan/Yolanda struck the middle Philippines with extreme force, being the strongest ever registered. HOT mobilized volunteers to map the city of Tacloban in OpenStreetMap a day before the typhoon took land, which later was essential in comparing the map with post disaster imagery.
HOT worked closely together with the American Red Cross and UNOCHA to determine, where mapping effort was needed. Tacloban City has been most affected. Five days after the storm went over Tacloban, high-resolution satellite images were available to help determine collapsed buildings and damaged infrastructure. Remote volunteer mappers around the world used these images to revise the map. After only 8 days since Typhoon Haiyan/Yolanda

destroyed Tacloban and island around middle Philippines, more than 1000 volunteers from 82 countries had done 2.2 million edits on OpenStreetMap (Beland, 2013)[64].

Figure 35 Above, a screenshot from part of Tacloban in OpenStreetMap before and after volunteers added details. The red circle indicates the completely destroyed houses from the typhoon shown in the picture underneath.

3.5.2 Tagging

Search and Rescue

One of the first search and rescue efforts including volunteers emerged during January 2007. The trigger was the disappearance of Jim Grey. He was a very popular Microsoft researcher, also called “silicon valley legend” and an avid sailor. Near the Farallon Islands, a bit outside of the San Francisco Bay, Jim Grey was seen for the last time. After the US Coast Guard couldn’t find Jim, satellites from DigitalGlobe and GeoEye provided a huge amount of images. Then the idea came, to send a call out to volunteers from Amazon's Mechanical Turk, a service, that enables employers to hire online workers for short-term tasks, that computers don't do well, searching through the images, to tag suspicious objects, that would look like a boat. More than 12’000 volunteers from Mechanical Turk and friends of Jim participated in the search. Over the weekend, the volunteers tagged 20 pictures as likely and one as highly likely, showing Jim’s boat. Unfortunately, the weather for sending a search-plane was bad, and days passed since the photo was taken, which eventually led to an unsuccessful search for Jim Grey. Even if the first use of this new tool for search and rescue was unsuccessful for Jim and his family, crowdsourced tagging was since developed further.

Tomnod was used for finding refugee camps in the Afgooye Corridor, Somalia, to estimate the number of internally displaced persons. On August 2011 the UNHCR demanded support from the SBTF, because two full-time stuff members spent four weeks analyzing satellite images in this corridor. The SBTF then partnered with DigitalGlobe, who provided the high-resolution imagery and Tomnod to facilitate microtasking. The Tomnod platform sliced the satellite images into small patches that could be analyzed by a single person. Additionally, to maintain accuracy, only the pictures that individually get tagged as a shelter by three volunteers count as a data point and will be shared with UNHCR. After a trial run for better knowing how the shelters look like, the SBTF reached out to a network of graduate students, studying satellite imagery analysis. Together almost 4000 satellite images were analyzed by 168 volunteers in only 120 hours. 47’500 shelters were shared with UNHCR and pushed to a dedicated Ushahidi map (Patrick, 2011)[27].

In July 2013 the University of Central Lancashire, UK, working in conjunction with Patterdale Mountain Rescue Team, started an experiment, called AeroSee. Its purpose is reducing the search time for injured people with the help of drones and crowdsourcing. AeroSee used drones to spot injured walkers. Using live video-streaming, the drone sends photographs directly to their website, where volunteers can view and tag suspicious pictures. The volunteers can simply log on the AeroSee website and begin acting as a virtual mountain rescue search assistant. While the average search for the Patterdale Mountain Rescue Team requires several hours, the crowdsourced solution from AeroSee with 350 volunteers identified walkers with a dog and a missing person within just five minutes during a test run (Theobald, 2013)[65].

On March 8, 2014 a plane from Malaysian Airlines with 239 passengers and crewmembers went missing. Similar to the search for Jim Grey in 2007, a massive search and rescue operation was started, but did not find anything. 3 days later, on March 11, DigitalGlobe activated Tomnod and asked volunteers around the globe to help analyze small satellite imagery squares. It resulted in the largest crowdsourcing effort to date, even attracting more volunteers than during typhoon Haiyan/Yolanda. More than 3 Million people have joined the effort, tagging almost 3 Million features. Despite the huge response, no tags that claimed to see a plane shape or oil slicks could be confirmed. Due to the huge area and the rough conditions of the Indian sea, the possibility to find the missing plane was rather low, but it certainly helped to identify, where the aircraft is not located. Expert analysts now don't have to waste their time looking through thousands of bare ocean images. Thus the crowdsourcing effort reduced the noise to signal ratio, narrowing the potential signals to experts (South China Morning Post, 2014)[66].

Damage Assessment

To make crowdsourced damage assessments of disaster areas faster and more accurate, researchers from Tomnod had joined the GEO-CAN initiative and developed an improved interface, shortly after the 6.3 magnitude earthquake in Christchurch, New Zealand in 2011. The so-called disaster mapper is user friendly and runs in a desktop web browser. It integrates a training module, explaining the interface, that doesn't require any experience. It was immediately tested after the earthquake in Christchurch. 200 volunteers were asked to compare pre-and post-earthquake images to assess the damage. They should draw a line around collapsed or damaged buildings and then assess the damage by tagging it as (Barrington, et al., 2011)[67]:

1: substantial damage (green)
2: very heavy damage (yellow)
3: complete destruction (red)

Figure 36 The Tomnod interface developed with GEO-CAN for the damage assessment after the 2011 earthquake in Christchurch, New Zealand.

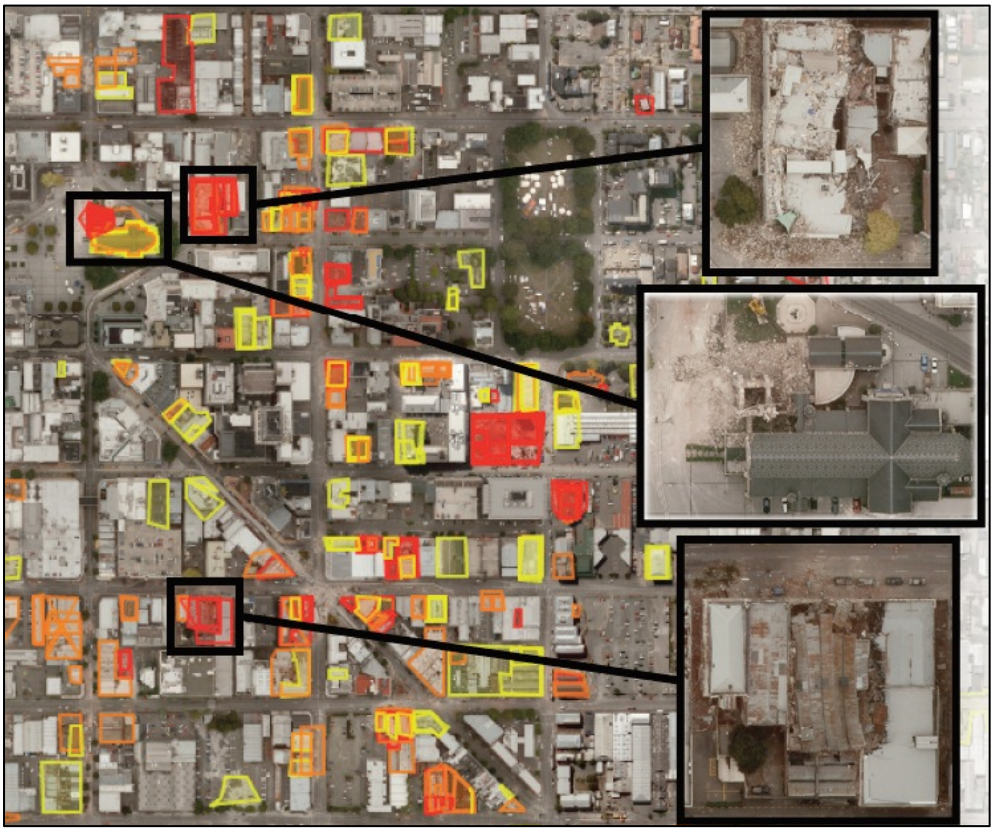

Figure 37 Overlaid damage assessments from different volunteers and enlarged pictures with high consensus.

The damage assessment by volunteers was compared to field based assessments.
It was found, that the reported damage from volunteers could be mostly confirmed by field investigations, although the damage was generally underestimated. Omission errors were about 54%, where especially very heavy or collapsed buildings could not be found by volunteers, due to damage inside the houses or failure of a lower story. Nonetheless, remote sensing will play an important role in the future, where the increased capabilities and range of remote imagery will be available (Foulser-Pigott, Spence, Saito, Brown, & Eguchi, 2012)[68].

In 2012, following Hurricane Sandy's landfall on the east coast of the USA in 2012, a similar micro-tasking platform, MapMill, was used by the Humanitarian OpenStreetMap Team to support FEMA in analyzing over 35'000 geo-tagged high resolution images, provided by the Civil Air Patrol (CAP). It was the first time, that CAP and FEMA asked a distributed third party to help them assess the damage. 6'717 non-expert volunteers participated in the project. In MapMill, the volunteers saw only one image at a time and had the option to tag it as little/no damage (ok); medium damage (not ok); or heavy damage (bad). While the tagging takes place, a heat map, also provided by MapMill, changes color to indicate where the worst damage occurred.
For quality assessment 11 experts from GISCorps tagged the 720 most problematic images with the same settings. 63% of these images were agreed upon between experts and non-experts. But in comparison with the damage report from FEMA on-the-ground, it lacked similarity. None of the pictures, rated as "destroyed" by FEMA, was rated as "highly damaged" by the volunteers and experts; they tagged them mostly as "no damage" (Chan, Crowley, Elhami, Erle, Munro, & Schnoebelen, 2013)[69].

Figure 38 Interface of the MapMill microtasking platform where volunteers can decide whether the damage in the satellite image is ok, not ok or bad.

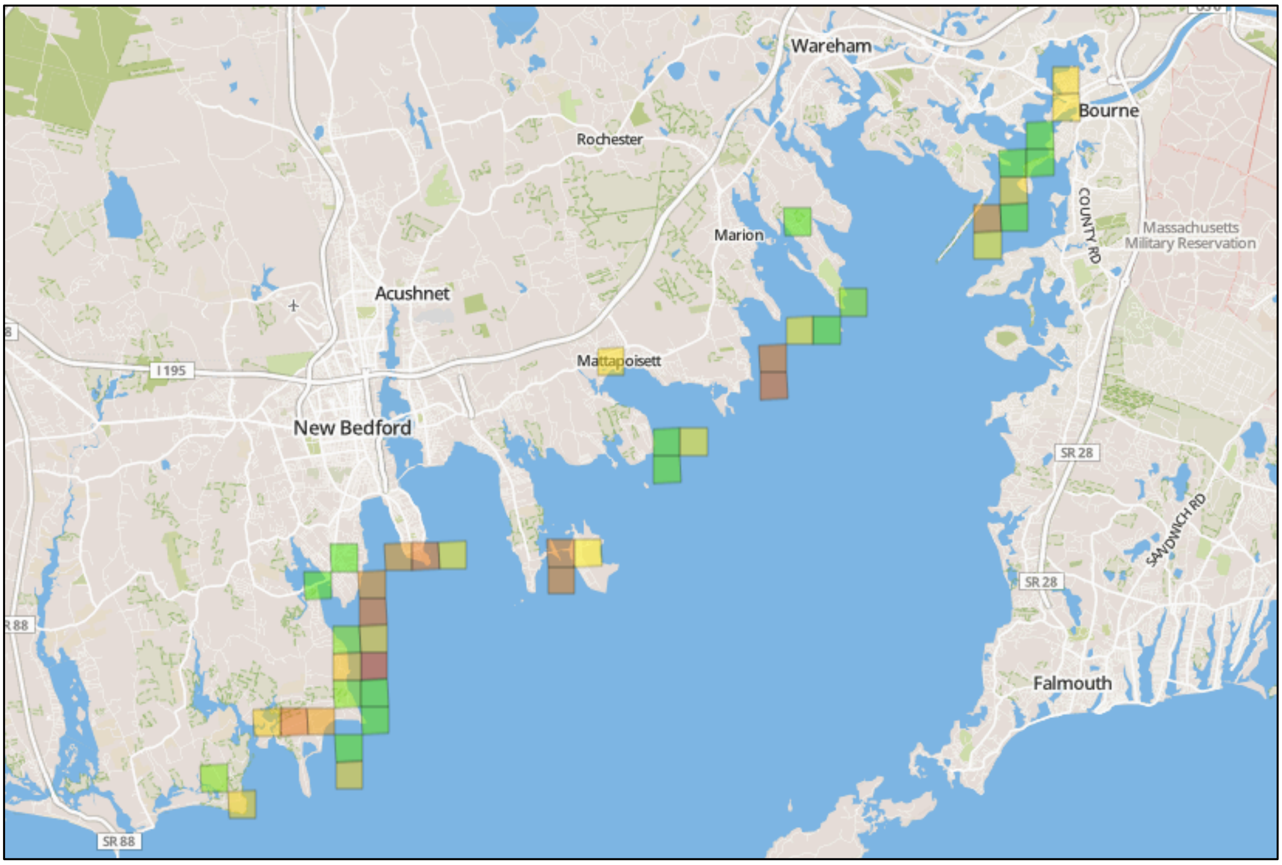

Figure 39 The map, also provided by MapMill shows the areas tagged by volunteers where the color indicates the grade of the damage.

Shortly after the Typhoon Pablo hit the Philippines in December 2012, the UNOCHA seeked help from volunteer communities. The Standby Task Force and Humanity Road answered the call. The task was to analyse the past three days of Twitter activity in the Philippines and find relevant information about the damage, caused by the Typhoon. The two VTC's sorted through over 20'000 tweets by using the micro-tasking and crowdsourcing platform PyBossa, that asks volunteers to tag tweets, if they contain relevant information for relief workers in the Philippines. They found 138 highly annotated tweets in about 10 hours (Resor, 2013)[22] (World Science Festival, 2013)[31].

These tweets provided links to photos and videos, large-scale housing damage, the analysis of damage like 5 houses flooded or 1 damaged roof, GPS coordinates, province, region and date. UNOCHA used this database and created a map of conditions, which was presented to other humanitarian actors and the Philippine government, only three days after the storm hit the coast. The data was stated to be useful in getting a clearer overview of the situation and to help humanitarian actors establish a two way communication with the affected communities, also including them in decision making processes (Humanity Road, 2013)[70] (Meier P. , iRevolution, 2012)[71].

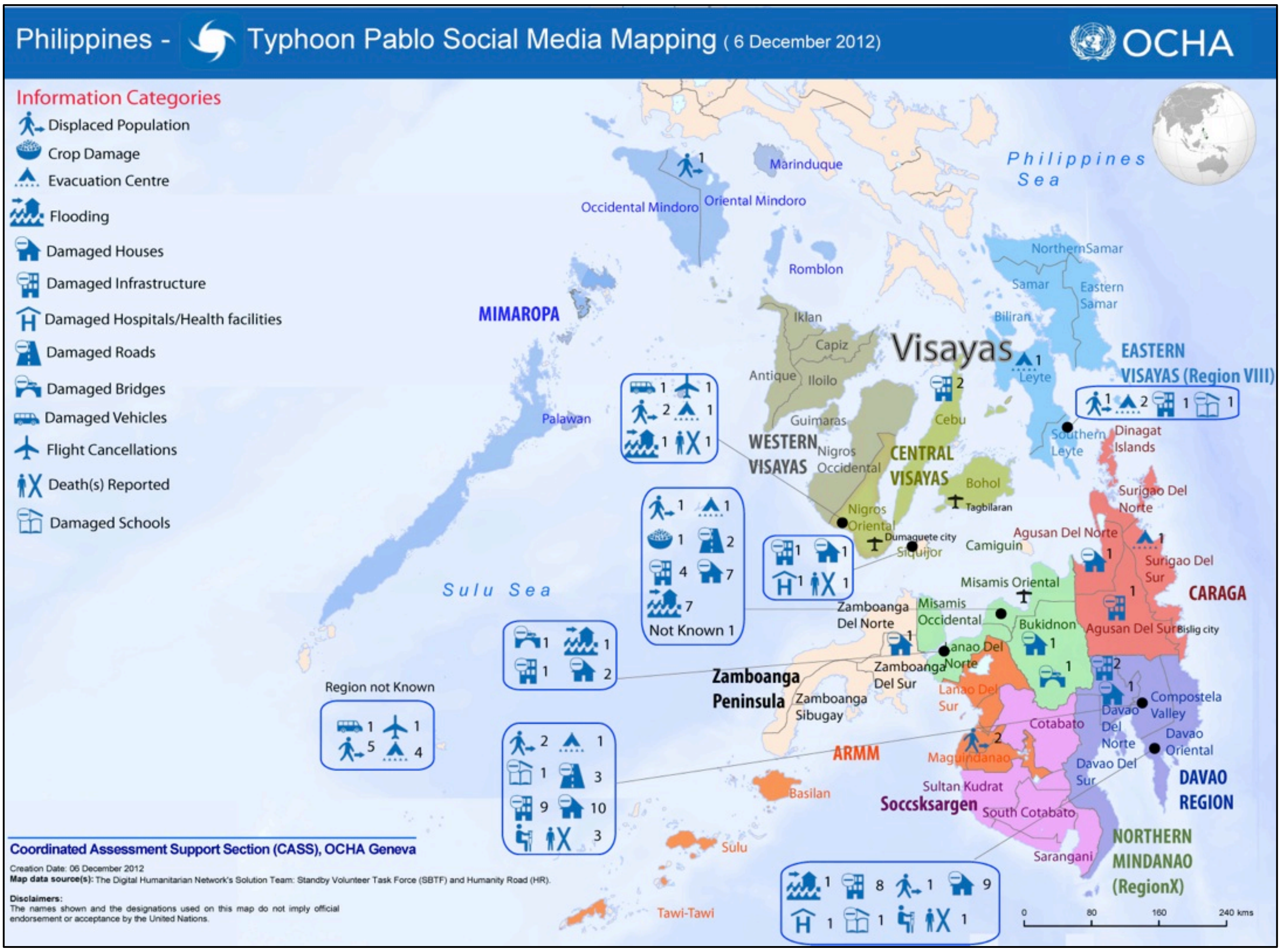

Figure 40 Crisis map by UNOCHA with the help from Humanity Road and the SBTF.

3.6 Summary

Table 2 The y-axis gives a summary of all crowdsourcing projects, divided into type of participation (Crowd as a sensor, as a social computer, as a reporter and as a microtasker). The x-axis gives further details about the event. Where a "-" is listed, no information could be found.

	Name of application or authors	Event it was tested	Date of first implementation	Purpose	Type of technical instrument	Partnerships	Analyzed tweets	Number of non-expert volunteers participated
Crowd as a sensor	Univ. Passau / London School of Economics / ETH Zürich	Lord Mayor's Show in London and Zürich Festival 2013, Switzerland	Nov. 2011	Monitor crowd densities	Mobile app	-	-	27'000 (Zurich Festival)
Crowd as a social computer	Twitcident	Storm during a Pop festival in Belgium (Pukkelpop 2011)	Aug. 2011	Automated analysis of Twitter messages	Twitter	-	96'957	-
	Starbird et al.	Occupy Wall Street protest in New York	Sept. 2011	Identify on-the-ground Twitterers	Twitter	Project EPIC	270'508	-
	Imran et al.	Joplin Tornado, Missouri	May 2011	Automated analysis of Twitter messages	Twitter	-	206'764	-

	Chae et al.	Hurricane Sandy, Northern United States	Oct. 2012	Identify public behavior patterns during natural disasters	Twitter	-	-	-
	Crisis Tracker	Syrian civil war	2012	Combine crowdsourcing with automated analysis to gain situational awareness	Twitter	SBTF, SyriaTracker	Ca. 3'500'000	-
	Dashti et al.	Colorado floods	Sept. 2013	How geo-tagged tweets can support geotechnical experts in a emergency	Twitter	Project EPIC	212'672	-
Crowd as a reporter	Did You Feel It? (DYFI)	Earthquakes	2000-today	Overlays earthquake responses from citizens in a map	Website	-	-	2'790'000
	SeeClickFix (SCF)	Local problems and issues in neighborhoods	2008-today	Fosters transparency between citizens and their government	Website	-	-	-
	Tweak the Tweet (TtT)	- Earthquake in Haiti - Hurricane Sandy	Jan. 2010	Make crisis related tweets machine-readable by using several hashtags	Twitter	Project EPIC, Ushahidi	-	-
	SyriaTracker	Syrian civil war	2011-today	Monitor human rights violation by integrating eyewitness reports to the SyriaTracker website	Twitter, e-mail	Crisis Mappers, SBTF, Ushahidi, Crisis Tracker	Over 80'000000	-
	Patrick Meier	Violence in southern Kyrgyzstan	May 2010	Discuss misinformation sent via SMS	Skype	-	-	Over 2'000

	CrowdHelp	Not yet used	2010	-	Mobile app	-	-	-
	Mission 4636	Earthquake in Haiti	Jan. 2010	Set up a SMS short code for victims, to gather information from the disaster-affected population	SMS	Ushahidi, FEMA, UNOCHA, USAID, Marine Corps		
Crowd as a microtasker	OpenStreetMap (OSM)	Earthquake in Haiti	Jan. 2010	Create a detailed street map of Haiti, especially Port-au-Prince	Mapping platform	DigitalGlobe, GeoEye, World Bank	-	Over 2'000
	Ushahidi Help Map	Russian wild fires	2010	Facilitate the coordination between individuals in need and volunteer helpers	Crisis information platform	Ushahidi (Gupta & Sharma, 2013)	-	50
	OSM	Jakarta floods, Indonesia	March 2011	Help building resilience against floods by mapping critical facilities	Mapping platform	HOT, UNOCHA, World Bank, GFDRR		Over 500
	OSM, TweetClicker, ImageClicker	Typhoon Haiyan/Yolanda, Indonesia	Nov. 2013	Map buildings and infrastructure to help asses the damage	Mapping platform	HOT, MicroMappersUNOCHA, SBTF, GISCorps, MapAction, HumanityRoadAmerican Red Cross	-	Over 1000
	Mechanical Turk	Search for Jim Grey	Jan. 2007	Analyzing satellite images to spot Jim Grey's boat	-	DigitalGlobe, GeoEye	-	12'000
	Tomnod	Earthquake in Christchurch, New Zealand	Feb. 2011	Compare pre- and post-earthquake images to assess the damage	Tagging platform	GEO-CAN	-	Over 200

	Tomnod	Afgooye Corridor, Somalia	Aug. 2011	Find refugee camps by tagging satellite images	Tagging platform	SBTF, UNHCR, DigitalGlobe, Ushahidi	-	168
	MapMill	Hurricane Sandy, east coast of the USA	Oct. 2012	Tag satellite images to help asses the damage	Tagging platform	HOT, FEMA, Civil air Patrol, GISCorps	-	6'717
	PyBossa	Typhoon Pablo, Philippines	Dec. 2012	Analyze past three days of Twitter activity to find relevant information about the damage by tagging tweets	Twitter, Tagging platform	SBTF, Humanity Road, UNOCHA	Over 20'000	270
	AeroSee	Experiment, United Kingdom	Jul. 2013	Tag images provided by drones to find injured or missing persons	Tagging platform	University of Cenctral Lancashire, Patterdale Mountain Rescue Team	-	350
	Tomnod	Missing Malaysian Airlines flight MH370	March 2014	Tag satellite images to spot debris, oil slicks or the plane itself	Tagging platform	DigitalGlobe	-	Over 3'000'000

4 Discussion

4.1 Chances and Risks

4.1.1 Accuracy

One of the major challenges concerning crowdsourcing in the humanitarian sector is the accuracy of social media content. The tweets in Twitter and reports from other social media contain a huge amount of unusable information, the so-called “noise”, that doesn’t refer to the event one is searching for. It consists mainly of spam, advertisements, rumors or fake images. Automated processes can help to approach this problem. A commonly used technique is stop-word removal. Stop-words contain only little meaning such as “the”, “a”, or “to”. After they are removed the automated algorithm for mining relevant information will work more efficiently. The data text then is commonly transferred into vectors, the preferred format for machine learning algorithms. A good and more upcoming machine learning technique is called semi-supervised learning. At first, humans rank the reports into categories or attach predefined labels. Then, the machine-learning algorithm uses the obtained information to label a new set of unlabeled reports on its own. To calculate the accuracy of the automated process, the labeled reports are verified against the correct values from humans. The more reports are shared with the algorithm, the more accurate it gets (Barbier, Zafarani, Gao, Fung, & Liu, 2012)[72] (Starbird, Muzny, Palen, 2012)[45].

Classification and clustering techniques also foster the accuracy of crowdsourced social media data. The Bayesian classifier is widely used, together with regression methods and binary features. They will automatically classify a post into predefined categories or tags. A cluster groups tweets with similar words (Barbier, Zafarani, Gao, Fung, & Liu, 2012)[72] (Starbird, Muzny, Palen, 2012)[45]. Together with volunteers and the automated processes, incoming reports can be filtered, tagged and structured into stories that will facilitate the handling of the huge mass of information, coming from social media. The techniques still aren’t as accurate as humans, but can handle way more content in a short time. They aren’t meant to stand alone, but work together with volunteers and experts to achieve the best possible output in a timely manner, which is indispensable during a crisis.

4.1.2 Trust

A further challenge, that crowdsourced information faces, is trust. How can emergency responders be sure, the message sent via Twitter or other sources aren’t a fraud report from a malicious person (Gao, Barbier, & Goolsby, 2011)[73]?

Various techniques could mitigate this issue. A well-known example would be the voting system of social media sites, such as YouTube that uses a thumps up/thumps down method, or Facebook, that uses the "like" button. Likewise, the Ushahidi platform enables the user to vote on the credibility of reports (Barbier, Zafarani, Gao, Fung, & Liu, 2012)[72].

Another technique to maintain trust, was used by Andy Carvin, a Senior Strategist at the National Public Radio (NPR) in Washington DC, during the Arab Springs in 2010. He began asking his followers on Twitter to prove, if reported events in the social media space have actually taken place. In doing so, he relies on sources that have proven to be reliable.

The Verification Team of the SBTF uses a two-way approach. At first, they review the lifeline of the reporter in Twitter or Facebook and search for names, pictures, links etc. The second step is to triangulate the content by checking other unconnected sources for identical reports. But still one of the best methods is called "bounded crowdsourcing", also referred to snowball sampling in statistics. The purpose is, to start with a trusted network of participants, who then on their own invite people they trust and so on. This technique was already mentioned in chapter 3.4.3, where a Skype group grew to over 2000 volunteers to help verifying reports from Kyrgyzstan (Meier P. , 2011)[58].

The latest application, that wants to increase trust for crowdsourced information from Twitter, is called TweetCred, created by (Gupta, Kumaraguru, Castillo, & Meier, 2014)[74]. At first they collected over 10 Million tweets from 6 major disasters in 2013. Then 500 randomly selected tweets from each event was annotated by volunteers, if the post is related to the event but contains no information, contains information about the event or if it's not related to the event. This training data and 45 defined features were used to build the learning algorithms for TweetCred. The application then was tested by 717 Twitter users, who computed the credibility score of more than 1.1 Million tweets. TweetCred would show a trust rating from 1 to 7 for a tweet and asks the users to decide, if they agree with the rating or if they would change it, which improves the algorithm more and more (semi-supervised learning).

Figure 41 On the left: A tweet from BBC News correctly rated by the algorithm. On the right: The credibility of the Red Cross was not rated correctly and the system asks the user to adjust it.

To keep crowdsourced information trustworthy, the voting system from TweetCred surely improves the accuracy by giving indications. It can decrease the time, needed for analyzing posts. Nevertheless it has to be further tested and improved to reach the majority of users (Gupta, Kumaraguru, Castillo, & Meier, 2014)[74].

Bounded crowdsourcing has proved to be efficient, but decreases the possible crowd participants dramatically, also turning to a non-representative sampling group.

4.1.3 Exchange format

The unstructured reports from victims and volunteers hinder a processing and integration into the existing information system of relief agencies. That's why they often do not cooperate with crowdsourcing infrastructures from other organizations. An accurate example was during the Haiti Earthquake in 2010, where several relief agencies worked on its own and couldn't officially join another (Ortmann, Limbu, Wang, & Kauppinen)[75].

(Ortmann, Limbu, Wang, & Kauppinen)[75] present Linked Open Data to overcome this problem. Real-time information coming from Twitter, articles, news and more are identified and linked through URL's. Additionally, the unstructured data gets structured by processing them into RDF-triples, which is a standard model for data interchange in the World Wide Web. This open data then can be used and easily integrated into existing systems and thus serves as a common exchange format.

4.1.4 Safety

In corrupt and unsafe systems the use of social media to report incidents can be very dangerous, when it reveals the user's identity. (Chamales & Genius, 2013)[76] describe a fatal example, where citizens in Nuevo Laredo, Mexico, came together to track the activity of a drug cartel by posting in several social media and websites. In return, four of the volunteers themselves were tracked down and murdered. Another example, during the War in Iraq 2007, shows the risk of geo-tagged photos in war zones. The Military believes, that the picture from a new fleet of helicopters in a carrier plane, which was taken during the flight line by a soldier and uploaded to the internet, caused a precise mortar strike, shortly after they arrived at the base. From the uploaded photos, insurgents could exactly determine the position of the helicopters within the area and plan the attack (Rodewig, 2012)[77].

SyriaTracker for example, which was described in section 3.4.2 noticed this problem and granted the reporters in the conflict zone of the Syrian civil war anonymity.

4.1.5 Mapping/tagging performance

In the field of microtasking comes another issue, namely the performance of the volunteers. Volunteer mapping is already well established and enfolds several expert organizations like the GISCorps or the SBTF. Non-expert volunteers, who want to help in a disaster, are guided and trained by the Humanitarian OpenStreetMap Team to use OpenStreetMap. Yet tagging images for damage assessment is still under development. The platforms for microtasking like Tomnod and MapMill were continually improved and today are delivering results in an astonishing speed. The performance of the remote volunteers although differ from field-based damage assessments. The American Red Cross evaluated the performance of volunteer contributors to damage assessment, after the typhoon Haiyan hit the Philippines. (American Red Cross)[78] recommends:

1. A standardize set of damage tags, that could also be used for future disasters
2. A good partnership with humanitarian agencies
3. A visual guide on how to tag damage
4. A quality score for the volunteers
5. Pre-disaster imagery should always be used if possible
6. Imagery providers should streamline imagery releases to make it openly accessible within hours
7. Humanitarian response agencies should build strong relationships with satellite imagery providers to ensure, that the images taken, truly cover the affected areas

Keeping this in mind, the volunteered work of the crowd can offer a significant help to the affected community.

4.1.6 Timely response

What almost all crowdsourcing efforts have in common is the super fast answer to the call and result delivery. Plenty of examples can be listed. To name a few, which I also described in the results chapter:

- Real-time density observation using mobile phone sensors during Zurich Festival
- Mapping the capital Port-au-Prince in a matter of days
- Detection of events during the Syrian civil war before official sources
- Analysis of 4000 satellite images for refugee shelters in 120 hours
- Sort through 20’000 tweets in 10 hours to find relevant information after the Typhoon Pablo hit the Philippines
- Finding a missing person during a test run in just 5 minutes using images sent via drones

The benefit of such a timely response is obvious during a crisis, where information can be considered as a lifesaver.

4.1.7 Good-hearted volunteers

A further benefit of crowdsourcing is its often for free working volunteers. During a crisis people want to help each other and offer their free-time. But also people who aren't directly affected by the disaster can simply support the crowdsourcing effort from their homes, using a computer. The contributions differ; some spend days tagging pictures, where others spend only minutes. However, these small contributions from all over the world get big together and can have an essential impact. Furthermore, there are crowdsourcing platforms that use paid volunteers. CrowdFlower is the leader in this field with over 5 million contributors (CrowdFlower)[79]. Paying expert-volunteers for their microtask effort can further motivate for more participation and has been stated as cost-effective for a small number (Chan, Crowley, Elhami, Erle, Munro, & Schnoebelen, 2013)[69].

In conclusion, we see, that numerous challenges arise, when turning to crowdsourcing in the humanitarian sector. Still the volunteer organizations have learned and improved a lot from previous disaster like the Haiti Earthquake, Hurricanes and civil wars. Today the solutions to major problems, like the accuracy of crowdsourced social media, trust issues and tagging preciseness, exist. Now the main challenge is, that the VTC's have to gain more acceptances by the emergency agencies and should be considered as a real help. This can be underlined by the statement, that 80 percent of the American public believes, that emergency organizations should regularly monitor social media sites. The American Red Cross already recognized this issue and launched its Digital Operation Centre in March 2012 together with Dell (OCHA, 2013)[6]. Building strong relationships between the volunteer community and emergency agencies is the key factor for future success.

4.2 Complex analytic crowdsourcing tasks

The volunteers require a growing and active participation in the crowdsourcing task beginning from crowd as a sensor and social computer to crowd as a reporter and lastly as a microtasker. But mostly the duty is not complex. Report an issue in Twitter or Facebook, tagging an image as “no damage”, “some damage” and “severe damage” or map streets and buildings in OSM doesn’t require a complex analysis. The latter needs some instructions and guidelines to be accurate, nonetheless, is it possible for the crowd to do complex analysis? I define complex analytic crowdsourcing task where a volunteer crowd not only gathers data but also develops strategies to a certain problem. During my research I couldn’t find any evidence where a volunteer crowd was referred to a complex analysis. However some efforts tend to reach into this area. Let’s look at the example of the Skype chat that was established to counter rumors during violence’s in Kyrgyzstan. Member of this chat not only reported what they knew but also themselves investigated the rumors. One tracked a rumor SMS that said that humanitarian aid are being poisoned and found that the owner of the phone was not at the said place where he stated (Meier P. , iRevolution, 2011)[80]. The volunteer himself created a strategy to solve the problem and could be considered as a complex analysis. Furthermore established VTC’s like the SBTF or HOT can plan a whole project and design their strategies by themselves using different specialized volunteer teams. The SBTF for example includes an analysis team that will generate situation reports to the activator of the SBTF, as was the case during typhoon Haiyan. One can say that these volunteer organizations doesn’t represent the “crowd” but we have to keep in mind that the SBTF and the OSM contributors consists of more than 800 and 300’000 volunteers respectively. The core of these VTC’s represents experts who are indispensible for the coordination and successful implementation of analytic crowdsourcing tasks.

5 Conclusion

As the world gets connected with technology in a rushing speed, the opportunity for crowdsourcing also rises. This research explored the role of crowdsourcing in the humanitarian aid community.

The governments and agencies using crowdsourcing to address a disaster are consistently growing, reaching over the whole planet. Mostly the World Bank, other parties of the United Nations and the American Red Cross foster the integration of crowdsourcing in their systems. Likewise, the Volunteer and Technical Communities (VTC), that implement crowdsourcing projects, expand strongly. The Haiti Earthquake in January 2010 enabled the breakthrough of these communities, also leading to the establishment of The Global Earth Observation - Catastrophe Assessment Network (GEO-CAN), the Standby Task Force (SBTF) and the Humanitarian OpenStreetMap Team (HOT).

Turning to the crowd, this paper used the classification by Poblet et al., namely crowd as a sensor, crowd as a social computer, crowd as a reporter and crowd as a microtasker. For emergency response, volunteers acting as a sensor aren't common at all. It needs further research to fully understand the potential, despite the success of the mobile app, developed by University of Passau, Germany and ETH Zurich, Switzerland, to monitor crowded areas.

The crowd as a social computer generates a huge database. Mainly Twitter is best suitable to leach out information nuggets with useful input to emergency agencies, due to its short 140-character text messages and its application-programming interface (API). Several automated techniques were used, ranging from classification, clustering to semi-supervised learning. These procedures have been tested to significantly reduce the "noise" of social media content and became widely adapted by VTC's. Especially semi-supervised learning, where humans show a machine, how to tag reports, attract researches for further simplification of information extraction from the massive data, that lay in social networks. While the accuracy was a big problem during the early stages, present methods clearly improved the performance and offer usable outputs. Social networks must be seen as a supporting source to humanitarian responders before, during and after a disaster occurred, because they can accelerate the response considerably and detect hotspots of people in need. To allow a smoothly process, VTC's have to be fully integrated in their systems.

From the perspective of the crowd as a reporter, a few applications and method exists to engage in humanitarian aid. The field of applications spreads from websites, E-mails, mobile phones, Skype, Twitter, and other social media with which earthquakes, eyewitnesses during war, health symptoms, needs and more can be reported to platforms, specialized in crowdsourcing. It turned out that security and trust issues have to be considered in planning such a platform. Today, these issues can already be handled in an acceptable way, but minimizes the potential crowd. Volunteer reporters had the best success in detecting rumors and causalities. Also the developed SMS short code for Haitians after the earthquake was claimed to have saved lives. Yet it has to be determined, if such platforms have a bias in helping richer people (those who have internet access or can afford a phone).

Finally, the crowd as a microtasker was analyzed. With mapping and tagging efforts, the volunteers can effectively support emergency agencies in an astonishing way. The workload of simple tasks, such as finding objects or people on satellite images or mapping streets and building outlines in OpenStreetMap (OSM), were scaled down to a fracture in many occasions. While the performance of damage assessment using satellite images needs further improvement and adjustments to field based observations, tagging tweets, whether they are important to emergency responders, tagging images, if they contain refugee shelters and tagging images to find a missing person was found to be very useful and accurate. The lacking accuracy of damage assessment could be improved by using more volunteers, tagging the same picture to calculate the overall agreement.

Complex analytical crowdsourcing tasks as in means of strategy development, can be considered in small non-expert volunteers, eager to help with their entire workforce and in established VTC's. Such volunteer organizations with an expert core-team and volunteer members truly have the ability to solve problems on their own and represent the future of successful crowdsourcing projects.

Crowdsourcing for humanitarian aid has already a solid variety of options, which work, but can still be further improved. The Volunteer community is growing every year and comprises a huge potential help, when a disaster happens. I recommend researchers and emergency agencies to fully utilize this workforce.

6 Future research

The accuracy of crowdsourcing tasks rises with participations. Now, a future work of field could be investigating, whether News Media could play a role in attracting volunteers. The current case of the missing Malaysian Airline for example allured over 3 million volunteers, which seems to be the biggest crowdsourcing-microtask event ever. Likewise the search for Jim Grey, although seven years earlier, where crowdsourcing was only at its beginnings, attracted about 12'000 volunteers and friends. Could the degree of popularity also foster crowdsourcing events and could it be used by celebrities during disasters?
A second possibility to motivate the participation in microtasking could be a gamified approach. An example application by (Castellote, Huerta, Pescador, & Brown, 2013)[81] already exists. They created a game for android smartphones to solve the inexactness of geographical names in Spain. A game has the opportunity to grant rewards to the volunteers such as prizes, points, badges and many more. Exact geographical names are important to emergency responders. The game has yet to be fully tested, but this gamified approach of crowdsourcing could foster the participation in smaller crowdsourcing projects.

This research gave a solid overview of the most named crowdsourcing projects in the humanitarian sector; even so it was mainly done through literature search and recommendations from experts in the United States. A next step would be to analyze projects, initiated from other regions, such as Asia. This approach would widen the horizon of possibilities to optimize crowdsourcing for humanitarian aid and foster the exchange between these regions.

7 References

[1] International Telecommunication Union. (2014). *Facts and Figures.* Geneva.

[2] Harvard Humanitarian Initiative. (2011). *Disaster Relief 2.0: The Future of Information Sharing in Humanitarian Emergencies.* UN Foundation & Vodafone Foundation Technology Partnership, Washington, D.C. and Berkshire, UK.

[3] Meier, P. (2. July 2012). Retrieved 15. July 2014 from National Geographic: http://newswatch.nationalgeographic.com/2012/07/02/crisis-mapping-haiti

[4] *Duden*. (no date). Retrieved 23. August 2014 from www.duden.de/rechtschreibung/crowdsourcing

[5] Estellés-Arolas, E., & Gonzalez-Ladron-de-Guevara, F. (2012). Towards an integrated crowdsourcing definition. p. 1-14.

[6] UN Office for the Coordination of Humanitarian Affairs (OCHA). (2013). *Humanitarianism in the Network Age.*

[7] Gupta, D. K., & Sharma, V. (2013). Exploring crowdsourcing: a viable solution towards achieving rapid and qualitative tasks. *Tech News* (2), p. 14-20.

[8] Wechsler, D. (August 2014). Crowdsourcing as a method of transdisciplinary research - Tapping the full potential of participants. *Futures* , p. 14-22.

[9] Narvaez, R. W. (2012). *Crowdsourcing for Disaster Preparedness: Realities and Opportunities.* Graduate Institute of International and Development Studies, Geneva.

[10] Poblet, M., Garcia-Cuesta, E., & Casanovas, P. (2014). IT Enabled Crowds: Leveraging the Geomobile Revolution for Disaster Management. *Proceedings of the Sintelnet WG5 Workshop on Crowd Intelligence: Foundations, Methods and Practices*, (p. 16-23). Barcelona.

[11] United Nations. (no date). *United Nations*. Retrieved 7. July 2014 from www.un.org/en/aboutun/

[12] United Nations Office for the Coordination of Humanitarian Affairs. (no date). *OCHA*. Retrieved 4. July 2014 von www.unocha.org/about-us/who-we-are

[13] World Health Organization. (no date). *WHO*. Retrieved 4. July 2014 from www.who.int/about/en/

[14] Cross Border Directory. (no date). *crossborderdirectory*. Retrieved 4. July 2014 from www.crossborderdirectory.org/charity-in-the-spotlight-what-does-the-world-health-organization-do.html

[15] United Nations High Commissioner for Refugees. (no date). Retrieved 4. July 2014 from www.unhcr.org/pages/49c3646c2.html

[16] United Nations. (no date). Retrieved 4. July 2014 from www.un.org/en/globalissues/briefingpapers/refugees/aboutUNHCR.html

[17] United States Agency for International Development. (no date). Retrieved 4. July 2014 from www.usaid.gov

[18] United States Federal Emergency Management Association. (no date). Retrieved 4. July 2014 from www.fema.gov

[19] International Federation of Red Cross and Red Cresent Societies. (no date). Retrieved 4. July 2014 from www.ifrc.org

[20] The World Bank. (no date). Retrieved 4. July 2014 von www.worldbank.org

[21] Global Facility for Disaster Reduction and Recovery. (no date). Retrieved 7. July 2014 from www.gfdrr.org

[22] Resor, E. (2013). *The Neo-Humanitarians: Assessing the Credibility of Organized Volunteer Crisis Mappers.* Massachusetts Institute of Technology.

[23] MapAction. (no date). Retrieved 6. August 2014 from www.mapaction.org

[24] Blanchard, H., & Chapman, K. (2012). *Volunteer Technology Communities: Open Development.* World Bank.

[25] Chapman, K., Wibowo, A., & Nurwadjedi. (2013). Disaster Risk Management in East Asia and the Pacific. *Distance Learning Seminar Series 2013.*

[26] Crowley, J. (2013). *Connecting Grassroots and Government for Disaster Response.* Commons Lab of the Woodrow Wilson International Center for Scholars, Washington, DC.

[27] Patrick, M. (2011). *New information technologies and their impact on the humanitarian sector.*

[28] Meier, P. (2013). Human Computation for Disaster Response. In *Handbook of Human Computation* (p. 95-104). Springer New York.

[29] Chapman, K. (19. March 2013). *Knight News Challenge*. Retrieved 17. July 2014 from opengov.newschallenge.org/open/open-government/submission/mapmill-crowdsourced-disaster-damage-assessment/

[30] Tomnod. (no date). Retrieved 17. July 2014 from www.tomnod.com

[31] World Science Festival. (21. November 2013). Retrieved 21. July 2014 from www.worldsciencefestival.com/2013/11/helping_one_click_at_a_time_micromappers_and_the_digital_humanitarian_respo/

[32] Meier, P. (18. September 2013). *irevolution*. Retrieved 21. July 2014 from irevolution.net/2013/09/18/micromappers/

[33] Heinzelman, J., & Waters, C. (2010). *Crowdsourcing Crisis Information in Disaster-Affected Haiti.* United States Institute of Peace, Washington, DC.

[34] CNA. (2011). *Social Media in Emergency Management Camp*, (p. 56).

[35] Random Hacks of Kindness. (no date). Retrieved 24. July 2014 from www.rhok.org/about

[36] Humanity Road. (no date). Retrieved 5. August 2014 from www.humanityroad.org/aboutus/

[37] Xiao, Y., Simoens, P., Pillai, P., Ha, K., & Satyanarayanan, M. (2013). Lowering the barriers to large-scale mobile crowdsensing. *Proceedings of the 14th Workshop on Mobile Computing Systems and Applications.* New York.

[38] Pan, B., Zheng, Y., Wilkie, D., & Cyrus, S. (2013). *Crowd Sensing of Traffic Anomalies based on Human Mobility and Social Media.* Orlando, FL.

[39] Mun, M., Reddy, S., Shilton, K., Yau, N., Burke, J., Estrin, D., et al. (2009). *PEIR, the Personal Environmental Impact Report, as a Platform for Participatory Sensing Systems Research.* Krakow, Poland.

[40] Goldman, J., Shilton, K., Burke, J., Estrin, D., Hansen, M., Ramanathan, N., et al. (2009). *Participatory Sensing: A citizen-powered approach to illuminating the patterns that shape our world.* Woodrow Wilson International Center for Scholars.

[41] Evans-Pughe, C., & Bodhani, A. (March 2013). Comms in a crisis. *Engineering and Technology* (8), p. 74-77.

[42] London School of Economic (LSE). (13. July 2012). *LSE*. Retrieved 25. July 2014 from www.lse.ac.uk/newsAndMedia/news/archives/2012/07/crowd-control-app.aspx

[43] Schmid, F. (8. July 2013). *ETH Life*. Retrieved 25. July 2014 from www.ethlife.ethz.ch/archive_arcticles/130708_bilanz_app_zueri_faescht_fs/index

[44] Chae, J., Thom, D., Jang, Y., Kim, S., Ertl, T., & Ebert, D. S. (21. October 2013). Public behavior response analysis in disaster events utilizing visual analytics of microblog data. *Computer and Graphics* (38), p. 51-60.

[45] Starbird, K., Muzny, G., & Palen, L. (2012). Learning from the Crowd: Collaborative Filtering Techniques for Identifying On-the-Ground Twitterers during Mass Disruptions. *Proceedings of the 9th International ISCRAM Conference.* Vancouver, Canada.

[46] Terpstra, T., Vries, A. d., Stronkman, R., & Paradies, G. (2012). Towards a realtime Twitter analysis during crises for operational crisis management. *Proceeding of the 9th International ISCRAM Conference.* Vancouver, Canada.

[47] MacEachren, A. M., Jaiswal, A., Robinson, A. C., Pezanowski, S., Savelyev, A., Mitra, P., et al. (2011). SensePlace2: GeoTwitter Analytics Support for Situational Awareness. *Visual Analytics Science and Technology (VAST)*, (p. 181-190). Providence, RI.

[48] Imran, M., Elbassuoni, S., Castillo, C., Diaz, F., & Meier, P. (2013). Extracting Information Nuggets from Disaster-Related Messages in Social Media. *Proceedings of the 10th International ISCRAM Conference.* Baden-Baden, Germany.

[49] Rogstadius, J., Vukovic, M., Teixeira, C. A., Kostakos, V., Karapanos, E., & Laredo, J. A. (October 2013). CrisisTracker: Crowdsourcing social media curation for disaster awareness. (57).

[50] Dashti, S., Palen, L., Heris, M. P., Anderson, K. M., Anderson, S., & Anderson, T. J. (2014). Supporting Disaster Reconnaissance with Social Media Data: A Design-Oriented Case Study of the 2013 Colorado Floods. *Proceedings of the 11th International ISCRAM Conference.* Pennsylvania, USA.

[51] St. Denis, L. A., Palen, L., & Anderson, K. M. (2014). Mastering Social Media: An Analysis of Jefferson County's Communications during the 2013 Colorado Floods. *Proceedings of the 11th International ISCRAM Conference.* Pennsylvania, USA.

[52] Atkinson, G. M., & Wald, D. J. (June 2007). "Did You Feel It?" Intensity Data: A Surprisingly Good Measure of Earthquake Ground Motion. *Seismology Research Letters* (78).

[53] Young, J. C., Wald, D. J., Earle, P. S., & Shanley, L. A. (2013). *Transforming Earthquake Detection and Science Through Citizen Seismology.* Woodrow Wilson International Center for Schloars, Washington, DC.

[54] Mergel, I. (2012). *Distributed Democracy: SeeClickFix.com for Crowdsourced issue reporting.* Syracuse University, Syracuse, USA.

[55] Meier, P. (25. March 2012). *irevolution*. Retrieved 31. July 2014 from http://irevolution.net/2012/03/25/crisis-mapping-syria/

[56] SyriaTracker. (18. Mai 2014). Retrieved 31. July 2014 from https://spotfire.cloud.tibco.com/public/ViewAnalysis.aspx?file=/users/dmosenkis/Public/SyriaTracker5&waid=e16af0633730abdb85ca1-23133667fddccd

[57] Starbird, K., & Palen, L. (2011). *"Voluntweeters": Self-Organizing by Digital Volunteers in Times of Crisis.* Vancouver, Canada.

[58] Meier, P. (November 2011). *irevolution*. Retrieved 31. July 2014 from irevolution.files.wordpress.com/2011/11/meier-verifying-crowdsourced-data-case-studies.pdf

[59] McClendon, S., & Robinson, A. C. (2012). Leveraging Geospatially-Oriented Social Media Communications in Disaster Response. *Proceedings of the 9th International ISCRAM Conference*, (S. 10). Vancouver, Candada.

[60] Besaleva, L. I., & Weaver, A. C. (2013). *Applications of Social Networks and Crowdsourcing for Disaster Management Improvement.*

[61] Humanitarian OpenStreetMap Team. (no date). *hot*. Retrieved 5. August 2014 from http://hot.openstreetmap.org

[62] The World Bank. (no date). *gfdrr.* Retrieved 5. August 2014 from www.gfdrr.org/sites/gfdrr.org/files/Pillar_1_Using_Participatory_Mapping_for_Disaster_Preparedness_in_Jakarta_OSM.pdf

[63] iipdigital. (5. October 2011). (Cultivating Civil Society 2.0) Retrieved 5. August 2014 from http://iipdigital.usembassy.gov/st/english/publication/2011/09/20110913140603yelhsa0.2868311.html#axzz39WmejtTb

[64] Beland, P. (17. November 2013). *Humanitarian OpenStreetMap Team*. Retrieved 7. August 2014 from http://hot.openstreetmap.org/updates/2013-11-17_r%C3%A9ponse_dopenstreetmap_au_typhon_haiyan_yolanda

[65] Theobald, C. (29. July 2013). *University of Central Lancashire (uclan)*. Retrieved 17. July 2014 from http://www.uclan-ac-uk/news/search_and_rescue_drone_trial_is_major_success.php

[66] South China Morning Post. (18. March 2014). *scmp*. Retrieved 7. August 2014 from www.scmp.com/news/asia/article/1451444/three-million-people-join-crowdsourcing-satellite-hunt-missing-malaysia

[67] Barrington, L., Ghosh, S., Greene, M., Har-Noy, S., Berger, J., Gill, S., et al. (20. October 2011). Crowdsourcing earthquake damage assessment using remote sensing imagery. *Annals of Geophysics* (54).

[68] Foulser-Pigott, R., Spence, R., Saito, K., Brown, D., & Eguchi, R. (2012). The use of remote sensing for post-earthquake damage assessment: lessons from recent events, and future prospects. *WCEE* .

[69] Chan, J., Crowley, J., Elhami, S., Erle, S., Munro, R., & Schnoebelen, T. (May 2013). *GIS Professionals Volunteering for a Better World.* Retrieved 14. August 2014 from www.giscorps.org/index.php?option=com_content&task=view&id=135%Itemid=63

[70] Humanity Road. (4. October 2013). *slideshare*. Retrieved 9. September 2014 from http://de.slideshare.net/CatGraham/typhoon-pablo-bopha-activation

[71] Meier, P. (6. December 2012). *iRevolution*. Retrieved 5. August 2014 from http://irevolution.net/2012/12/06/digital-disaster-response-typhoon/

[72] Barbier, G., Zafarani, R., Gao, H., Fung, G., & Liu, H. (September 2012). Maximizing benefits from crowdsourced data. *Computational & Mathematical Organization Theory* (18), p. 257-279.

[73] Gao, H., Barbier, G., & Goolsby, R. (2011). *Harnessing the Crowdsourcing Power of Social Media for Disaster Relief.* IEEE.

[74] Gupta, A., Kumaraguru, P., Castillo, C., & Meier, P. (2014). *TweetCred: A Real-time Web-based System for Assessing Credibility of Content on Twitter.*

[75] Ortmann, J., Limbu, M., Wang, D., & Kauppinen, T. Crowdsourcing Linked Open Data for Disaster Management. *Terra Cognita 2011 Workshop at the ISWC*, (p. 11-22). Bonn, Germany.

[76] Chamales, G., & Genius, R. (May 2013). Towards Trustworthy Social Media and Crowdsourcing. *Policy memo series* (2).

[77] Rodewig, C. (7. March 2012). *Official Homepage of the United States Army*. Retrieved 19. August 2014 from www.army.mil/article/75165/Geotagging_poses_security_risks/

[78] American Red Cross. (no date). Retrieved from http://americanredcross.github.io/OSM-Assessment/ on 19 August 2014

[79] CrowdFlower. (no date). Retrieved 20. August 2014 from www.crowdflower.com

[80] Meier, P. (26. March 2011). *iRevolution*. Retrieved 20. August 2014 von http://irevolution.net/2011/03/26/technology-to-counter-rumors/

[81] Castellote, J., Huerta, J., Pescador, J., & Brown, M. (May 2013). Towns Conquer: A Gamified application to collect geographical names (vernacular names/toponyms). *AGILE 2013* , p. 14-17.

Declaration of originality

This signed "Declaration of originality" is a required component of any written work (including any electronic version) submitted by a student during the course of studies in Environmental Sciences. For Bachelor and Master theses, a copy of this form is to be attached to the request for diploma.

I hereby declare that this written work is original work which I alone have authored and written in my own words, with the exclusion of proposed corrections.

Title of the work

Crowdsourcing In The Humanitarian Network - An Analysis Of The Literature

Author(s)

Last name	First Name
Hörler	**Raphael**

With my signature, I hereby declare:

- I have adhered to all rules outlined in the form on „Citation etiquette", www.ethz.ch/students/exams/plagiarism_s_en.pdf.
- I have truthfully documented all methods, data and operational procedures.
- I have not manipulated any data.
- I have identified all persons who have substantially supported me in my work in the acknowledgements.
- I understand the rules specified above.

I understand that the above written work may be tested electronically for plagiarism.

Herisau, 20.10.2014

Place, Date

Signature*

* The signatures of all authors are required for work submitted as a group. The authors assert the authenticity of all contents of the written work submitted with their signatures.