POLITECNICO DI MILANO

CROWDSOURCED DATA VALIDATION IN MASS NATURAL DISASTERS

By

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A THESIS

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It has been a period of intense learning for me, not only in the academic arena, but also on a personal level. I would like to reflect on the people who have supported and helped me so much throughout this period.

Foremost, I would like to express my sincere gratitude to my supervising professor Daniela Carrion, for her continuous support, for her patience, enthusiasm and immense knowledge.

I would like to thank my family, my parents and my sister for their immense love and support in my time staying here in Italy. Thank you, God, for having such a wonderful family. Another gratitude is reflected to my dear friends, if the family is like a root then friends are like wings. I want to highlight the following ones, Alua, Dina, Sayash and Venera. We were not only to support each other by deliberating over our problems and findings, but also happily in talking about things other than just our papers.

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Saltanat Tolebay

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ABSTRACT

The natural calamities are an overwhelming issue and affecting many countries since century time. So, there were always need in assistance from outside. The nowadays post calamities effect could be well performed by rescue teams by the help of innovative system of 20th century – the crowdsourcing.

Crowdsourcing has recently proved to play a key role in data collection in aftermath of disaster. Therefore, my thesis work begins from the introductory overview one of the deadliest, destructive and costliest calamities like earthquake, flooding and hurricane occurred in Nepal, Haiti, Queensland state of Australia and US. In the moment of disaster, information and data inflow was demonstrated in huge amount. Without an adequate interpretation and correlation of these received data, there is no any ways to move forward with relief actions. Need of reliant and on time data is a key success of any relief management system. All these aspects are main discussion of Chapter 4, where examination of data validation, groups of responsible people, terms and means of validation and so on are the part of this Chapter. Another condition I want to mention is that out of analyzing four of mainly horrifying disasters, two of them developed in economically stable countries, while other two were compounds of poor financially developed ones. Consequently, final chapter represents and involves language issues, which opened broad opportunities of communication ways between affected population and relief communities

Whereas climax of the thesis work devoted to the conclusion of the main idea of my thesis work, consummating and combining overall aspects of crowdsourcing in validation of data throughout four major destructive and disastrous natural calamities.

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1 INTRODUCTION

The main study driving this thesis work is to reveal what is data validation of natural disasters, where crowdsourcing and citizen science performed as data/information sources. Unfortunately, the so called natural hazards don't have tendency to get predicted. We may only get an advance announcement prior to leave a dangerous zone. This causes some harsh consequences in terms of people settlement arrangements, provision of necessary food, hygienic etc. staff. But, there is a nice possibility to get the assistance to the suffered people of the affected zones and districts. It could be done by means of volunteering groups and representatives of various non-profit organizations. Where primary importance refers to crowdsourcing and networks allowing to manage the process.

Moreover, human interaction and collaboration occurring on a large-scale through social media during times of mass disruption – a phenomenon of increasing interest to researchers, news, reporters, formal emergency responders, humanitarian agencies, and the public at large. The Internet has created new virtual spaces for large-scale interaction and opened countless new channels where information flows. Ubiquitous technology (including mobile devices) now provides access to these spaces and the information produced within them from more places, geographical and virtual. Emergent, digital convergence activities include both information generation (i.e. citizen reporting) and information organization. Without overlooking the former, this study intends to take an in-depth look at the latter component, investigating the myriad ways in which social media users are processing a flood of data into useful information during mass disruption events. Important resource is human, human responsibility level, his

motivation reasons and knowledge which he may introduce and develop in responding via information technologies to relief groups, in timely manner.

In my thesis, crowdsourcing is represented as the main source of information, where data was also provided by nonprofessionals' and sometimes data was full of unstructured information and noise. Crowdsourcing has become a widely applied practice in the context of innovation and problem solving. So, first, thesis provides an overview in State of Art of Crowdsourcing in post disaster events in terms of definitions used, application areas, players involved as well as processes and tools implemented (Chapter 3). While in the next Chapter 4, discourse of key aspects of Crowdsourced data validation involve data generation aspects and crowdsourcing platforms, communities and organizations as an integral of crowdsourced data validation. Language challenges in diverse racial and ethnic communities are also part of this Chapter. Culmination of the analysis the thesis work, is directly correlated with Conclusion Chapter.

All the analysis was based on diverse scholars' research works, which involved natural disasters in 2015 Kathmandu earthquake of Nepal and 2010 Port-au-Prince quake of Haiti, 2010-2011 Queensland floods of Australia and 2012 Sandy hurricane from Atlantic Ocean of United States.

2 The Case Studies

2.1 Very brief overview of the calamities occurred in Nepal, Haiti, Australia (Queensland) and US (Hurricane Sandy)

When certain zones of countries are affected to any kind of natural disasters it always causes dramatic consequences and tremendous death toll rate. Any affected countries ought to know more about the amount of displacements, certain quantity of human needs (shelter, beverages, medical assistance etc.) and other relevant information for relief teams' further management.

Unfortunately, natural disasters are somehow unpreventable and, in the most cases, uncontrollable. Even if fast recovery works occurs, while natural disasters can have long-term effects.

The severity of damage caused by natural disasters can be affected by the factors like population density in disaster-prone areas, community preparedness, as well as the use of public safety announcements in competent way and presence of knowledge among local people on how to respond correctly at the first sign of danger. My thesis work is correlated with the mass disruptive natural events and a brief discussion on the nature, distribution, and impact of these disaster events via crowdsourcing monitoring. Essentially, topic covers natural disasters happened in mainland like-2015 Nepal and continents like 2010-2011 Australia (Queensland state) and 2012 United States, and of an island of 2010 Haiti.

Context of my thesis will introduce data collection and data validation during following four natural disasters throughout the crowdsourcing tools, involving variations and similarities in data processing and validation

approaches. Let me start from the brief introduction of each of four calamities. Whereas, I will start from acquainting you with Nepalian case, then Haiti, further you will witness Queensland and Sandy disasters.

Nepal earthquake of 2015, also called Gorkha earthquake, severe quake that struck near the city of Kathmandu in central Nepal on April 25, 2015. About 9,000 people were killed, many thousands more were injured, and more than 600,000 structures in Kathmandu and other nearby towns were either damaged or destroyed. The earthquake was felt throughout central and eastern Nepal, much of the Ganges River plain in northern India, and northwestern Bangladesh, as well as in the southern parts of the Plateau of Tibet and western Bhutan. The initial shock, which registered a moment magnitude of 7.8 Mw, struck shortly before noon local time (about 06:11 AM Greenwich Mean Time). Its epicenter was about 21 miles (34 km) east-southeast of Lamjung and 48 miles (77 km) northwest of Kathmandu, and its focus was 9.3 miles (about 15 km) underground[1]. Figure 1 illustrates epicenter of the earthquake, where red squares in the middle of landscape of Nepal represents them. Unfortunately, quake followed by two large aftershocks with magnitude 6.6 Mw and 6.7 Mw afterwards. L.Clark [1], evolves his study on Kathmandu case, where he claims that high demand of the conditions and overview of the situation on the ground were in demand, which lead to the volunteer groups assistance in building the mapping data from the satellite imageries as well as from social media.

1 https://en.wikipedia.org/wiki/April_2015_Nepal_earthquake

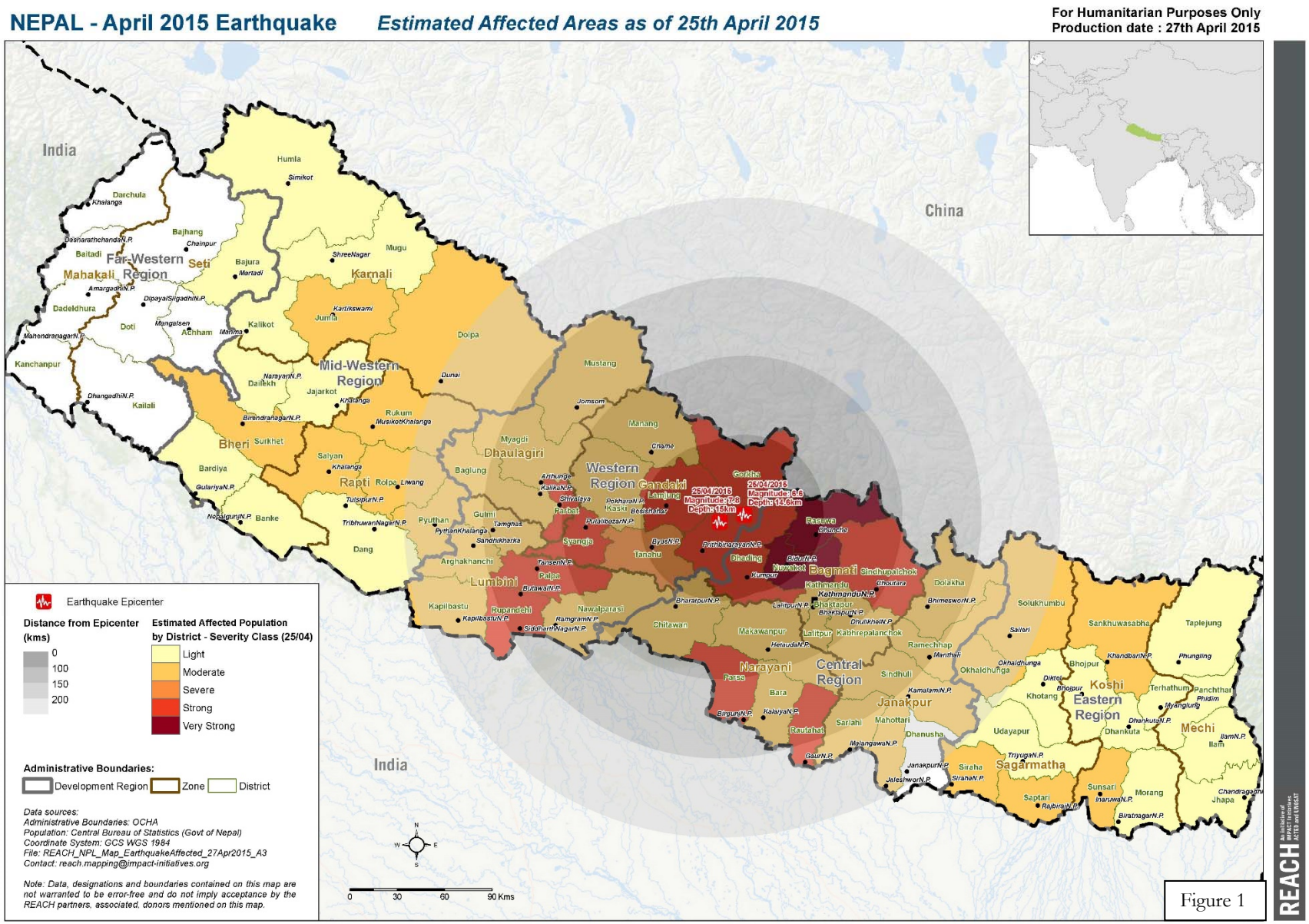

Figure 1 – Nepal affected areas April 2015 earthquake[2]

2 http://reliefweb.int/map/nepal/nepal-april-2015-earthquake-estimated-affected-areas-25th-april-2015

On the contrary, Haitian earthquake occurred five years earlier than Nepalian one, in 2010. Haiti earthquake was a catastrophic magnitude 7.0 Mw earthquake, with an epicenter near the town of Léogâne (Ouest), approximately 25 kilometres (16 mi) west of Port-au-Prince, Haiti's capital. The earthquake occurred at 16:53 local time (21:53 UTC) on Tuesday, 12 January 2010. Haiti earthquake also witnessed aftershocks, but in comparison to Nepal, the amount of them were a way more, at least 52 of them by 24th of January[3]. Figure 2, demonstrates an overview of the magnitude of severity of the quake depending on its distance from the epicenter, starting from extreme (around epicenter) and decreasing to moderate level (far from epicenter)[3].

Among first aiders I want to introduce P.Meier [4] and his team of volunteers from the Fletcher School at Tufts university (US, Massachusetts), who developed quick and mobilized remote assistance. Many more other scholars contributed their analysis of on these calamities, which you will be able to observe in Chapter 4.

Another important fact is that the media can play a leadership role in changing the mindset of society for making it more proactive rather than reactive. It also has the responsibility to make the message more valuable and credible for the public. As an evidence of evolving the map in OSM, through analyzing the coming data from both social networks and mainstream media. Role of media was vital in overall promotion of a better disaster management regime within affected countries. Continents like Australia and US also was exposed to disastrous aftermath of mass flooding and harmful hurricane. In Wikipedia, a series of floods hit Queensland, Australia, beginning in December 2010. At least 90 towns and over 200,000 people were affected. On Thursday 13th January 2011

3 https://en.wikipedia.org/wiki/2010_Haiti_earthquake

Brisbane, the state capital of Queensland, Australia (27°30' S, 153°1' E) (Figure 1), experienced its second highest flood since the beginning of the 20th Century. The flooding caused the loss of 23 lives in the Lockyer Valley and one in Brisbane, and an estimated 18,000 properties were inundated in metropolitan Brisbane, Ipswich and elsewhere in the Brisbane River Valley[4]. In Figure 3, you can find rainfall coverage in Australia, related to week ending December 28 of 2010, and some more other information[4].

And finally, the fourth calamity introduced in my thesis, is hurricane Sandy occurred in United States in 2012. Hurricane Sandy, was a late-season post-tropical cyclone, swept through the Caribbean and up the East Coast of the United States in late October 2012. The storm left dozens dead, thousands homeless and millions without power. The death toll from Sandy as of Nov. 1 was at least 149. In the United States, Hurricane Sandy affected 24 states, including the entire eastern seaboard from Florida to Maine and west across the Appalachian Mountains to Michigan and Wisconsin, with particularly severe damage in New Jersey and New York[5]. Whereas, Figure 4 demonstrates surge height of the affected states along and within the coast of UN[5].

Magnitude of a natural disaster was always considered and mentioned in researchers works, hence it refers to the size of impact on both people and the environment with the latter being of less importance when people are not directly impacted. For instance, rural and urban regions of developed countries like Haiti and Nepal were analyzed as a case study. However, population density is not the only factor to influence the scale of impact, an important factor is the magnitude of the event. Hence an overall analysis of the above-mentioned calamities including certain objectives would be depicted in Chapter 4.

4 https://en.wikipedia.org/wiki/2010%E2%80%9311_Queensland_floods
5 http://edition.cnn.com/2013/07/13/world/americas/hurricane-sandy-fast-facts/

Comparison of approaches and methods of crowdsourced data validation in Nepal, Haiti, Queensland and US calamities were based on my observation of common resemblances in approaches to the ways of data processing, found in scholars' articles.

By observation of main aspects of crowdsourcing data validation, its terms, methods and people involved there, I may assume that communication is the most important means for achieving of well-organized relief objectives. My thesis work highlights challenges and investigates opportunities associated with validation of crowdsourced data to yield useful information, as well as details how crowdsource information and technologies can be used for response-coordination during natural calamities happened in four above recognized countries.

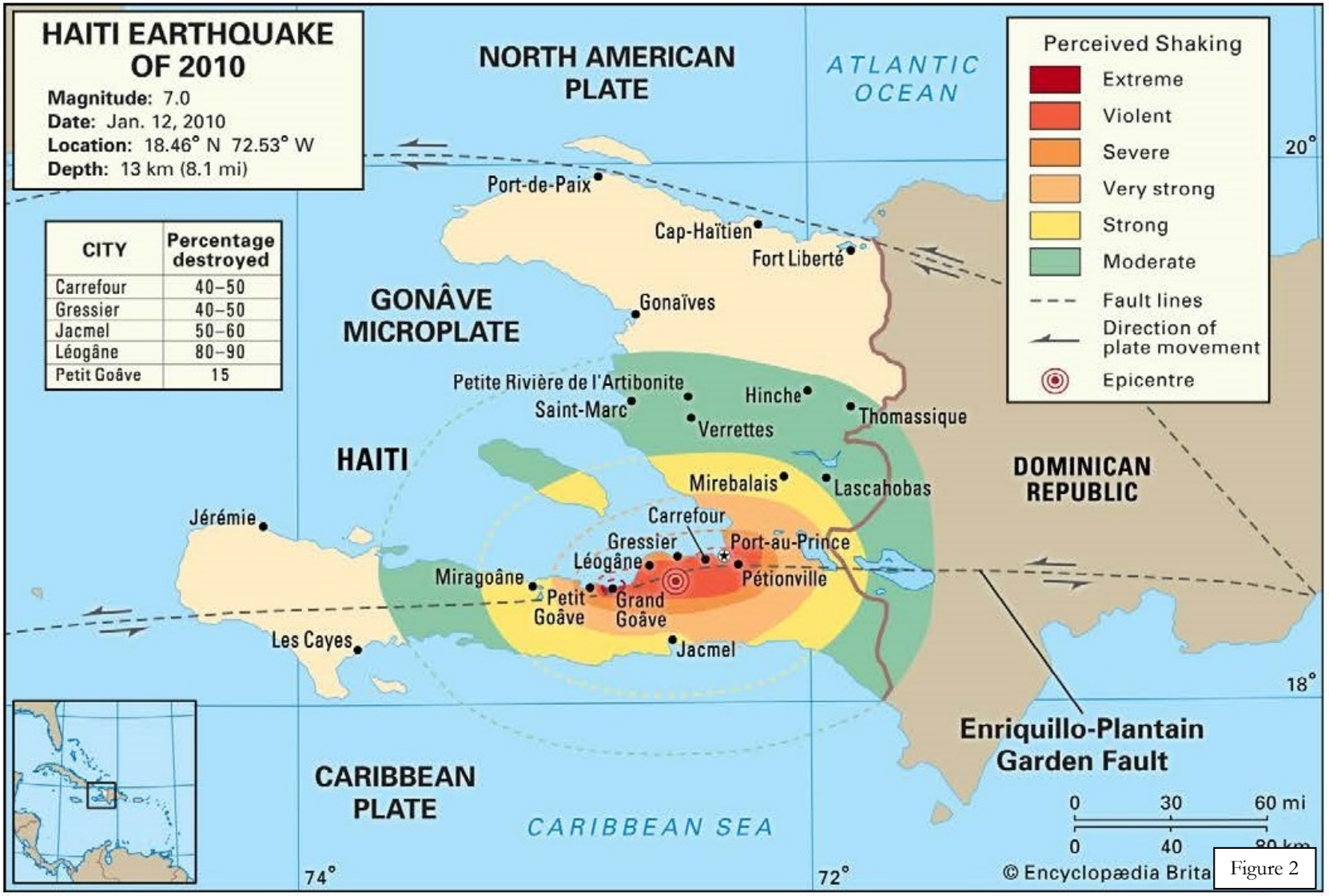

Figure 2 – Map of Haiti depicting the intensity of shaking and the degree of damage incurred by the Jan.12, 2010 earthquake[6]

6 https://www.britannica.com/media/print/1659695/138132

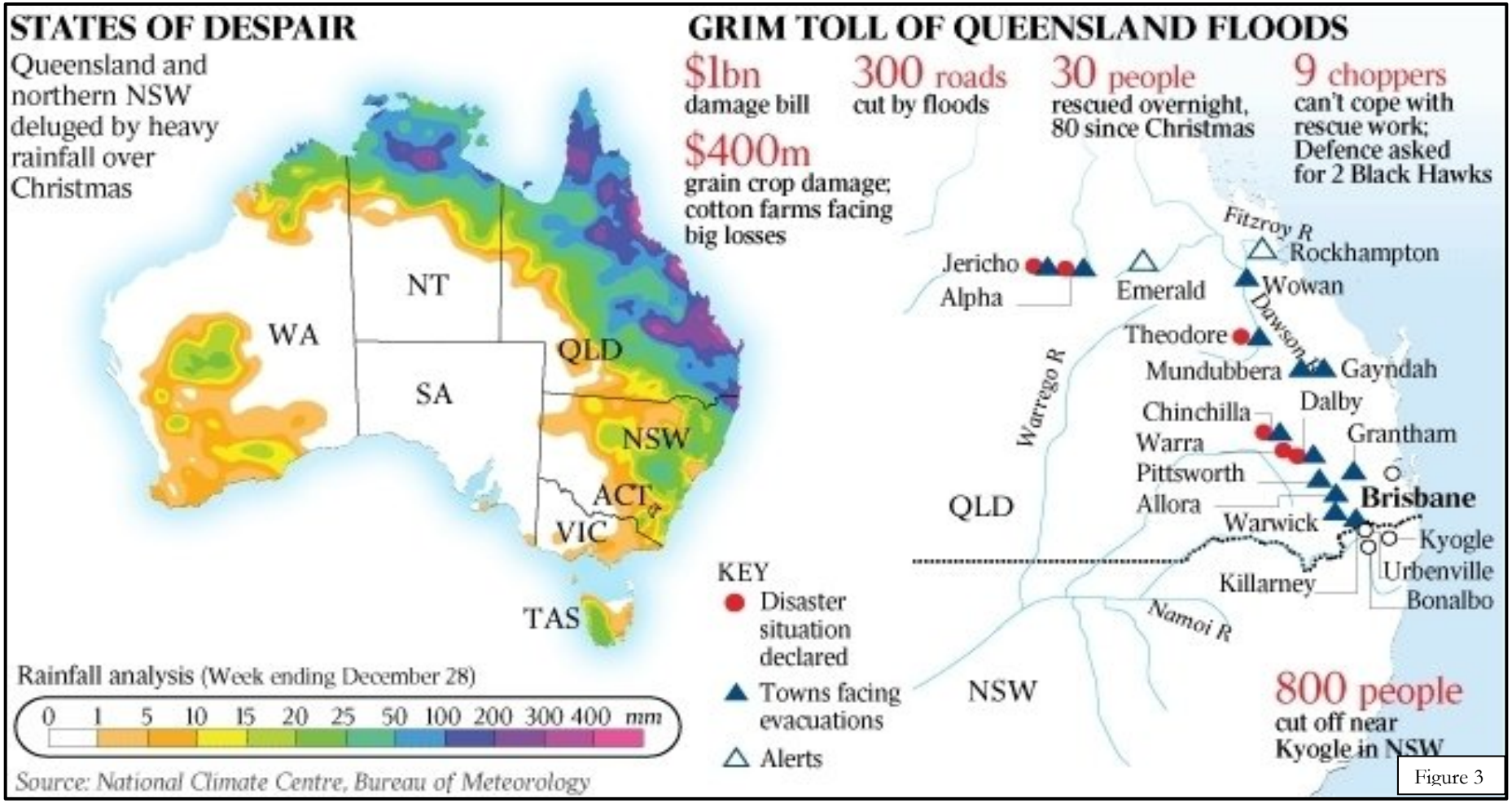

Figure 3 - States of despair during floods in Australia (Queensland 2010-11)[7]

7 http://southeastasianews.org/archives/aussie_floods_periodic_not_catastrophic.html

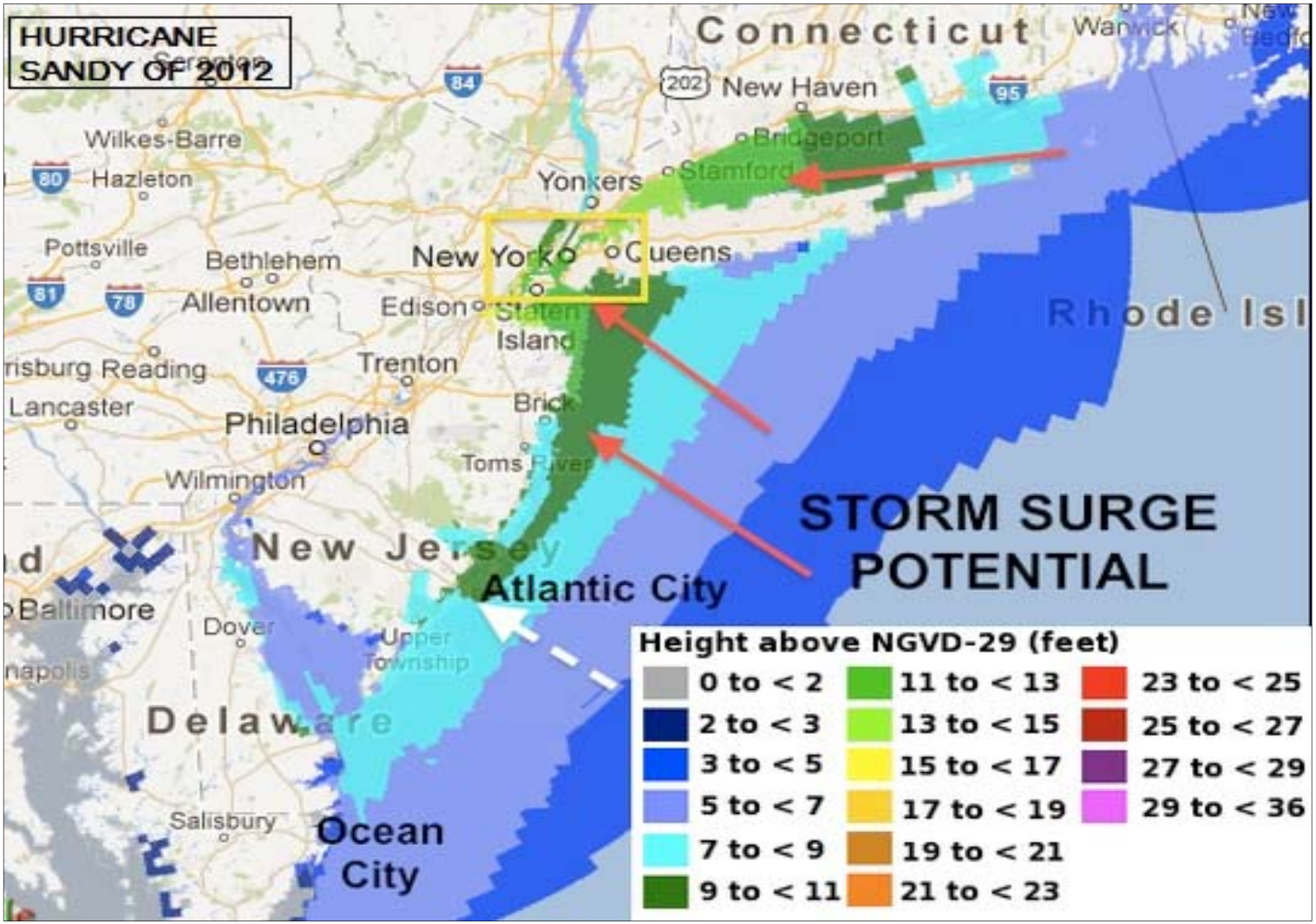

Figure 4 – Affected zones by Hurricane Sandy in 2012, precipitation map[8]

8 http://www.christianpost.com/news/national-hurricane-center-hurricane-sandy-2012-path-turns-toward-new-jersey-nyc-track-map-84103/

3 State of Art of Crowdsourcing in post disaster events.

3.1 Related Work

As it was already mentioned in the previous chapter, further talk involves the objective case of study of my work and its smooth translation into the crowdsourcing and crowdsourced data analysis. So, the purpose of this study is to conduct a comparative case study analysis of crowdsourcing efforts in support of recovery efforts that occurred during Haitian and Nepalian earthquakes, flooding in Australia and hurricane in US coast.

3.1.1 Objective of the study

The main idea of the thesis work is correlated with interlinking crowdsourcing as a method of data collection in aftermath of natural post disasters. I would say that crowdsourcing has been evolved as a key part of investigation in post disaster events.

In the aftermath of disasters, huge amount of information flows freely on both social and mainstream media. It is impossible for a single person or a small team to keep up with the overwhelming amounts of data. “The real challenge is to make sense of the huge amounts of information. It was like looking for needles in a haystack”, explained by Meier[9]. In the humanitarian space, the overflow of information can be as paralyzing as the lack of information boosting crowdsourcing of volunteers in, who evolved their role in checking each tag and keyword for priority and actionable information among the millions of bytes of information. Response could be presented in terms of actionable data validation of enormous amount of crowdsourced

9 http://digitalhumanitarians.com/team/dr-patrick-meier

data (step 1 in Figure 5). Consequently, for some visual understanding I have decided to create a flowchart including steps of evolution of objective of my thesis work.

During natural disasters or crisis, users on social media tend to easily believe contents of postings related to the events, and retweet the postings, hoping that the postings will be reached by many other users. Unfortunately, there are malicious users who understand the tendency and post misinformation such as spam and fake messages with expecting wider propagation (Step 2 in Figure 5). This tendency was found in all my four disasters, but I have determined three of them, US, Australian and Haitian cases in Chapter 4. Overall analysis of crowdsourced data has been circuited around Haiti and Nepal quakes, Australian flooding and hurricane in US (Step 3 in Figure 5).

Next stage refers to crowdsourcing in promoting a collection of data from various crowds of people. Where the collection of data following a natural disaster, corresponds with the idea of collection of information from large groups of people. People played a powerful, self-organizing, and collectively intelligent force, information and communication technology could demonstrate a transformational role in humanitarian assistance and disaster relief efforts as it was represented in disasters of my thesis work (Step 4 in Figure 5).

Nowadays disasters are global emergencies that affect all aspects of human needs and human health case. Therefore, there is practical need for an international approach (Step 4 in Figure 5). Corresponding result substantially could facilitate data organization during data management.

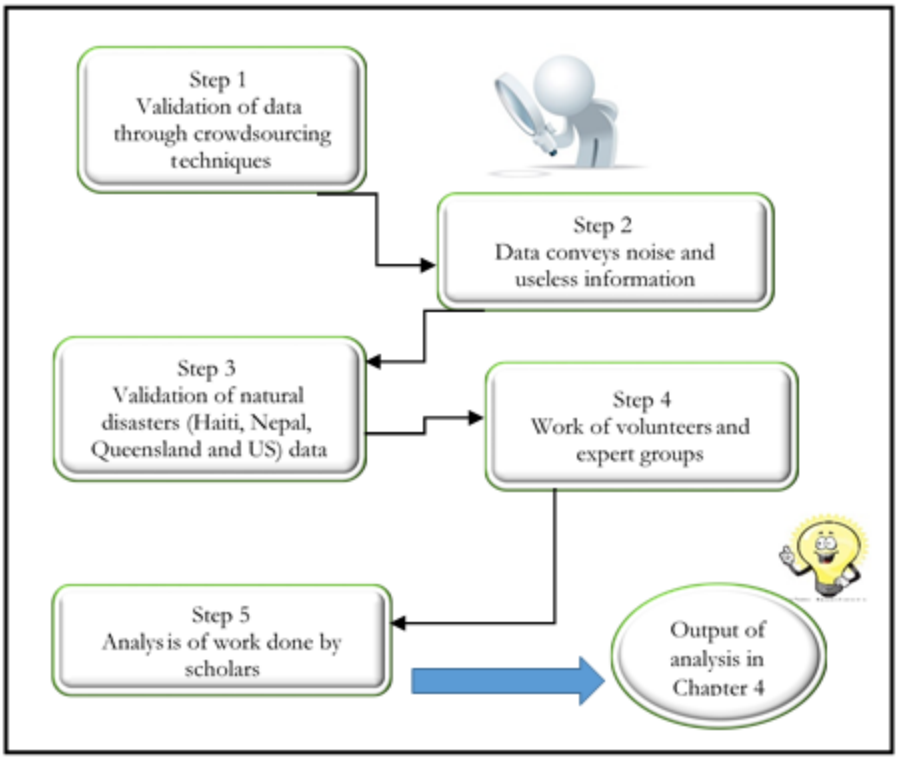

Figure 5 – Evolution steps of work objectives related to Crowdsourced Data validation

3.2 What is Crowdsourcing and Crowdsourced data

The dedication of my thesis work is correlated on crowdsourcing, whereas crowd performed their work in data collection and processing. The term crowdsourcing (Figure 6) was first coined by Jeff Howe in 2006 when referring to "the act of taking a job traditionally performed by a designated agent (usually an employee) and outsourcing it to an undefined, generally large group of people in the form of an open call" [13]. Wikipedia[10] online source released another definition, where crowdsourcing is given as the process of obtaining needed services, ideas, or content by soliciting contribution from large group of people, and especially from an online community, rather than from traditional employees or suppliers. Besides

10 https://www.shutterstock.com/image-vector/crowdsourcing-word-cloud-85311292

that, crowd could be any efficient group of people without any borders and having an instant access to the internet via mobile phones, laptops or any other information technology devices. In crowdsourcing, a task or a job is outsourced but not to a designated professional or organization but to public in the form of an open call (Howe 2006). In this way, crowdsourcing usually combines (a) digital technology, (b) human skills, (c) human generosity and it is a technique that can be deployed to gather data from various sources such as text messages, social media updates, blogs etc. The project presented by Flew et al. [64] investigates the role of social media and related online mobile tools for public communication in responding to natural disaster in Australia. F.Mulder et al. [3] outlines how crowdsourcing was used in the immediate aftermath of the earthquake in Haiti,

Figure 6 – Crowdsourcing cloud stock image[11]

drawing on the examples of Open Street Map (OSM) and Ushahidi and Nepal earthquake regarding OSM community and development of Quick Map civic technology that runs on the Ushahidi platform. Social media provides good opportunities for disaster relief efforts that can be planned, based on data collected from these sites.

According to D.C.Brabham [12], crowdsourcing is a type of participative online activity in which an individual, an institution, a non-profit organization, or a company proposes to a group of individuals of varying knowledge, heterogeneity, and number, via flexible open call, where

11 https://www.dreamstime.com/royalty-free-stock-image-crowdsourcing-word-cloud-image21290546

the voluntary undertakes of a task. The undertaking of the task, of variable complexity and modularity, and in which the crowd should participate by performing their work, knowledge, and / or experience, which always covers mutual benefit. D.C.Brabham [12] also highlighted several ingredients of crowdsourcing (which were already evaluated by other group of scholars):

- *An organization that has a task it needs to perform;*
- *A community (crowd) that is willing to perform the task voluntarily*
- *An online environment that allows the work to take place and the community to interact with the organization;*
- *Mutual benefit for the organization and the community;*

In A.Brunes [24] article definition like 'e-democracy' was found, which inherently highlights the importance of active participation – meaning not simply access to information, but direct and productive engagement with it, in turn generating material (ideas, comments, contributions) which may again be shared with other participants using the same or additional online media spaces. These interrelated dynamics also discussed in article of C.Soresina [13], since J.Howe released that the crowdsourcing covers definition of "crowd wisdom", which entails the following postulate stating that: "using *the collective intelligence of people within or outside an organization to solve complex problems*".

Disaster relief and response management is always complex network of combined groups of people all together. In my evaluation of four natural disasters the approach coincides with Howe's postulate and includes collaboration within wisdom of the crowd, where many volunteering groups of locals and remote location people as a part of crowdsourcing on the other side of networking.

3.3 Why do we need Crowdsourcing in post disaster events?

The first and principal objective of disaster response is to obtain "situational awareness", i.e., a detailed picture of the situation on the ground, the scale of the damage, and above all, the needs of affected people. In other words, an assessment with firsthand information is needed as fast as possible to plan and conduct relief efforts. Sourcing and mapping information about displaced people, infrastructure and a host of other essential data is helping aid agencies to build better contextual understanding about humanitarian needs.

In the chaos of a post-disaster environment, a common contextual understanding of urgent needs is of utmost importance, but is often a nightmare to achieve. Crowdsourcing is a clear opportunity to speed our ability to gather this important and time-sensitive data. Digitally connected communities can be used to either generate-whether actively or passively or analyze data. The process fundamentally relies on mobile phones, internet-capable devices, online networks, and internet-based applications. Where volunteerism and access to such technologies coexist.

Crowdsourcing is one possibly way of collecting and visualizing important information [20]. Especially when used with mobile device (e.g., smartphones), it is a potentially valuable near-real-time tool for managing and understanding situations as they unfold, rather than relying on retrospective analysis. The usefulness of this approach resides in the sheer number of participants and the vast amount of information that can be generated quickly.

The rapid growth of crowdsourcing applications for disaster relief profits from the development of online social media that provide an open, convenient platform that can collect data from various sources in a short time. It has leveraged Web 2.0 technologies to integrate data from multiple sources – phones, Web applications, email, and social media sites such as Twitter and Facebook – to provide an up-to-date, publicly available crisis map that is in turn available to relief organizations. Whereas Twitter is an online news and social networking service where users post and interact with messages, "tweets", restricted to 140 characters. Registered users can post tweets, but those who are unregistered can only read them[12]. Meanwhile, Facebook is a vast, sprawling network and you can make whatever you want of it. For that you should sign up putting some detail, and the preferably a photo of yourself, on the Facebook website[13].

The involvement of different actors and stakeholders in disaster management requires the existence of a coordination and collaboration mechanism. What makes crowdsourcing so important is the belief that more heads are better than one. Integration of local knowledge into the process of mapping may provide an important factual data and ideas about social and physical environment.

The use of local knowledge in disaster management also could enable local communities to participate actively in the decision-making process. Therefore, crowdsourcing might extend to crowdmapping, which uses crowdsourced information to create real-time maps as incidents are occurring.

Leveraging crowdsourcing for disaster relief has few advantages. I would like to split these advantages in three following stages. First,

12 https://en.wikipedia.org/wiki/Twitter
13 http://www.bbc.co.uk/webwise/guides/about-facebook

crowdsourced data, including user requests and status reports are collected almost immediately, as an example could be Haiti while after the 12 January of 2010 earthquake volunteers from Tufts University in Medford, Massachusetts designed and implemented a short message service (SMS) based on emergency reporting and response system [6]. News of this free emergency number was spread through local and national radio stations. Moreover, as of 25 January of the same 2010, the Haiti crisis map had more than 2,500 incident reports, with more reports being added every day. The large amount of nearly real-time reports allowed relief organizations to identify and respond to urgent cases in time. Second, crowdsourcing tools can collect data from emails, forms, tweets, and other unstructured methods and then do rudimentary analysis and summaries, such as by creating tag clouds, trends, and other filters. J.Heinzelman et al. [19] reveal that these can help partition the data into bins (such as medical help, food, shelter, or people trapped), Haitian response via Ushahidi platform demonstrates and illustrates this statement in Figure 7. Relief agencies can then concentrate on the issues and events that are most important to the relief effort and other filtering features. Using crowdsourced map, relief organizations can coordinate resource distribution and make better decisions on their analysis of crowdsourced data. Fallback plans can be further developed for the top events or to cover much of events.

Third, where providers can include geo-tagged information for messages sent from some platforms (such as Twitter) and devices (including handheld smartphones).

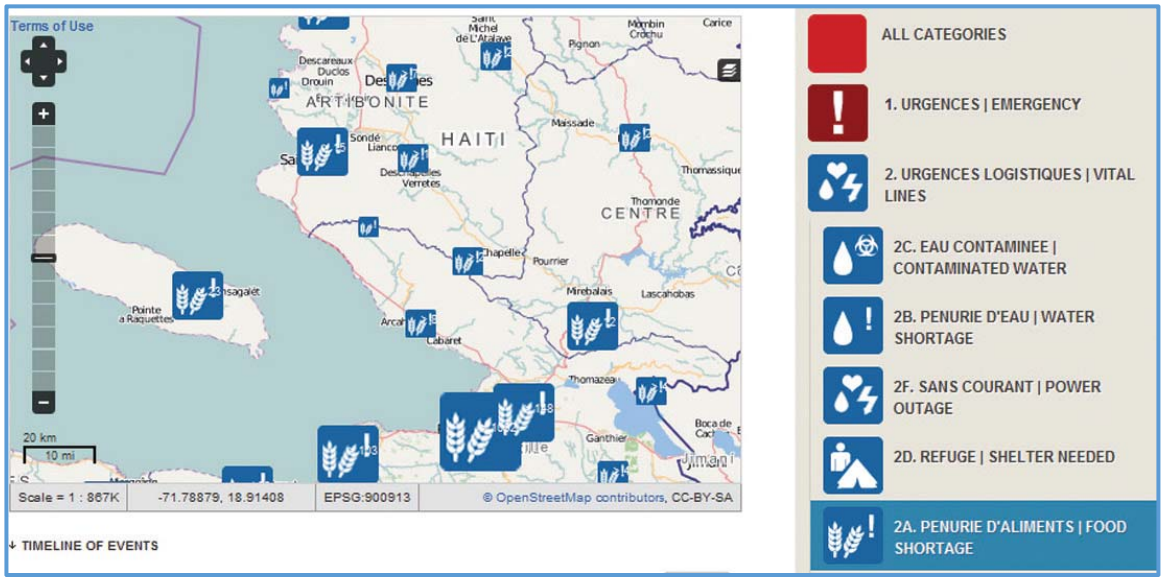

Figure 7 – Food requests after the Haiti earthquake. The Ushahidi-Haiti crisis map helps organizations intuitively ascertain where suppliers are most needed

In H.Wang et al. [65] work of Hurricane Sandy, scholars revealed that analysis of tweets were only included if they were geotagged and located in Washington DC or one of 13 US states affected by Sandy: Connecticut, Delaware, Massachusetts, Maryland, New Jersey, New York, North Carolina etc. Such crowdsourced data can help relief organizations accurately locate specific requests for help. Furthermore, visualizing this type of data on a crisis map offers a common disaster view and helps organizations intuitively ascertain the status.

Eventually, aftermath conditions demonstrated high need of networking systems and people who is eager to assist in data collection and operation. Out of all advantages spoken above, I would like to outline them in the following way:

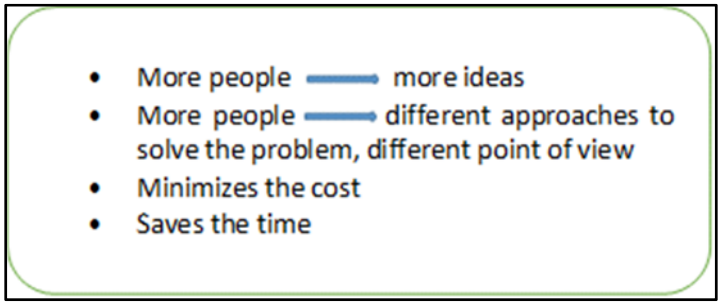

Figure 8 – Benefits correlated with crowdsourcing [51]

3.4 What type of crowdsourcing is more relevant in aftermath of disaster?

E.Estellas-Arolas [16] introduces several typologies of crowdsourcing, i.e. five of them:

1. Crowdcasting. Contest like crowdsourcing initiatives, where a problem or task is proposed to the crowd, being rewarded who solves it first or do it better;

2. Crowdcollaboration. Crowdsourcing initiatives in which communication between individuals of the crowd occurs.

3. Crowdcontent. In these crowdsourcing tasks, the crowd uses their labor and knowledge to create or find content of various types but not in a competitive way.

4. Crowdfunding. In the crowdfunding initiatives, an individual, organization or company seeks for funding from the crowd in exchange for reward.

5. Crowdopinion. In this case, the objective is to know the user opinions about a particular issue or product votes, comments, tags or even sale of shares.

As soon as my analysis based mostly on efforts made by scholars on research of volunteering groups of local and non-local people in data collection and crowdmapping, so I have decided that an appropriate and relevant typology for my thesis, is the one called 'crowd collaboration'. E.Estellas-Arolas [16] report defines it in the following way: "*crowd collaboration initiatives on which communication between individuals of the crowd occurs, while the initiator of the initiative stays on the sidelines.*" In research work on Queensland flooding promoted by A.Ahmed et al. [66] crowd collaboration factor introduces key actors categorized as local authorities, social media volunteers, traditional media reporters and members from non-profit, humanitarian and community associations and their effectiveness during the communication process. Various scholars extend various types of crowdsourcing; names could vary but their primary nature could remain the same. Another scholars like H.Ali-Hassam et al. [8] have made an analysis on various scientists works where typology of crowdsourcing was analyzed. Comparing and by bounding crowdsourcing into groups by their similar functionality, scholars have identified twelve groups out of all reviewed paper articles. I have highlighted two of them as the relevant ones to my study case, which are *Crowdsharing* and *Crowd-Relief* categories. The former one was about sharing videos and images in social networks like Twitter, Youtube and so on. Execution of the task was based purely on altruistic and social incentives of people. Performing this category of people, the task initiator was not known and there was not any

time limitation in processing of information. Through this system K.McDougall [15] witnesses Flickr in Queensland flooding, photography and imagery of the floods across different regions were posted on this site. While the latter category was dealing directly with aftermath of any type of calamity occurred, like hurricane, flooding, quake etc. The role of the crowd was about submitting an information and arranging updates via text messages, mapping and pictures using social media and the internet. In addition, in report of Homeland Security [26] city of New York one of the suffered states of US by Sandy hurricane was also maintaining numerous channels, including, Facebook pages, Flickr, Google+, Tumblr, Twitter (in both English and Spanish), and YouTube. So, during natural disasters volunteers could share eye witnessed information directly online.

After a disaster occurs, many people need items, as food, drinking water and medical case and supplies. However, helping the affected population and providing basic supplies is a real challenge since the roads might be blocked or perhaps the area has not been mapped, as is often the case in developing countries like Haiti or Nepal. After earthquake in Nepal, the Kathmandu Living Labs (KLL) team, working together with the Humanitarian OpenStreetMap (OSM), started to coordinate mapping activities along with the OpenStreetMap community to provide detailed and accurate maps that could enable humanitarian organizations to locate people at risk and provide good and services to the areas that needed them most[7].

After examining the issues raised by all above mentioned authors, my concern is to propose all their statements as an appropriate challenging performance mentioned in each of calamity (Haiti 2010, Nepal 2015, Queensland 2010-2011 and US 2012) of my thesis work.

4 Crowdsourced data validation in aftermath of natural Disasters

Devastation and damages are basic consequences of any natural disaster. Where in the immediate aftermath of a disaster event, a sudden swell of data is created in the response: social media, media reporting, field reports, and other open-source information are quickly generated and made available for responders. At present time, the greatest challenge in disaster response intelligence is not data collection-however difficult this remains - but timely data processing and analysis.

So, this chapter discusses power of the crowd and methods of data validation and credibility check. Also, discussions are organized around research findings regarding different units of analysis, including individuals, groups and organizations, social networks, and communities. Although this chapter presumes primarily on research of crowdsourced data evaluation in post affected zones (2010 Haiti, 2015 Nepal, 2010-2011 Queensland and 2012 US).

4.1 Crowdsourced data generation

Without data, you're just another person
With an opinion.
Denis Coombes, Director of Sales, ROS Revolution[14]

Mobile technologies and social media have transformed the landscape of emergency management and disaster response by enabling disaster affected citizens to produce real time, local information on critical events. During and post disaster, responding organizations deal with severe uncertainties in making vital decisions. They need situational information (e.g., status of the civil, transportation etc.). Accuracy, timeliness and reliability of situational information help decision-makers make appropriate decisions as well as reduce deaths and injuries, prevent secondary disasters, economic losses, and social disruption. Crowdsourced data generation inherently requires a method for aggregating many small pieces of information into valid measures of our quantities of interest. As an alternative to utilize the army of people connected to the internet (via both wired and wireless technologies) and to empower them to be additional "boots on the ground" that can provide electronic reports, observations, pictures. T.Shelton et al. [67] report that people are turning to social media during times of crisis. A definition 'data shadows' of tweets reveals here, in Sandy hurricane analysis, which describes the imperfect representation of the world derived from the digital mediation of everyday life. Scholars conceptualize the importance of analysis of small subsets of big data, especially georeferenced social media information. Quantitative and qualitative analysis with further Territory-Place-Scale-Network (or TPSN) framework for understanding sociospatial relationships have been scope of

14 https://www.linkedin.com/in/denis-coombes-a3419461/

the study based on user-generated content. Hurricane Sandy defines in most recent examples the large volumes of user-generated data: “social media use during Hurricane Sandy produced a ‘haystack’ of half-a-million Instagram photos and 20 million tweets”, P.Meier [18]. During Haitian earthquake, Heinzelman with his colleagues introduced the deployment of Ushahidi platform, to produce maps, based on volunteer-driven information sharing, which is again a concern of user generated data. Which can be proved by creation of a free system of the number 4636, allowing people directly submit the alerts through their mobile phones aggregated in report of J.Heinzelman et al. [40]. Jing Guo also shows how individuals can come together on Ushahidi and OpenStreetMap platforms yet significant capacity of user led content creation online in 2010 Haiti quake response. During mapping process, volunteers who were responsible in evaluation of this maps proved to create not only new information, but also helped verify the existing geographic data. We have previously explored the idea that during a crisis, people are increasingly turning to the Web, mobile phones and social media to find emergency-related information such as when to evacuate, where to find shelters, how to locate emergency care, or how to find news about loved ones. Emergency service personnel are also using mobile device platforms to assess impact, coordinate response efforts across agencies and provide useful information to the public. Currently, maps and geospatial data are often at the heart of these technology trends and play a critical role in crisis preparedness and response.

The main flow of information in Nepal throughout the big crisis data making process was like i.e. from the affected online people, via the data processing volunteers, to the analysts and decision makers at formal organizations, but there were also smaller, two-way flows of information

between the different groups of actors in F.Mulder et al. [3] description. This constitutes an important difference in terms of the reliability of the data set and the potential of crowdsourcing initiatives to include local people. Another online blogging network introduces 'citizen generated data' definition, which means the following: 'citizen generated data is data that people or their organizations produce to directly monitor, demand or drive change on issues that affect them. It is actively given by citizens, providing direct representations of their perspectives and an alternative to datasets collected by governments or international institutions'. Hereby, OpenNepal[8] introduces several citizen generated data – including crowd-sourced mapping efforts, mobile phone apps generating data on various social issues, and community monitoring endeavors.

Lots of work has been done on extracting situational information through crowdsourcing, e.g., through analysis of content posted on online social media like Facebook and Twitter using data mining and natural language processing techniques. Haiti and Nepal quake as well as hurricane Sandy correlates not only in user generated categorization factor, but also key approach determined to geolocation aspect in building crisis map from incoming crowdsourced data.

4.2 Practical and potential use of Crowdsourced data

You can have data without information, but
You cannot have information without data.
Daniel Keys Moran[15]

When the world was brought closer through the Internet and social media, a powerful catalyst for information sharing was born. Crowdsourcing

15 https://en.wikipedia.org/wiki/Daniel_Keys_Moran

is a powerful tool as it can deliver a large set of data to work with to analyze a problem at a faster rate than any one person on his own. David Bratvold published in "DataInformed" the following definition: "You can use crowdsourcing to do big data analysis and you can use crowds to collect data". Crowdsourcing is a general term that describes the wider trend of curating many inputs from the crowd to generate valuable insights.

BIG DATA + CROWDSOURCING = A HAPPY COUPLE[16]

Crowdsourcing is an innovative approach in the age of big data as it improves distributed processing and big data analytics. Thanks to J.Howe, who has introduced the Crowdsourcing term in 2006 in Wired Magazine (in his article "The Rise of Crowdsourcing").

In industry of experts and researchers the crowdsourcing has been categorized by the following 4 variables, let me introduce them to you [13]:

- Crowdsourcing based on the type of labor performed;
- Crowdsourcing based on the motivation to participate;
- Crowdsourcing based on how applications function;
- Crowdsourcing based on the problems that crowdsourcing is trying to solve;

It's all about the crowd and the output they may contribute. In correlation of the above 4 variables, I made study of crowdsourced data in Nepal 2015 and Haiti 2010 quakes, Queensland of Australian 2010-2011 and Sandy od US 2012 in the next following chapters.

Basic analysis of my work is determined to data coming from crowdsourcing platforms submitted by the crowd. Due to quick propagation of information through information technology systems, it has proved to be

16 https://www.dezyre.com/article/big-data-vs-crowdsourcing-ventures-revolutionizing-business-processes/127

the proper way of data collection. The use of social networks as part of crowdsourcing operations constitutes a true opportunity for connection. Majority of data were spread through the volunteering groups of people, most of them were the local people of devastated areas, that showed their eagerness in assessment and help. In bunch of articles by various scholars, I didn't find any trace of peoples' interest in monetary reward for their performed relief work, on the contrary there was an existence of personal interest in acceleration of rescue works. Internet connection, mobile devices allowed to allocate the positioning of the places in need, sometimes even providing the data of latitude and longitude. Even though unlimited access to internet involved the help from outside of the destroyed countries, like some communities of people staying abroad, but originally coming from those places. The development of the Internet and of the ability to make exchanges regardless their physical location or even language barriers.

Moreover, OpenStreetMap, Twittering and SMS messages were common in use. Due to its affordability, flexibility, and quick accessibility by any human. In Haiti, Nepal, Queensland and US we observe their common use and implementation in further chapters.

Moreover, I would say that two-way information flow between locals and emergency response organizations, rapid sharing of the information was a result of cooperative work.

4.3 Platforms and Communities in Crowdsourcing

"… There is an immediate response that isn't just about individual altruism, there's a collective ethos that occurs during a disaster. And when they give, they're expecting a humanitarian act to take place. I think there's something there we can tap into because people don't want bad development, they want really good development.
Leonard Doyle [17]

Communication systems during disaster relief operations are crucial. Various natural disasters are in need for more effective systems to aid in warning and rescue operations. As it was presented in previous chapter, social media and other Internet-based communication technologies have become critical components of emergency response and recovery. When crisis occur, the platforms are exploited for many different purposes including: exchanging emergency warnings / alerts, seeking and disseminating event-related information. Social media platforms have been effectively used as venues for collective information gathering, raising awareness of volunteering, aid and support opportunities by population distributed across the globe. Considering disaster response aspects, people work to solve problems to leverage connective technology and human computation power to process information during mass disruption events. In some cases, self-deployed volunteers', appropriate available ICT attempt to contribute to response efforts. In others, technical volunteers have built systems to support the work of information processing during crises. Coordination of work via imposing community works and data acquisition of

17 https://www.iom.int/leonard-doyle

social media goes along together, providing an efficient or complete data output for rescue teams. Main idea of this chapter is about social media tools and applications implemented during the calamities of my study work and considerable impact of responsible communities or organizations have also been defined by a competent analysis.

4.3.1 Digital volunteering impact in Crowdsourcing

A life is not important except in the impact it has on other lives.
Jackie Robinson[18]

While we turn to an idea of volunteering and digital systems all seem so efficient and clear, but the idea of digital volunteering came alongside with the new capabilities of technologies starting from 20th century until now. Terrific importance which digital systems and applications impose during disasters is uncountable, but this all would never be efficient and complete without human impact and cooperation, we will talk about it in further chapter 4.5.4.

During and in aftermath of natural disasters, from various scholars' papers, I observed huge number of people, who is always eager to cooperate and help to citizens in need and it is not only about local people who is willing to cooperate and help, but it concerns remote volunteers as well. Therefore, now we may see the birth of 'digital volunteering' groups, no matter where people allocated, it is always bringing reliable and sometimes the only help needed during the calamity.

18 https://en.wikipedia.org/wiki/Jackie_Robinson

The public used media to contact family and friends, communicate problems and needs to emergency officials, and to provide information and show support to the affected communities. Virtual volunteering groups, such as Humanity Road in Hurricane Sandy, helped the on-line effort by aggregating information and key messages from many different sources in information verification. For example, Snopes.com used crowd-sourcing to discredit many fake photos and helped to correct rumors and misinformation in report of 'Department of Homeland Security' [26].

Over 2,000 tweets were sent from official New York City Twitter accounts, and at its peak, the city's official Facebook page reached over 300,000 individuals. Similarly, FEMA's Hurricane Sandy was viewed over 2.8 million times in two months, and the FEMA website had just under one million views in that same time [26]. Also, unprecedented, was the level of engagement and leveraging of capabilities that occurred between the emergency officials and the digital volunteer community. In many instances, digital volunteers acted as information resources, by searching for, aggregating, verifying, sharing and posting information on-line using social media tools like Twitter, Ushahidi, Sahana, blogs, websites, etc. These efforts were either directly supporting or complementing official response operations. Organizations like Humanity Road, National Voluntary Organizations Active in Disaster (NVOAD), Geeks Without Bounds (GWOB), Occupy Sandy, and the others, supported the relief effort by connecting information and resources to the affected community of Sandy. Additionally, the American Red Cross deployed previously trained and certified volunteers in relaying information to and from the public [26]. Although most of the digital volunteer organizations had established relationships with the official emergency management organizations prior to the storm, some were

established during response activities. The latter scenario posed some challenges, as the more specific volunteer groups were not familiar with the roles, responsibilities and manner of operations of the official responders, which resulted in friction and frustration for both sides [26].

The digital volunteering community used a wide variety of online tools during Sandy, most of which were free and open-source. The volunteer group Occupy Sandy, for example, used Sahana Eden software to track requests for assistance, follow work orders, etc. The group also maintained a WordPress site to push out information, connect individuals in need with resources, register and direct volunteers and to solicit donations.

Another common aspect of digital volunteers' contributions was displaying data geographically on maps, which is particularly helpful in disasters and geo-tagging social media data and that can enhance real-time situational awareness. During Sandy, several different volunteer groups helped to populate maps with information gathered through social media. Google's Crisis Map application was used extensively. One example was the 'Hurricane Sandy Communications Map', which displayed locations of available Wi-Fi connections in areas hit by Sandy, as well as telephone outages. The map was crowdsourced through people on the ground reporting locations and details of service. Another map, which developed by Hurricane Hackers New York City (NYC), showed aerial imagery of hurricane affected areas with an overlay of areas where recovery efforts were taking place [47]. J.Dugdale et al. [39] and [19] report that Haiti disaster marked a turning point of sorts in the domain of disaster response, because for the first time the affected population massively turned to mobile and online technologies, such as social media and SMS, to ask for help. Furthermore, thousands of people around the world responded to these calls

for help by relaying, aggregating, translating and transmitting these messages and therefore 'remotely' supporting the relief efforts. The humanitarian organizations and emergency responders became quickly overwhelmed with the volume of information coming in through various channels, and were ill-prepared to generate actionable knowledge from this massive flow of data. While digital volunteer community on the other hand, was much better prepared in dissemination of SMS and social media messages. However, at the time formal channels of communication between the digital volunteers and the humanitarian organizations did not exist and so in many instances the information produced by the digital volunteers intensified the information overload problem. In reverse to Haiti, Sandy case didn't experience such problem, the performance of work and interrelated cooperative coordination among responsible groups of people was demonstrated. On the other hand, when the digital volunteers did have established relationships with officials prior to the disaster, the information they produced was invaluable to the responders. One thing that became apparent during the response phase was that trust played a big role in relationship building. While there was willingness on the part of the digital volunteer community to participate in the official response, humanitarian staff on the ground was not as eager to include this new group into their operations, mostly because they couldn't be sure if the information supplied by the volunteers could be trusted [40]. When Sandy case performs the existence of volunteering groups, appeared during disaster, it provoked official responders to be skeptical to the provided outcome.

Despite the massive damage, many of the cell towers in Haiti remained operational following the earthquake, allowing Haitians to send hundreds of thousands of pleas for help via SMS to Twitter and Facebook. The most

prominent information management systems used during the Haiti disaster were Ushahidi, Sahana and the UN interagency One Response website. Moreover, we may see that social networks like Twitter, Sahana and Ushahidi revealed as common major platforms introduced during Sandy and Haitian Calamities. These volunteer platforms, created with open-source and mostly free software, not only augmented traditional information channels, but also became critical to effective disaster response by providing key geo-spatial situational awareness to the affected population as well as eventually the official responders. The response to the Haitian disaster also demonstrated the fact, that new technological opportunities (information technology) should not be introduced during active relief operations, but rather the human capabilities should be considered into pre-disaster planning, to create more efficient information flows, statement found in Disaster Relief 2.0 [40] report of Harvard Humanitarian Initiative. At the same time, some limitations of using these technologies became apparent including: information overload, widely varying speed of actionable information delivery and difficulty with processing information in various data standards represented by J.Dugdale et al. [39]. Furthermore, these systems lacked the ability to easily interface with the systems employed by many of the relief organizations both in Haiti and Sandy. Heinzelmen and Waters [19] released a report about useful data generation by the digital volunteer community through aggregating, analyzing, and mapping information coming in social media. Whereas, disaster-response system employed by relief actors in Haiti concentrated on enabling information-sharing among teams of responders from the international community. But this system lacked the ability to aggregate and prioritize data that came from

outside source, making it difficult to benefit from valuable information coming from the Haitian community.

This chapter reveals, that even with all the advances in technology, the predominant method of creating useful information still relies on people aggregation, analysis and processing the information to create useful intelligence within specific context. Digital volunteers played an instrumental role in the response to Haiti and Sandy. In Haiti presumably use of social media, social networking platforms, SMS, and open-source software, thousands of volunteers around the world the majority of them from the Haitian Diaspora-span into action to help the disaster-affected population in Port-au-Prince. Whereas Sandy in collaboration with FEMA internalized the importance of collaboration with emergent groups.

4.3.2 Role of social media in collaboration with Crowdsourcing.

Social media is not a media. The key is to listen, engage,
And build relationships.
David Alston[19]

The world has been a witness to the excessive growth and development of technology, from radio to television, to the invention of cellular phones, and to the continuous development of the internet. With these technological advancements, a lot of processes have been made easier and more accessible; this includes the communication process, which also develops and creates new media. The presence of the internet and social media enables people to

19 https://www.linkedin.com/in/davidalston/

update or get updates instantly regarding important events. Because of media, people can update or get updates with an internet-enabled device. Even news may spread through social media in just click of a button.

In this sub-chapter, I would like to introduce analysis based on scholars' contribution built on investigation of various social media networks and their collaborative work with organizations and authorities within 2015 Nepal and 2010-2011 Queensland catastrophes.

B.R.Lindsay [41] constitutes social media into two approaches, first when social media can be used somewhat passively to disseminate information and receive feedback via incoming messages, like Federal Emergency Management Agency (FEMA) have used social media. A second approach involves the systematic use of social media as emergency management tool. Both introduced approaches are the part of Nepal 2015 earthquake and Queensland 2010-2011 flooding.

Numerous research studies show that social media is used throughout the emergency management cycle to detect potential hazards, to gain situation awareness, to engage and mobilize local and government organizations, and to engage volunteers at the disaster recovery stage. Users of social media at disaster time include victims, volunteers, and relief groups [64].

Interrelation between victims, volunteers and relief groups are made throughout social media interaction. While victim and volunteering people provide a contribution to the crowdsourcing relation. Therefore, a cumulative work proceeds to an idea to extract data from various social media platforms relevant to a disaster in progress. Once the information like specific locations, street names and specific buildings affected by a disaster are extracted from social media platforms in collaborative assistance of

digital volunteering groups, the emergency responders at the command center can more effectively respond to the crisis. Depicting that, B.J.C.Malasig et al. [42] have made a research of impacts and role of Twitter during earthquake in Nepal through considering hashtag-message #NepalEarthquake submitted from worldwide, allowing them to examine Twitter use on a macro scale, including use inside and outside the area affected by the crisis. As a reason scholars perform their concern around limitation communication function of Twitter, whereas Nepal had less than 0.6 % of total global users and an estimation that there were only 100,000 Twitter users in the country, proving existence of major data acquisition from outside of Nepal. Nevertheless, even this allowed recognition of earthquake reflected problem of tweets for 100 % within three days after of earthquake, implying that people could easily access information through the media [4]. Scholars claim that blogs appeal to the youth as they offer an outlet for personal expressions and reflection, as well as way to communicate and connect with others. On the contrary, even though limitation in local data performance was not a drawback in data acquisition and dissemination. P.Dhungel [43] in his report claims many positive benefits executed during earthquake. He outlines many social media networks which role was from safety of people introduced by Facebook 'SafetyCheck' and Google's 'Person Finder' up Quakemap.org website, allowing people to report earthquake damage in real-time asking for required aid around the country. Social media was handy and useful for the crowdsourcing. Involvement of various Non-Governmental Organizations (NGOs) / International Non-Governmental Organizations (INGO) like Nepal Red Cross, United Nations (UN) Pulchowk Nepal, World Vision, Doctors without Borders (Medecins Sans Frontieres) contribution in rescue, relief and rehabilitations works was pointed out here.

Role of online websites for donation and volunteered groups of youth assistance for injured people were collaboratively prosecuted. D.Preiss [44] claims work of OpenStreetMap in compilation of relief map in assistance of Kathmandu Living Labs (KLL). As it was spoken at the beginning of this chapter, about huge contribution of worldwide aid on Twitter messaging, D.Preiss gives an example of Earthquake Relief Volunteers on a Facebook page created by an American PhD sociology at UC Boulder by involving volunteers from Nepal, US and Canada.

Despite any disaster either earthquake or flooding, all these disastrous cases extend to dramatic human losses, increase in displaced people and loss of certain basic needs on the ground.

Queensland state in Australia faced horrifying flooding occupying with a size of France and Germany, as it was presumed by A.Brunes [45]. In the article of Brunes “Towards Distributed Citizen Participation” terminology like ‘e-democracy’ introduced, which sustains active participation of citizens in the public discussions and in the organization of communal activities and initiatives to address such matters, through the use of online, digital media. The quality of such active participation in ‘e-democracy’, much like the quality of active user participation in any other online space, depends on the sustained presence of a substantial community of users [45]. A scholar operates the Australian and international mainstream media activity in Queensland flooding, like contribution of Facebook and Twitter, when in fact, Facebook was determined under Queensland Police Service (QPS) responsibility at @QPSmedia, where they had possibility to establish own advisories and news updates with messages automatically cross posted then to another social networking media Twitter. The QPS Facebook page became a key source of information and its popularity rapidly grew as the wet season

continued to impact the state. A.Brunes [45] reports that Facebook assisted these above mentioned organizations in disseminating environmental messages to the public due to its accessibility and high user interface.

Meanwhile, in Nepal and Queensland we see the involvement of volunteering users and Queensland disposed allegation of local volunteering groups contribution. Another aspect of coordination of flood response activities was an introduction of Google Maps addressing information on road closures or expected flood levels, whereas Nepal Google aimed at Person Finder online searching techniques. Indication of e-democracy approach is interlinked with importance of institutional sources during the event, along with @QPSmedia other prominently featured accounts of Austalian Broadcasting Corporation (ABS)' @abcnews, Brisbane newspaper @couriermail, breakfast TV show @sunriseon7, local ABC radio station @612brisbane, @7NewsBRISBANE, and the Brisbane City Council's @brisbanecityqld, inter alia committed their importance. We may recognize variety of social media networks witnessed by a scholar, from newspapers up to radio and even TV shows. More to say, Queensland major severe impact covered southeastern part of Australia with the state capital Brisbane many acronyms outlines Brisbane. Performance and crowdsourcing supplement of Nepal media comprised NGO and INGO, we meet it in P.Dhungel [66] article. Both quake in Nepal and floods in Queensland tweets were commonly coming from worldwide, providing macro scale opportunities, including use inside and outside the area affected by the crisis.

Besides D.Bird et al.[46] correlated some investigation on official sources and other social media roles for flood information in Queensland, where 74 % of responders stated the use of commonly Facebook, while Twitter combined only 6 % of responders who used it. Resemblance in both

flooding (Queensland) and earthquake (Nepal) disasters was – work process throughout broad-scale mobilization of social media accounts and everyday users' assistance. Only support of users – through retweets and other means of sharing and distributing information - provided these accounts with the social capital to guide and direct the overall community effort. Nepal response management unfortunately was limited in rural centers, while Queensland didn't pertain to this type of obstacles in aftermath. Moreover, I would like to highlight the fact that any crises attract the attention of several social media users which is why the dissemination of information regarding a certain crisis becomes faster and broader as it was explored in Nepal and Queensland examples above.

4.3.3 Platforms as a key unit of digital volunteering

The best way to find yourself is to lose
yourself in the service of others.
Mahatma Gandhi[20]

Recent advances on information technologies and communications, coupled with the onset of the social media applications have sustained a new landscape of emergency and disaster response systems by enabling affected citizens to generate real time information on critical events. As an extension of studies from previous chapters crowdsourcing makes emphasis on the resources of people to produce, aggregate, or filter original data, automatic tools make use of information retrieval technique to analyze publicly available information.

20 http://www.biography.com/people/mahatma-gandhi-9305898

New technologies were used to collect and organize data from multiple sources moments after disaster. Much of this work – including media tracking, geolocation, mapping, data cleaning, translation, and social – networks monitoring – was done as it was mentioned before by volunteers working groups from their homes and offices around the world. Establishing this interrelation between volunteering groups contribution and help of social networking platforms would be primary interest of this chapter, covering earthquake in Port-au-Prince of Haiti 2010 and hurricane Sandy 2012 of US.

The Haiti 2010 earthquake relief effort marks greatest volunteering effort; social media made this effort possible by providing new opportunities of communication and collaboration. As it was noted in previous chapter concerning digital volunteering, we have witnessed a big support from worldwide, whereas many foreign volunteers were involved in data collection and dissemination. Hereby I would like to emphasize their endeavor during Haiti earthquake.

Foreign volunteers contributed by developing computer programs and technology applications to assist the relief effort. Many of these programs helped enable the massive social media relief effort that proceeded according to K.Stardird [68]. Some other tools captured by M.Zook [5], particularly “We Have We Need” and HaitiVoiceNeeds [5] were conceived and developed by CrisisCamps volunteers specifically for application in Haiti, designed to make communication between distant individuals and groups more efficient. Ushahidi, a program originally designed to track election violence in Kenya, created *Haiti.Ushahidi.com*, a site that was responsible for tracking people, emergency incidents, and search and rescue options. Starbird mentions about SwiftRiver involvement

for WeHaveWeNeed platform which was facilitating data information filtering and classification. The maps created for this initiative rely on an open-source mapping program that depends on volunteers to provide geographical information. What make any disaster in aftermath exposed it's a high demand and need in maps, in the meantime M.Zook et al. [5] established that prior to the earthquake, the map of Haiti contained only major roads. A day after the quake, Port-au-Prince had been almost completely mapped by groups of remote volunteers, a task that normally would have required a great of time and money. These maps enabled people on the ground to more effectively provide relief, when and where it was needed. Digital volunteering contributed to the Haiti relief effort by participating in people locating projects as well. One example given by E.Harmon [47], the Haiti Earthquake Support Center project, which was created by "The Extraordinaries" – a micro work volunteer website – allowed volunteers to log online to match photos of missing persons in Haiti to pictures taken at relief centers. By doing this, friends and families of the missing individuals were alerted that the missing were safe. Individuals had possibility to post photos of missing relatives and friends, and other would post taken at relief centers. Volunteers had two primary tasks: to sort and tag these thousands of photos by age, gender, and other attributes to develop a missing person database, and to sift through this database to match missing persons with people photographed in relief centers. Beneficial aspect of the organization brought a development of an iPhone application, which allowed volunteers to work remotely from anywhere in the world. Another group of digital volunteers assisted the Haiti relief effort by participating in "crisis camps" technology community mentioned by M.Zook et al. [5], significantly groups that would do both activities, and analyze Twitter and other social

media sites for information from victims. Scholar outlines their responsibilities in responding to requests from relief teams on the ground in Haiti, looking up coordinates for building, finding directions, and answering other needs from people on the ground with limited technological access. These crisis camps set up command centers in major cities including Washington, Los Angeles, London, and Bogota [5]. Along with missing person finders and mapping systems, scholars recognize crisis relief centers as a significant contribution to the Haiti relief effort as an example of digital volunteering through the application of social media technology. Analysis and investigation of post disaster regions always consolidated with the establishment of crisis maps. Allocation of an appropriate road networks could much more facilitate works of rescue and support teams. Same recognition was happening in affected by Sandy Hurricane US states. Department of Homeland Security, Science and Technology [26] distinguishes impact of Disaster Tech lab, which was involved in the post-Sandy response effort with the members of the CrisisCommons organization, while in the case of Haiti CrisisCommon introduced platforms like WhatHaveWeNeed [38]. An outsource of this group was Hurricane Sandy Communication Map powered by Ushahidi platform, which comes in Haitian quake analysis as well. CrisisCommon performance concerned the request and effort on collecting and gathering information on various gas maps [26], due to high level of outage, while in Haiti M.Zook [5] doesn't mention this scope of work. When E.Harmon [47] establishes "Extraordinaries" photos matching group in Haiti, Sandy in similar way had common feature based volunteer organizations released in K.Kaminska [48] report, who were conducting to discredit many fake photos and helped to correct them. These advances have expedited the speed and effectiveness of response efforts

aiding in need. Although seldom seen on television footage of disaster stricken regions, these digital volunteers have provided a much-needed service to emergency managers and responders around the world, enhancing the information needed to improve the efficiency and effectiveness of the relief efforts. So, as it was observed from the perspectives of diverse scholars and researchers, utilizing virtual volunteers, who filled the gaps by staffing and budget cost (most of the volunteering groups were working with altruistic efforts).

Construction of clear perspective to the way how to examine efficiency of crowd work during mass disruption events, was based on numerous scientists' empirical theoretical research works. 2010 Haiti and 2012 Sandy disaster proved to show the value of digital volunteers' existence in response effort. And essential part, that in both case no matter what type of disaster attacks a country, there is always an existence of virtual volunteering groups providing real-time situational analysis to field teams by means of social networking platforms.

4.3.4 ICT technologies and the crowd

The new information technology… Internet and e-mail
Have practically eliminated the physical costs of communications.
Peter Drucker [21]

On the light of the above consideration the use of information and communication technologies (ICTs) in disaster management has been

21 http://www.drucker.institute/about-peter-f-drucker/

considered more and more seriously because of the potentials it has in anticipating, communicating and organizing actions before, during and after disaster events. Now more than ever, the wide and inexpensive variety of communication means and the diverse ways in which information is passed on, has helped in making to ensure the advantages of using technology. The advantage of technology in disaster could be held precisely by those whoever has access to it – whether it is the emergency responder or the first to witness a hazard strike – wherever he or she is. ICT, by themselves are not the solutions to disasters. Rather, they form an integral part of disaster management and acts as an enabler of communication flows and facilitator of coordination. ICT allowed to see how fast production of information to multiple audiences could be, depending upon the context-the exact moment at which requests for information are done in proximity to a disaster-changes in terms of magnitude, quantity and quality. This chapter's purpose is to assess the impact of ICT on the humanitarian sector (crowd), moreover the role of discourse between technology and crowd of Nepal 2015 and Haitian 2010 quakes.

In my further examinations of Nepal and Haiti calamities, they essentially perceived self-evident challenges of mobilizing information technology (IT) technical assistance. You would be able to uncover impact phenomenon of applications 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 assessment observed in Nepal and Haiti.

Online website TechChange evolved in Samita Thapa [49] article, determines huge impact and significant role on telecommunication systems like Skype, Viber and Google Voice, which allowed her and many more rest

of the people around Kathmandu to reach their families by free calls to mobile and landlines in the minutes of earthquake aftermath. This aspect is prerogative as soon as Nepal is related poor and low-income country, where any help and assistance with less financial involvement is more likely to succeed. Samita gives relatively good credits to drones which were facilitating and giving an overall picture of the devastated buildings and destroyed facilities from the air. A.R.Khanal [50] demonstrates an ad-hoc solution in terms of mobile base stations on a vehicle to increase the coverage and capacity of mobile devices. Ad-hoc installed devices facilitated feedback correlation in Haiti as well [5]. Role which ICT technical devices or applications played during rescue efforts has been promoted by S.Pandey [51], where role of mapping of affected area, crowdsourced incident reports and restoring family links were cogent. A student at the University of Sheffield Olivia Crane [52] made a research about ICT capabilities in Nepal as a key factor of Disaster Response. She has been analyzing urban and rural districts, signifying that rural people were more affected by the disaster and had only mobile connections to get in touch with their families or radio stations were a point of contact for dispersed workers, while urban people had more privileges of having volunteers, Facebook and other technological means. But unfortunately, B.Fung's post [53] evaluates that not everything was smooth and efficient during implementation of information technology, for instance free calls drawbacks, as it was witnessed by Alexander Thomas, who was among those who arrived to Nepal to establish emergency satellite connection in the hours after a humanitarian disaster. Thomas realized appearance of hackers and online criminals who tried to target humanitarian organizations and tried to get ahold of some of their sensitive data [53].

Appearance of fake and bogus data, activated UN members to introduce some minor monetary fees for certain types of applications, like Google Voice in Nepal. If we go back to Haitian case, we can see that privilege was given to mobile phones and their application, same privileges met in Nepalian case. Moreover, Nepal had more wide spread communication in urban areas, rather than in rural regions [54]. A cell phone text-messaging system was created to provide support to UN, Red Cross and other relief groups. Most common aspects of low-income countries were development of free toll messaging numbers, like Haitian #4636 and on the contrary Nepal had 'almost free' 1 cent per minute call #. Moreover, D.King [54] performs similar drawbacks of fraud SMS data including misinformation. Official language of Haiti is French Creole or Haitian Creole and Nepalese is Nepalian, thereby emerging language barriers and problems, since most of the volunteering groups were not native people. To resolve this, in the next chapter of my thesis work, topic of misinformation concern would be extended up to analysis of language deficiency and way of solving them. The reason why I have chosen and established to consider Haiti and Nepalian case, was that both countries are countries with low income, leading to concern that it may affect and provoke the involvement of external means or crowds to participate in relief effort. Consequently, all the works were provided in coordination and collaboration of abroad / international volunteering groups. Nearly all these groups created ad hoc processes for sharing information in response to emergencies.

By studying scholars works in Haiti and Nepal, I would like to outline that literacy level of Haitian and Nepalian population in adoption of mobile applications were well functioned, which has allowed to cover various recovery stages of people's needs. Whenever study case concerns developing

countries, we shall always understand the difference of rural and urban regions response, like it was in Haiti and Nepal where urban people were more developed rather than rural ones. Moreover, Haiti and Nepal relate to economically unstable and poor countries where formal language was not English, providing some additional problems of data inflow. Non-adequate information is always a headache and trouble maker for those who are in need and the ones who is eager to help. More about language barriers and ways of resolving occurring issues would be the topic in the last chapter (4.7).

4.4 Language barriers in non-English speaking countries

"Language is a tool for communicating and not a barrier to writing"
Bernard Kelvin Clive [22]

Language is the primary vehicle for communicating information that allows individuals to make informed decisions across all phases of a disaster. The effectiveness of educational disaster preparedness materials, emergency response trainings, emergency warnings, and post-disaster recovery services, are all contingent upon information being conveyed in a linguistically appropriate format.

Community and individual preparedness is a critical first step in mitigating the effects of disaster and enhancing community resilience, as it was mentioned already in previous chapter (4.6.1). Federal, state, and local authorities have invested substantial resources into training education, and preparedness campaigns to foster behaviors, such as stock as stockpiling resources and creating a disaster response plan. Encyclopedia of Disaster

22 https://bkc.name/bio/

Relief introduces the limited-English proficiency (LEP) acronym in United States including people like newly arrived immigrants, such as cultural isolation and low socioeconomic status, which further contribute to disaster vulnerability of these communities [60].

My further study would cover Haitian and Nepal cases with their native languages, specifically in distant rural regions, provoking challenges across the phases of response and recovery, as they face communication barriers with first responders and are often unaware of, or unable to obtain, post-disaster recovery aid because of dissemination of English-only information. Involvement of relevant responsible group of people, primarily remotely based volunteers in Haiti and volunteering translators in Nepal, while Nepalis themselves allowed to reduce the effects of LEP during these earthquakes. All these factors would be the case study of this sub-chapter.

So now, F.Mulder et al. [5] made a contrast evaluation of big data during disaster response, by comparing two earthquakes which hit Haiti in 2010 and Nepal 2015. Challenges concerning language issues were also part of scholars' research work. Haiti's formal language is French Creole, where IT application like free toll #4636 was responsible to provide incoming messages, while Nepalian formal language was called Nepali. As we can see, both cases had their own formal language. So, if we compare Haitian and Nepalian translation management process, we find that Nepal did not arrange any structured crowd of translators: information was either left untranslated, or was translated into English by digital humanitarians or affected people who were bilingual [5]. Mulder et al. [5] introduced communication loops between responsible parties in Figure 9 and Figure 10. As it was already mentioned above, we can see from those figures the red arrow indicating one way flow, which performs flow of data in Haiti from

volunteers to diaspora translating groups and not vice versa, whenever in Nepal we don't see any correlation or generation of translating groups, we can observe only volunteering groups who ought to generate feedback loops to locally based people [5].

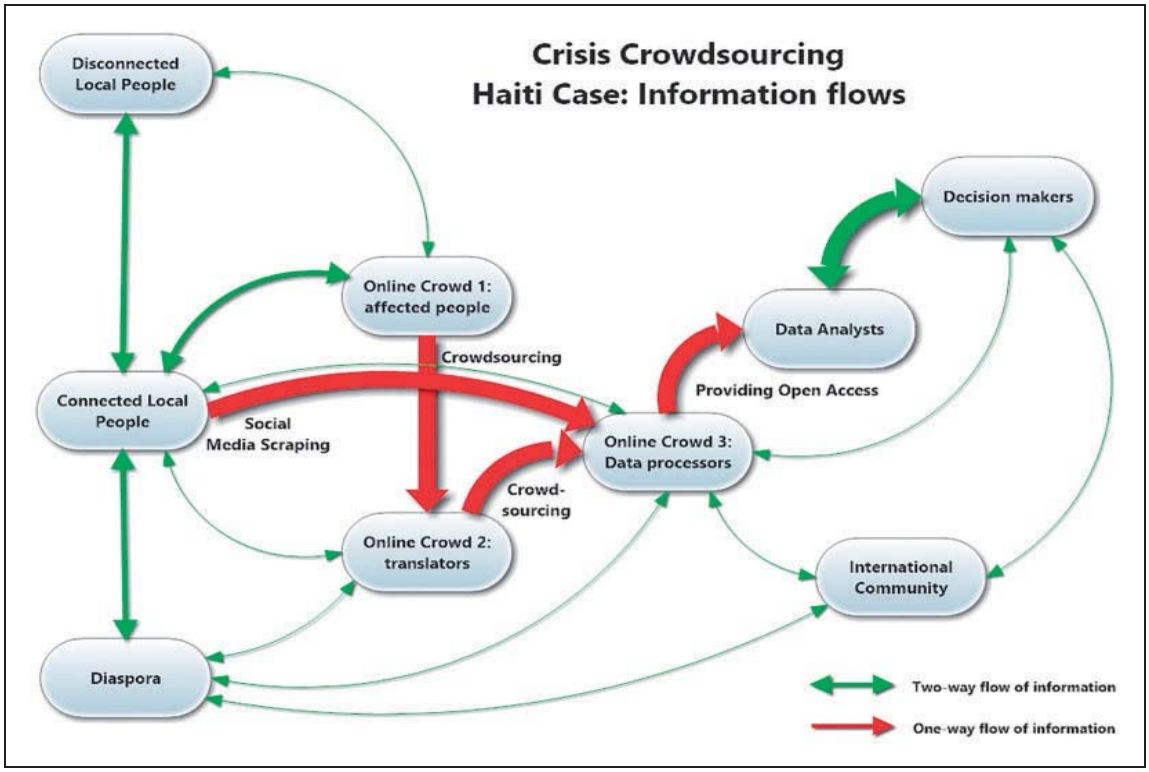

Figure 9 – Information flows in post-earthquake crisis data crowdsourcing Haiti 2010 [8]

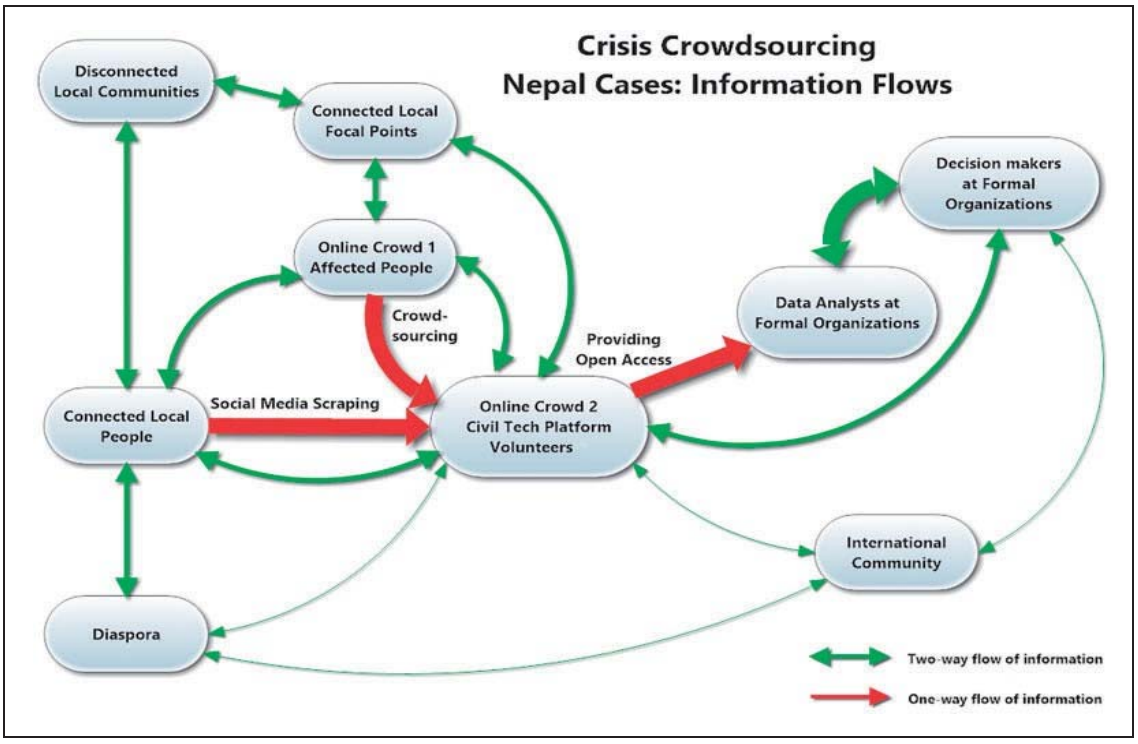

Figure 10 – Information flows on post-earthquake data crowdsourcing Nepal 2015 [8]

N.Waidyanatha [28] in evaluation of Nepal's Emergency communication systems mentions role of Translators without border and spontaneous diaspora volunteers once again. The availability of usable translations literally became a matter of life and death. As soon as post disaster events involves tremendous amount of information inflow through variety of social networks, so the scholars C.Hu et al. [61] operated some simulation scenario over Haitian Emergency SMS. In their research work, they have introduced an idea of *monolingual* crowdsourcing for translation, which has involved groups of people who know only the source or target language. Main concept of the analysis was to use a translation system MonoTrans2 that combines machine translation with human computation using two "crowds" of monolingual source (Haitian Creole) and target (English) speakers. Correspondence of an experiment, fluency and adequacy distribution was low; hence Google Translate between Haitian Creole and English was still in alpha phase.

We have already underlined that communication in the native language of those suffering from a disaster is crucial. For that reason, both developing countries released volunteering assistance with language translation and interpretation in providing aid. Some translation humor was making the rounds of the Internet a while back, for example: underneath a picture of an empty roll of toilet paper was the caption, "Translation is like toilet paper. No one thinks about it until they need it". I liked this caption, and I think it correlates with translation features provided by nonprofits. In *Accessible Translation Solutions* [62] magazine we define for ourselves implementation of Translation Without Borders (TWB) nonprofit organization in assistance with volunteering groups in Nepal. In another

magazine, *The Chronicle* an interpreter Lori Thicke [63] presents thousands of translators all over the world who wanted to help alleviate Haiti misery, further Translators without borders as a registered US based charity was used.

As a conclusion of this sub-chapter, we can outline that many of the language issues reduce the quality of data and minimize utilization of disaster relief services. International response to large-scale disasters or complex emergencies like Nepal and Haiti entailed aid workers that are unfamiliar with local languages. Due to insufficient time to train relief workers prior to their deployment, organizations Translators Without Borders were used to facilitate communication.

4.5 Crowd and data validation

Disasters occur every day in a myriad of settings and scales across the globe. One of the common characteristics uniting disasters (no matter if it is manmade or natural disaster), is the need to respond in effective and timely manner to certain responsible relief groups. Finding competent and sufficient assistance within community resources (groups), is also main concern of post disaster relief work. Community evolves into crowd of volunteering people, who is considered as the main part of the relief assisting groups. We can say that volunteers in disaster situations have potential to create linkages through involvement between professional response personnel and the impacted community. An important concern when assigning work to crowd workers with varying levels of ability and experience

is maintaining high-quality work output. In J.F.Lebrety et al. [14] article, the concept of crowd is stated as: “The word ‘crowd’ represents a coming together of any individuals, no matter the chances are that cause them together”. Typically, crowd is interpreted as a group of diverse people connected by some event. Beyond the differences between members of a crowd, a crowdsourcing operation may produce a feeling of ubiquity, since the crowd is everywhere.

While data is coming to disaster managers from within the impacted zone, data can also come from individuals across the world, as we could observe from discussion of previous chapters. This is true power of crowdsourcing; individuals coming together from across the globe, who possess different sets of skills and can work together to solve a complex problem quickly and efficiently. During the Haitian earthquake, volunteers from the United States and Canada translated reports from individuals impacted by the earthquake. This information was sent to another group of volunteers outside of Haiti who mapped trends such as lack of food, water, or electricity.

People want to help during a disaster and for all their good intentions, the truth is that sometimes the information they provide is inaccurate. This could be because the geo location provided is not accurate or because the information is delivered or analyzed hours or days late. Regardless of the reason, the information must be verified before it is acted upon and verification is an extremely time consuming process. However, before a resource can be dispatched, the information must be processed, otherwise valuable and potentially scarce resources will be wasted, diverted, or go unused [40].

My analysis is based on four countries like Nepal, Haiti, Australia and USA, selected from four disaster prone regions of developing and developed countries. The countries were selected as those with a high vulnerability and exposure to natural hazards and which were in various stages of their development.

Furthermore, involvement of improvements during the working process were a part of data verification stages. Moreover, people always try to cope with the selecting valuable resources among wide range of unreliable sources of information. Next sub-chapter offers overview of data validation throughout disasters analysis.

4.5.1 What is data validation of Crowdsourced Data?

The goal is to turn data into information,
And information into insight.
Carly Fiorina[23]

Aftermath of any natural disaster like earthquake, hurricane or flooding is always interlinked with certain affected group of people who suffer and rescue groups who eager to support and assist to them. Raise of appropriate maps for people in need occurs. Now on stage comes crowdsourcing, who's role is to collaborate works of volunteering groups on the ground, could provide an appropriate data for mapping issues and its further application in platforms for rescue team. As it was stated previously by C.Soresina [13], collective intelligence role implies its beneficial aspects here. While crowdsourcing method plays an active data collection aspect. Crowdsourcing

23 https://carlyfiorina.com/meet-carly

platforms are usually publicly available and are widely used by big crisis data practitioners.

Any disaster involves enormous amount of data flow coming from the volunteering groups. Need of proper validation skills are never so in demand as for this type of crises. Without good data validation, there could be a problem of delays of support for people in destroyed zones which may affect the increase of death tolls and deceases. Unstructured submitted content requires administration and checking for data quality. F.Cheon et al. [7] introduced the term social network analysis (SNA) as key technique in the social and behavioral sciences in analysis of tweets in Queensland 2010-2011 floods. Where, focus of SNA is based on the relationships among social entities (e.g. communications among members of a group) and it makes use a variety of statistical and visual analyses to achieve this.

Moreover, after data collected and transferred, the next steps are to validate and process data, and generate reports for further rescue teams' operation works. Data validation is defined as the inspection of all the collected data for completeness, and the elimination of erroneous values. Due to the shortage of time, data must be validated as soon as possible. Another implications of study of tweets in Sandy of US was proposed by J.A.Knox et al [69]. They intended to create an intermediate level of breadth of tweets and depth of analysis of the tweets, thus their approach merged both statistical analysis with informed qualitative impressions based on the personal reading of thousands of tweets making it efficient via software. The role of validation of data therefore is crucial, so then the goal comprises the detection of as many significant errors as possible.

Data validation process requires knowledge of the type of information to be validated, a person familiar with the field activities is usually assigned

to the data validation of field documents. For instance, hurricane Sandy occurred in US caused an appearance of tremendous amount of scums like fake images of the flooded parts of the city, which on the other hand takes precious time to be spent for data processing of real images. Similar way of rumor analysis was used in Queensland flooding. As a consequence of Haitian earthquake, missing data has caused information verification throughout asking the people who supervised this process, while in Nepal, veracity for the number of internally displaced people was performed in creation of certain quantity of tents for people who lost their houses.

So, as it can be seen, validation process has a valuable impact on data itself and simplifies its further application and processing.

4.5.2 Why do we need validation of Crowdsourced data

The logic of validation allows us to move
Between the two limits of dogmatism and skepticism.
Paul Ricoeur[24]

As it was mentioned in previous sub-chapter and witnessed from some examples, crowdsourcing in aftermath of natural disaster collides with an enormous amount of big data coming from volunteering groups all over the globe. Timely data validation and an appropriate coordination of information about people in need may way more increase the capacity of rescue team post disaster relief efforts. Consequently, out of reading articles and reports on natural disasters correlated with Haiti, Nepal, Queensland and US, I have created several categories, which allowed to provide an

24 https://plato.stanford.edu/entries/ricoeur/

overview to the nature and importance of validation of crowdsourced data during disaster aftermath:

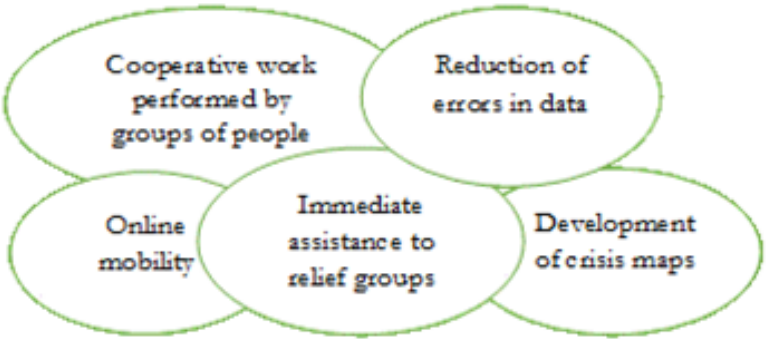

Figure 11 – Clouds of categories of beneficial aspects in validation

Besides, it was distinguished all these calamities prior role was creation of crisis maps with an appropriate indication of road networks of damaged regions. You may observe it from the studies made by L.Clark [1], where he distinguishes bunch of volunteering groups who could manage and build maps of landscapes within 48 hours in Nepal. Relevant works were done by other groups of volunteers in Haiti earthquake, whereas in P.Meier [4] article he identifies that for the case of Haiti there was more problematic way of map arrangements, due to poor mapping of the country itself, before the calamity occurrence. Data does not inflow only through one networking system, it may come as SMS text messages or messages from Twitter accounts, as it was common in Queensland and US. Whichever means of communications are used there is always an existence of errors and non-correct or even fake data combination. So, there is always demand and a way to clean and filter all unnecessary information to their further use. Cases in Queensland and US of Hurricane Sandy proves that. Hereby filtration of data throughout online rumor analysis was performed. All the aspects of inappropriate information

lead to data validation requirement. In Y.Kryvasheyeu et al. [30] perspective, where an importance of raw data filtration in Sandy included only those messages that contained geolocation information ('geo-tag'), but since only a minor amount of the tweet messages were geo-tagged, so scholars appreciated any attempt to extract this missing information from Tweet user profiles.

In all stages and senses crowdsourcing data contributed by presence of teamwork, whenever you are dealing with either natural or man-made calamity, where former one is the one of my study concern. On one hand, there are governmental associations responsible for coordination and management of people in need, on the other hand volunteering groups assist in data collection, allocation and transmission in combination with ICT applications and networking ones', capitalizing productivity growth.

All these collected estimates allow me to conclude the importance of data (information) and its validation itself.

4.5.3 The power of the crowd and intelligence of the experts

The intelligence of that creature known as a
Crowd is the square root of the number of people in it.
Terry Pratchett, Jingo[25]

It would be wrong to believe that in crowdsourcing there is nothing but the crowd. Alongside the crowd, there are the experts. By "expert", I mean in this case a person or group of designated as such by the organization, who

25 https://en.wikipedia.org/wiki/Terry_Pratchett

carries out the crowdsourcing operation. Expertise is a social status granted by public. In my case, the designated expert may be, for example, an independent team responsible for verifying the feasibility of a solution proposed by an individual in the crowd as part of crowdsourcing operation. While experts possess valuable experience and insights, they may also suffer from biases.

The benefit of crowds accrues from its diversity: it is typically the case that due to a phenomenon known as “the wisdom of the crowds”, the collective opinion of a group of diverse individuals is better what was defined by J.Surowiecki [22] in his book. M.N.K.Boulous et al. [21] report that crowds can be useful in disaster response in at least two different ways: firstly, crowdsourcing, in which disaster data is gathered from a broad set of users and locations, and secondly, crowdmapping, in which crowds help process and analyze the data so it may be effectively displayed and thereafter utilized. Surowiecki reports “wisdom of crowds” as the opinions insights, ideas, and knowledge of the “many” can be better than of a given expert. Suroweicki evolves four types of prerequisites to have a “wise” crowd, which are the following ones: 1) cognitive diversity, by which each individual has some private information; 2) independence, wherein each person’s opinion ordecision is not influenced by those around them; 3) decentralization, through which individuals can specialize and tap into local fonts of knowledge; 4) aggregation, which stresses the importance of structural mechanisms for translating many private opinions into a collective decision. In the following analysis of calamities, I have observed the common existence of prerequisites number one and number three.

Being specific, in Nepal case the bunch of university students and community groups, were taught how to collect the structural data for 2,256

schools and 350 health facilities in the capital of Nepal-Kathmandu. In A.Wiseman et al. [2] observations they suggest that even nonprofessional individuals can introduce their assistance and contributions of building the maps of the destroyed parts of lands, just by using the manuals (tutorials), already given on the webpage allowing us to monitor the cognitive diversity. Arrangement of the training videos for nonprofessional people, have given a good impact in producing the proper validated information of the mapped zones. Another bunch of example of decentralized and diverse crowd was provided in S.Heanue [23] report, where role of the public commonly was based on mobilization of young urban Nepalese wanting to help countrymen through the Quakemap.org website. Other than that, a local photojournalist has created an Instagram page with thousands of followers around the world, providing the posts which have included links to reliable aid organizations.

Analogous volunteering groups of students devoted their approach in assisting works of Haitian case. P.Meier [4] and his group of students of Fletcher School at Tufts university (US, Massachusetts) were working on building up of the crisis maps. Relatively almost all provided data involved diverse crowds (volunteering local people, Haitian Diaspora, graduate and undergraduate students). So, the credits to the tremendous work done should be given to any of the groups of people who has been involved in creation of crisis map through the translation skills of Haitian Diaspora, students of Fletcher School in working on Ushahidi Haiti Crisis Map building live maps with individual reports of needs, assistance of OpenStreetMap experts in detailed roadmap recreation.

An impressive work result of volunteers' hard work, can be seen from the words of gratitude, in the following brief excerpt from P. Meier article [4]

"...But it is YOUR data and YOUR work that is putting aid and assistance directly on the target and saving lives. Our big gap right now is locating NGOs and where they are working. Your site is helping with that. Keep up the good work!! You are making the biggest difference of anything I have seen out there in the open source world."

Furthermore, the efforts in Haiti were primarily led by remotely based volunteers with no personal links to Haitians, whereas the projects of Nepal, were initiated and led mostly by Nepalis. The incredible efforts following the Haiti earthquake demonstrated a huge potential for the future of humanitarian response. Student volunteers working online with the Diaspora using free mapping technology from Africa (Ushahidi platform) could help save lives in another thousands of km away without ever setting foot in said country.

Compared to the Haiti case, volunteers powering the online platforms in Nepal took on a far broader role: in addition to collecting and processing local crisis data, they also sought to generate feedback loops to locally based people, communicating directly with them about their needs and broadcasting directly with them about their needs and broadcasting information to them about the response - discovered by F.Mulder et al. [3]. Nepalian disaster could be outlined as in the case of Haiti by the presencef OpenStreetMap community to rapidly complete the maps of Nepal. The other factor was immediate creation of KLL (Kathmandu Living Labs) in Nepal, which was responsible for development of QuakeMap through Ushahidi platform. Moreover, they explicitly attempted to reach affected communities that were not online, for instance by sending volunteers into the communities or using low-tech collection methods. Furthermore, in contrast to Haiti, the Nepali initiatives did not draw on a separate crowd of

translators: information was either left untranslated, or was translated into English by digital humanitarians or affected people who were bilingual. In both countries of Haiti and Nepal online participation appears to be primarily determined by knowledge and skills, rather than by access to physical equipment.

At the same time during the Queensland floods more than 15,500 Twitter users participated using #qldfloods hashtags. Volunteering groups, as it was described in Nepal and Haiti also played a great role in Queensland flooding aftermath, where A.Gill et al. [24] state that the 2010 Haiti earthquake and 2010-11 Queensland flood performed the use of social media and supporting technology for real – time crowdsourcing of information from volunteers on the ground to build the overall ongoing operating picture of actual crisis conditions. During the early stages of flood event, as in the case of Haiti and Nepal earthquakes, the Australian Broadcasting Corporation (ABC) maintained an interactive map based on the Ushahidi crowdmap platform to gather information related to the Queensland floods 2010-2011. S.Koswatte et al. [70] found that scope of generated reports were distinguished by public and by ABC moderators (i.e. experts).

The fascinating thing for me is that even state police of Queensland were involved as a volunteering group community, by forming an online website in Facebook page, in other terms facilitating collaboration with online volunteers and getting online feedbacks introducing the so-called time management.

So, in this sub-chapter I wanted to unfold crowdsourcing as a combination and interconnection of cooperative, aggregative teamwork of groups of people, i.e. volunteer communities. I want to specify, that groups

of people (volunteers) could outperform individual experts, as outsiders could bring fresh insights to internal problems.

Meanwhile analyzing abovementioned calamities, the factor which was observed by me was that even if people were geographically dispersed around the globe, it did not impede the working process of creation a credible and adequate crisis map.

4.5.4 Responsible groups of people in data collection

The price of greatness is responsibility.
Winston S.Churchill [26]

When disaster strikes, access to information is as important as access to food and water. The vast volume of crisis information generated and consumed during emergencies are in increasingly digital and user-generated as we have seen it in chapter (4.3).

Indeed, in previous sub-chapter we reported that affected populations are increasingly able to source, share and generate a vast amount of real-time information, which is transforming the humanitarian information landscape. We note that humanitarian organizations are also adopting geospatial and mobile technologies such as smartphones for rapid digital data collection, allowing them to rapidly collect structured and geo-referenced data in multiple formats, such as text, image, video and voice. And so, while humanitarian organizations typically face a vacuum of information following sudden-onset disasters with limited situational awareness that

26 http://www.biography.com/people/winston-churchill-9248164

could only be filled by humanitarian on the ground or via established news organizations, one of the major challenges today is colossal volume of big data produced by affected communities themselves. Disaster affected populations have always self-organized in times of crisis regardless of external intervention. Humanitarian professionals, after all, cannot be everywhere at the same time; but the "crowd" is always there.

I must emphasize that in all introduced calamities of Nepal, Haiti, and US performance was established by the digital volunteering groups. But contribution of experts shall be distinguished as well. In answering the broad question of how the crowd helps to convert information overload into useful resources during disaster, I aim to improve our understanding of both how and why these efforts "work".

Fusion of non-authoritative and authoritative groups in Sandy flooding has played major role in establishing spatial and temporal data for the rescue assessment teams in citation of E.Schnebele et al. [25]. Scholars claim that the collaborative work is very much in need in the case of fast and prompt actions to be done. The scholars investigated that by using multiple data sources, flood and damage details not captured by one source can be provided by another. Spatial data was generated by non-authoritative groups (Civil Air Patrol) including Crisis Mappers and OpenStreetMaps, while the temporal data was contributed by authoritative ones (FEMA). Main purpose of them were creation of a road damage map. There were many other mapping initiatives involving multiple partners, nonprofit organizations, and volunteers, visualizing of data upon studies of Homeland Security [26]. Organizations like FEMA, CrisisCommons, The Maryland Emergency Management Agency (MEMA), Civil Air Patrol Damage Assessment and

many more could be distinguished as a part of collaborative work in development of crowdmaps of Hurricane Sandy.

The digital disaster response to the 2010 Haiti earthquake signaled the coming of a new force in the humanitarian space. Volunteering groups from The Fletcher School at Tufts University launched a live crisis map that detailed some of the damage and resulting needs following the earthquake prescribed by P.Meier [4]. Mirroring technique of Sandy Hurricane, volunteers from Humanitarian OpenStreetMap community used satellite imagery to create the most detailed street map of Haiti as well. Moreover, the administration of the UN FEMA and the US Marine Corps even claimed that the live crisis map of Haiti helped them save hundreds of lives.

Extreme dedication and participation in helping to people in needs in Haiti, where organized by digital volunteering group work 24/7, allowing to provide major individual reports on Ushahidi Haiti Crisis Map. The collaborative model used by OSM enabled individual volunteers, mapping experts, and international actors to update the map of Haiti rapidly and accurately to assist responders on the ground. Organizations such as World Bank, GeoEye, and the U.S. government were critical in providing base geographic information to the Yahoo maps that OSM originally imported. Communities and organizations like Crisis Mappers international community of experts, skilled volunteers engaged at the intersection of humanitarian crises, new technology, crowdsourcing, and crisis mapping, non-authoritative organizations Sahana Community, Volunteers from Fletcher School and Humanity Road organization were all part of humanitarian response to Haitian tragedy.

We should also mention that Nepalian landscape is allocated above tectonic plates, which in terms may trigger flashes of quakes in various parts

of the country, while the most the earthquake-affected population lives in remote villages in mountain areas near the Tibetan border with severe seasonal weather. Kathmandu quake evolved groups of digital volunteers who supported data collection assistance. A.Wiseman et al. [2] surveyed that most of the works were arranged in collaboration system with university students and community groups of people. In Mo Hamza's [27] report Kathmandu Living Labs (KLL) through its primary OpenStreetMap volunteers allowed people to contribute to maps of their neighborhoods. As in the case of Haiti, Nepalian catastrophic situation was supported by non-governmental organization of Humanity Road and MicroMappers from N.Waidyanatha [28] observation. Another volunteering organization of real-time crisis mapping Standby Task Force launched the remotely supported volunteering groups of people.

Variation of different organizations as a case of responsible groups of people, who has assisted in humanitarian response effort did not vary in their working factors. Cases of Haiti 2010, Nepal 2015 demonstrated coinciding communities like OSM and MicroMappers, many other platforms maintained fair enough resultant work. These groups use available online tools to respond to disaster events all over the world, thus these platforms did facilitate information-sharing behaviors that impacted response efforts.

My study lied in understanding impact and role of responsive people, where humanitarian groups and volunteering team are hand to hand assembled tools to cooperate with crowdsourcing applications

4.5.5 Methods of analysis of Crowdsourced Data

There is no such thing as failure.
There are only results.
Tony Robbins[27]

Natural disasters present a constant threat to society. Information flow during catastrophic events is a critical aspect of disaster management. Modern communication platforms, online social networks, provide an opportunity to study such flows. Conveniently, online social media, like Twitter and Facebook, have matured into prominent. Enormous number of messages as an outcome of Twitter has led to evolution and creation of "sentiment analysis". Where "sentiment analysis" is (a sentiment classification, opinion mining, subjectively analysis, polarity classification, affect analysis, etc.) in the multidisciplinary field of study that deals with analyzing people's sentiments, attitudes, emotions and opinions about different events and topics and so on defined in an article by G.Beigi et al. [31]. In other words, sentiment analysis deals with expressions of emotions in texts, so it could help to detect people in danger during crisis analysis [32]. That's why it was so important to investigate sentiment analysis for disaster relief which on the same stage would assist in accommodation of the task of disaster management.

Investigation part represented by Y.Kryshavesheyeu et al. [30] determined sentiment analysis by classifying the messages as positive, neutral and negative ones. An analysis of sentiment sensing technique was applied to the United States (Hurricane Sandy) in the period of October 21 and November

27 https://en.wikipedia.org/wiki/Tony_Robbins

7. Where all messages were aggregated hourly and the average sentiment was calculated to obtain a spatio-temporal evolution of density and sentiment of

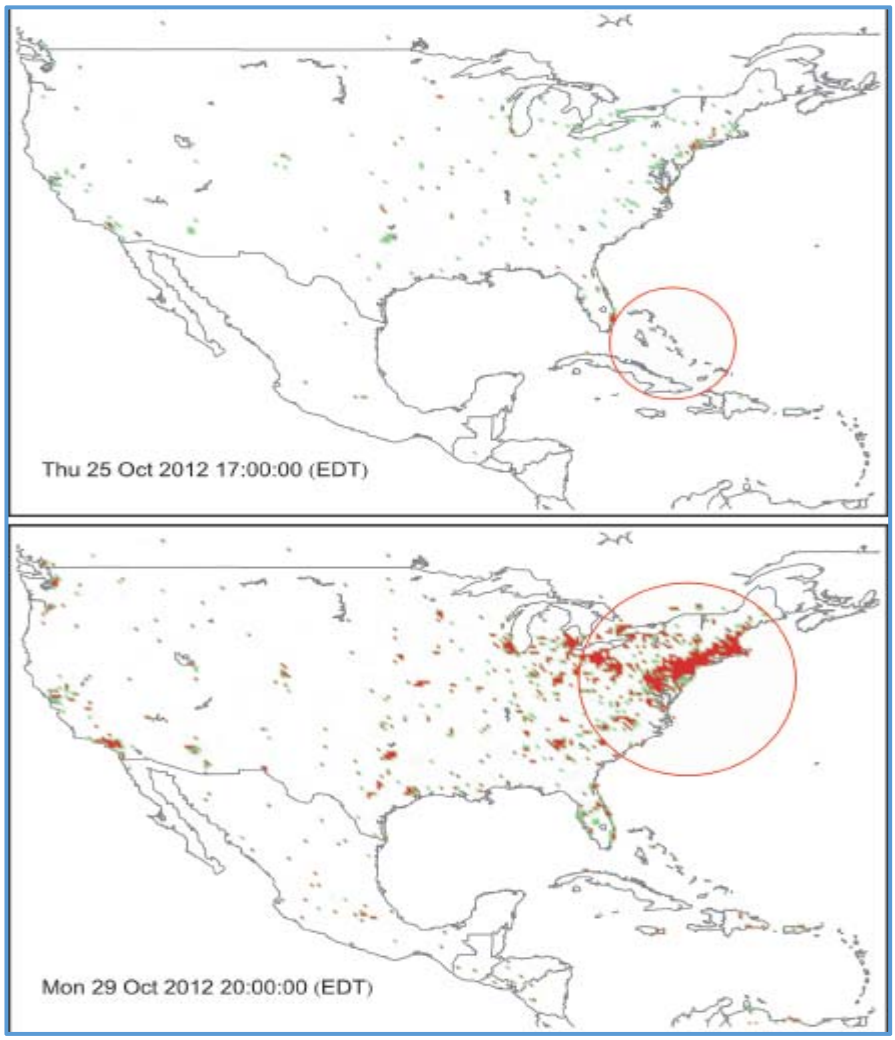

Figure 12 - Comparison of density and sentiment for messages posted during an hour-long period at 17:00 EDT October 25 (top) and 20:00 EDT October 29 (bottom). The polarity of sentiment is highlighted by green (positive average sentiment) or red (negative average sentiment). The density of messages is represented by the transparency of the color, where more solid shading indicates higher activity. At the early stage (top panel), prevalent sentiment is either neutral or positive, and the interest in the hurricane is comparatively low, except for the Miami area. Close to the landing time (bottom) the activity increases and the sentiment in the area affected by the hurricane is overwhelmingly negative. Unaffected regions remain neutral or positive [30]

tweets. Figure 12 shows an overview of sentiment and density comparison of the messages during an hour-long period illustrating 2 snapshot evolved

before and after hurricane has stood up. In correlations with the sentiment analysis, scholars contributed that the upper snapshot had low activity and sentiment was mostly neutral or positive, while the bottom snapshot determines the increase in activity and sentiment in affected area was overwhelmingly negative. At this point following analysis demonstrated that affected regions had rather neutral reaction, except for the major urban centers. C.Caragea et al. [33] also proved that extracting sentiments during a disaster could help responders develop stronger situational awareness of the disaster zone itself. As an evidence of the work, Figure 12 reveals the hemispheric shifts in Twitter use during Sandy's development, landfall and dissipation as in Figure 11. We can observe the similarities in propagations of the tweets with the hurricane propagation along the coast. As a result, scholars also claim that use of social media in disaster management scenarios as individuals are much more likely facilitate to share information via Twitter about a disaster and where it is occurring

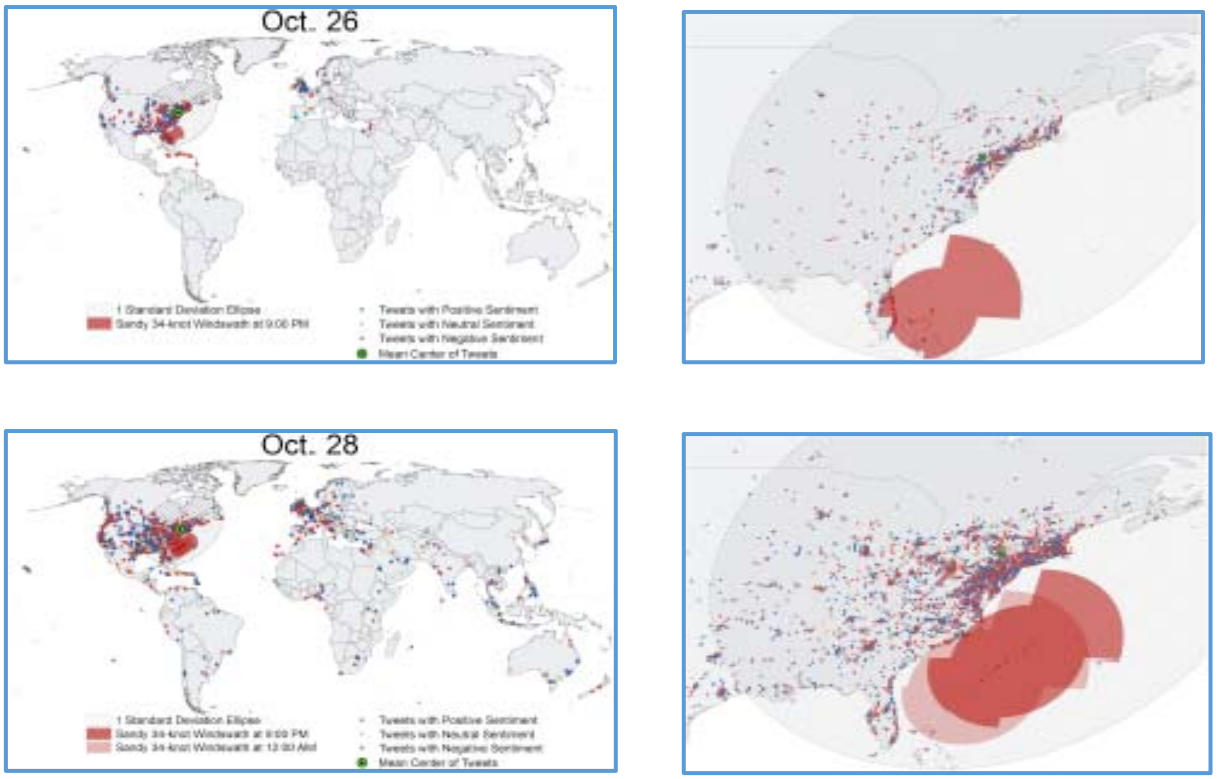

Figure 13 - Maps of Positive, Neutral, and Negative Tweets at global and regional scale. The varying size and position of the standard deviational ellipse and mean center, respectively, are consistent with clustering measures. Maps are shown in the Robinson projection. All distance calculations are done in an azimuthal equidistant projection centered on Sandy's landfall point [33]

If in the case of Hurricane Sandy sentiment analysis went through the tweets, then on the contrary Haiti earthquake emerged by classification of SMS data collected through 4636 free toll number in J.Heinzelman et al. [19] represented work. They claim that “sentiment analysis”, might serve to help assess conflict potential. For example, all the collected SMS data was sent in March to the European Commission’s Joint Research Center (JRC) for analysis. The center identified approximately 100 words and frequently used word combinations that were categorized as either positive or negative and cross-referenced them with the data to conduct a sentiment analysis. When in Sandy case (Figure 13), is known for the use of geographic representations

and cluster measures to examine spatial and temporal variation of Twitter data with respect to the hurricane is released in the original paper of C.Caragea et al. [33]. For further analysis, Patrick Meier [34] evaluates a graph in Figure 14 of sentiment reflected in the SMS data in Haiti, where it can be outlined by the increase during disaster of Sandy, where sentiment reflected SMS covers data between January 17th and February 5th. Moreover, scholar established that this kind of sentiment analysis can be done in real-time. Incidentally, the lowest point on this graph is associated with the date of January 21. The data reveals that a major aftershock took place that day. There were subsequent reports of trauma, food/water shortages, casualties, need for medication, etc., which drive the sentiment analysis scores down. Aligning with this view, Meier claims that deployment where SMS becomes the principle source to communicate with disaster affected populations, using this kind of approach may eventually provide an overall score for how the humanitarian community is doing. So, in both cases, we could say that sentiment analysis has the potential to track changes in emotion at a societal level, nevertheless of the source and type of crowdsourced data was maintained.

I can now outline, that scholars applied a Sentiment Analysis system for the methods of analysis of crowdsourced data to a set of tweets and SMS covering the period of Sandy hurricane and Haitian quake. As an outcome of sentiment analysis, scholars have revealed that positive tweets are not particularly useful in this type of analysis and they can be discarded so far, while a more fine-grained classification on the negative tweets may help to distinguish different kind of negative feeling, for instance fear.

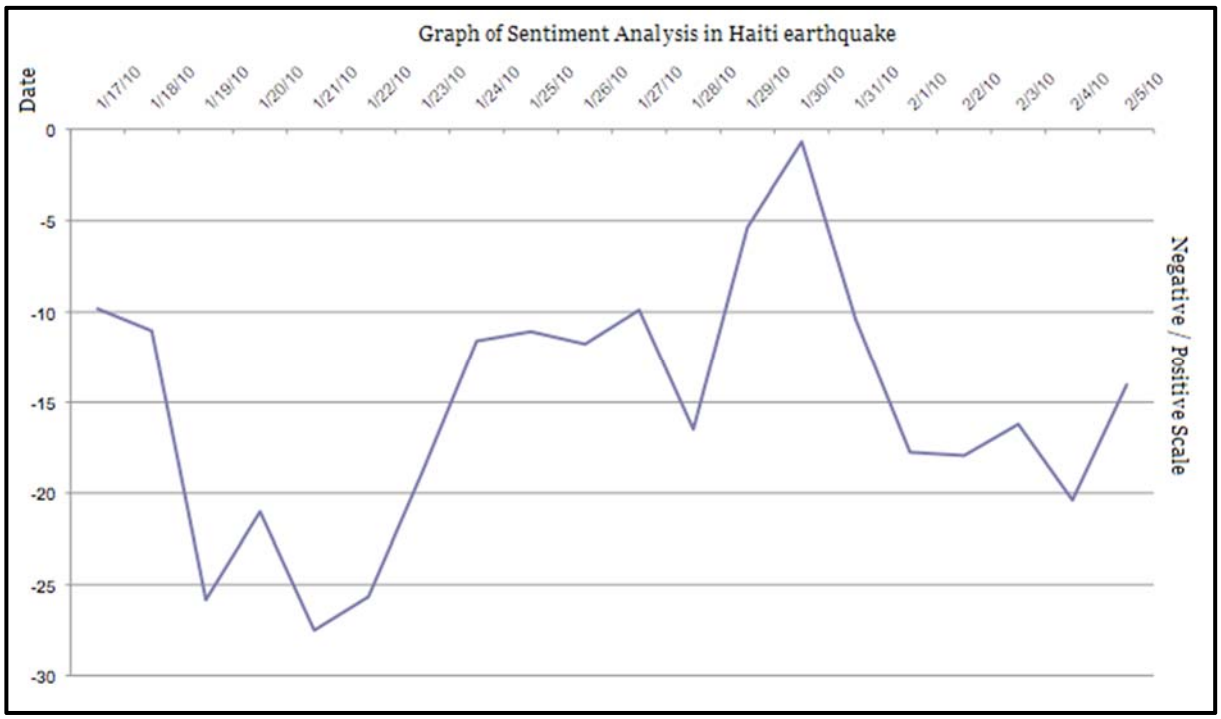

Figure 14 – Sentiment Analysis of Haiti SMS's [34]

4.5.6 Data credibility and its quality in mass disruption period

There are lies, damned lies and statistics.
Mark Twain[28]

Veracity of social media data is also a huge issue for those trying to use that information during mass disruption events. The problem of data veracity addresses the need to verify humanitarian / crisis data, so that the credibility of data sources is established and humanitarian efforts are not

28 http://www.biography.com/people/mark-twain-9512564

wasted through the spreading of incorrect or old information. In the social media space, the circulation and reposting of information over time can cause outdated information to appear as current, and rumors to spread quickly, often accidentally reposted by credible accounts. Hence verification and validation are important since it has been noted that citizens tend to exaggerate under pressure of extreme stressful conditions. Hoaxes are so common in the virtual environment, especially in the mainstream news.

The need for appropriate data for disaster mitigation and prevention has been an increasing concern of both development and response agencies. My analysis based on US 2012, Australia 2010-2011 and Haiti 2010 as three disaster prone regions of the world. Social media and various networks work has evolved major role in data collection and processing. Data itself comes from many sources of networks, which allows people around the globe to get involved in data transition from local audience to authoritative representatives. Significant role of true data, or I would say ground based real data is much important for relief groups on time support. Unfortunately, many of the disasters and calamites all over the globe are always exposed to poor data spread or even though fake and false ones to be propagated. Modern and ad hoc technology has provided huge assistance in data processing works and data filtration. In further US, Australia and Haitian cases I would like to investigate the approaches which were arranged for data validation process, due to tremendous data inflow from everywhere. Major networks of data inflow were Twitter, an online news and social networking service where users could post and interact messages. In their article A.Mukkala et al. [35] highlight the need of data preprocessing stages due to variety of noises and non-English tweets occurrence. Pre-processing stage of the data evolves following three stages: in the first stage software like

Tableau (a business analytics and visualization software) has been used to get an overview of how tweets were distributed over the covered period, at the beginning stage, 11 million of tweets were analyzed by authors. At the second stage of data processing the number of tweets drastically shrunk to 68,000 tweets as soon as the author's only interest was about the ones which were in English by narrowing them only to the affected area of Hurricane Sandy along the US east coast. So, now after final third stage of manual screening of the tweets, where all non-hurricane related data was excluded (advertisements, spam tweets, tweets that had mentioned hurricane but were not related to hurricane Sandy etc.), further actions went through the content analysis of the preprocessed remaining 68,000 tweets throughout of qualitative analysis. Authors manually conducted to screen the tweets with relevant information, which resulted in 677 identified tweets. Subsequently, those 677 geo-located tweets with relevant information were further analyzed by the following coding scheme. Coding schemes introduced two of them, where former one divided data into original and secondary one into information source categories. While latter one consisted of four major categories on the nature of messages: information messages, action-related, opinion-related and emotion-related. Now due to these new coding schemes, it was more feasible to analyze a tweet along the two dimensions: information source and nature of message. After all, coding manipulations has been done, the results from the analysis were checked by linguistic expert from the research group. Several stages of preprocessing, coding and filtration of data, allowed the data to be more clear and efficient to its further application.

Classification of tweets were based on the source of information it was coming from, whether it is original or secondary source, additionally the

content of the message and the links included in the tweets were also considered as a part of classification of tweets. “Original source” included the content of a message which contained first hand observations and experiences. Verification was done through cross-verification of URL or a link, by checking the person who created the tweet and the creator of the link itself. All other cases, the tweets classified as a “secondary source” tweet. The analysis of scholars distinguished that 75% of the tweets were original ones, while 25% belong to the secondary tweet category.

Author like Y.Kryvasheyeu et al. [30] demonstrated analysis of tweets in Sandy by categorizing them into two principal sets of Twitter messages. First, involvement of messages with the hashtag “#sandy” posted between October 15 and November 12 were collected, while the second dataset had a similar structure and was collected within the same timeframe; however instead of a hashtag, it included all messages that contained one or more instances of specific keywords, deemed to be relevant to the event and its consequences (“sandy”, “hurricane”, “storm”, “superstorm”, “flooding”, “blackout”, “gas”, “power”, “weather”, “climate”, etc.). So, these datasets were obtained through analytics company Topsy Labs. If previous sub-chapter 4.5.6 performs the importance of sentiment analysis of tweets and SMS data, then in this section Y.Kryvasheyeu et al. [30] try to consider the needs of content analysis due to variety of noises accumulated during data collection process. To eliminate noise from the datasets, only messages with a word “sandy”, either in a hashtag or keywords form, were included in the analysis. Filtration of the messages was performed in classifying them into: *without filtering, moderate filtering* (words include “sandy”, “storm”, “hurricane”, “huracan”, “superstorm” and “Frankenstorm”), and *strict filtering* (“sandy”). Out of this filtration classes the authors came to the point

that only the *strict filtering* succeeded in suppressing noise messages prior to the formation of the hurricane. Similar way of data filtering was introduced by J.A.Knox et al. [58], while MySQL[9] database used PHP[10] to accomplish this analysis, work program TweetReview was built. We may witness quantitative and qualitative analysis extended through sorting tweets as relevant (pertaining to Superstorm Sandy) or irrelevant (not referring to Superstorm Sandy). As it was publicized by [30], similar way of data filtration could be observed here as well. A set of filter words were created and plugged into program to help determine the relevance of the numerous tweets (Table 1).

Now if we consider Australian flooding, where data tracking and processing was established by *yourTwapperkeeper*, where detailed data-set of tweets was a key target of A.Brunes et al. [8]. Approach involved focus on tweets which contained the relevant hashtag (or hashtags) related to the crisis, so for the Queensland 2010-2011 floods, where following #qldfloods

was a key concern (with additional, and sometimes overlapping discussion also taking place using #thebigwet and other minor hashtags). Solution for

number	Filter words	number	Filter words
1	"red cross" or redcross"	23	"#nysandy"
2	"#sandy" if either"springs" or "beach" is not present	24	"ny1sandy"
3	"#hurricanesandy" or "#hurricainesandy"	25	"#nycsandy"
4	"hurricane sandy"	26	"#masandy"
5	"jersey shore"	27	"#vasandy"
6	"#njsandy"	28	"#mdsandy"
7	"hurricane death megation"	29	"#vtsandy"
8	"sandy aftermathpocalypse"	30	"#tosandy"
9	"halloweenpocalypse"	31	"#6abssandy"
10	"#postsandy"	32	"#lifeaftersandy"
11	"#aftersandy"	33	"storm sandy"
12	"#fucksandy"	34	If the tweet contains both "Sandy" and "Katrina"
13	"#fuckyousandy"	35	If the tweet contains both "Sandy" and "Irene"
14	"#fusandy"	36	"#thankshurricanesandy"
15	"#fusandy"	37	"#thankssandy"
16	"fuck sandy"	38	"#thanksyousandy"
17	"fuck you sandy"	39	"#damnyousandy"
18	"#ctsandy"	40	"#damnitsandy"
19	"#bptsandy"	41	"post-sandy"
20	"#nhsandy"	42	"post-sandy"
21	"dcsandy"	43	"#frankenstorm"
22	"#wvsandy"	44	"superstorm"

Table 1 – Filter words used in TweetRiver software to narrow the database to the most relevant posts [69]

tracking hashtags and other keywords on Twitter was presented as I mentioned before by open-source tool *yourTwapperkeeper*, which had an ability to capture #hashtag or keywords tweets allowing requesters specific terms to be tracked and then generated comprehensive archives of captured tweets which then was downloaded in a variety of formats. Formats like comma-separated values (CSV) was most common in use in Queensland destroyed area. Further actions involved building of PHP and MySQL, what we have met already in the case of Sandy [71], followed by drawing Twitter's

Application Interface (API)[11] to retrieve data set collection of hashtags (or other keywords).

Stages like content analysis introduced in Sandy case by A.Mukkala et al. [35], could be found in Queensland case either. A.Brunes et al. demonstrated qualitative analysis of content of #qldflood tweets by determining two approaches: first each twentieth tweet were selected and second all tweets sent or replied to Queensland Police Service Media Unit account @QPSMedia were selected for their further analysis. These two sets of tweets were then coded for the presence of specific content types. Authors have introduced five major categories like Information, Media Sharing, Help and Fundraising, Direct Experience, and Discussion and Reaction (Table 2). Which allows to get more appropriate and relevant data through sifting received ones by means of categorization filtration scheme.

Another example reveals data collection of Haitian quake, started from collections of hash-tagged message including #haitiearthquake between January 12th 2010 to January 21st 2010. Since, major mainstream social network data dissemination was considered as Twitter (Sandy, Queensland and Haitian cases), due to its efficiency and speed O.Oh et al. [10] introduce content analysis of tweets through manual coding scheme. As long as, native speaking language of Haitians was not English as it was in Sandy of US and Queensland of Australia, terms like collection of English language tweets was a major difference between these three calamities. For this reason, scholars outline three extensive hash-keywords more often made in English: #HaitiEarthquake, #HaitiQuake and #HaitiHelp. Further data was identified by content types of tweet posts through Rumor Interaction Analysis Systems (RIAS), as a part of a coding scheme. Which included

fourteen categories of communication modes: prudent, authenticating, interrogatory, belief, disbelief, directive, and uncodable (Table 3).

Several challenges were met in the case of Hurricane Sandy, where work exposed content analysis of tweets, which were based on URL and link check, while in Queensland content analysis scholars introduced an approach of Rumor Interaction Analysis technique.

It is difficult to emphasize, which technique is way better and which is not.

Type	Category	Assignment	Example
Advice	Information	Tweets that provide information about what to do (e.g. during evacuations), safety tips, and how best to act to streamline the relief and recovery process.	Advice for drivers stranded Wittcorr#thebigwet#qldfloods http://fb.me/yq1Ot405
Situational awareness		Tweets that provide information about the locations of floods, road closures, areas to avoid, and other risks. Includes maps and other visualisations. Specific, tailored information for locals. Includes information about rescue, response and recovery from a service-oriented angle, and reports on this process from official sources. Pertains to information from official sources.	RT@seqincidents:**EMERGENCY RED MESSAGE** 7M Wall of Water to come down Lockyer Creek within 10 minutes. ALL PERSONS SHOULD EVACUATE AREA NOW. #qldfloods
Request for information		Where individuals ask questions about the current situation or about specifics, such as looking for particular individuals, postings about lost dogs, etc. Includes requests from MSM for content or interview.	are CBD hotesl safe? With power? #qldfloods
News Media	Media sharing	Media updates, news reports, press releases and press conferences. Includes both links to other sources and headline-like	Sydney: 'Inland tsunami' devastates Queensland towns http://bit.ly/f36OHX#qld
Multimedia		Links to photo galleries, videos and images of the flooding	RT@rowangbrand: This is INSANE. Cars floating down the rapids http://bit.ly/qQySIX#TOOWOOMBA#qldFLOODS
Help	Help and Fundraising	Tips for how to help as well as requests for help, volunteers, etc. Both from official sources or individuals.	RT@ftfloods: Anyone who needs help with cleanups should post on http://fightthefloods.com there's over 150 people ready to help #qldfloods
Fundraising		Requests for donations, invitations to fundraising events, deals with help to raise money for the floods, announcements of donations.	RT@mintie: You can give a donation to #qldfloods when you pay for your groceries at Woolies. Money goes to the Salvo's appeal and is tax deductible.
Personal Narrative and Eyewitness Reports	Direct Experience	Includes tweets about direct, personal experience of the floods and eyewitness on the ground of events as they happen.	Just returned from Coles & picking D up & I must say the creeks in The Gap area are filling up pretty darn quickly O.o#qldfloods#thebigwet
Adjunctive Discussion	Reactions and Discussion	Use of the event in question to spark off other discussions about e.g. environmental politics or the performance of the federal government	@JuliaGillard and @TheQldPremier (Anna Bligh) suspend the #NBN and give that $1b to help QLD rebuild! #QLDFLOODS
Personal Reaction		Expression of reaction to the events as they unfold. Pertains to people who are responding to information about the event.	Total Chaos. Never thought I would see this in Toowoomba. Http://t.co./LP77d4w #qldfloods#thebigwet Lucky not 2 B driving home at this time.
Thanks		Expressions of thanks and appreciation to particular actors for their role during the flood crisis. Includes referrals and recommendations to Twitter users to follow particular official users.	RT@nicmclachlan: I am jaw-dropping awe of the fire and rescue guys (& girls) working in the #qldfloods#justsaying
Support		Expressions of support toward those affected by the event	thoughts go out to those who have fallen victim to the floods, in some way. And you're cats. #Qldflods
Meta-discussion		Discussions on Twitter and in the media about the significance of social media and its role in crisis response	This sounds stupid but it kind of feels important to be on Twiter today. #qldfloods

Table 2 - Coding categories [8]

Sandy, Queensland and Haitian cases distinguished that credibility factor mainly was up to experienced scientists or qualified authoritative peoples' responsibility, where they had a choice to decide which of the approach in data filtration is more reliant and suitable. Moreover, all the techniques were either manually or automatically processed, which is a part of analysis of the next sub-chapter.

Category	Definition
Emotional Statements	Emotional charged expression that includes both postive or negative feelings
	Ex) "My soul is deeply sad"
Authenticating Statements	"Those that express the person's attempt to add credence to what he or she is saying. Thus, citing news media as source, reference to self as an expert on something" (Bordia 1996, p.90)
	Ex) "CNN reporting a further 2 aftershocks in Haiti 5.9 and 5.5"
Interrogatory Statements	"Questions seeking information. This category does not include sarcastic remarks or persuation attempts" (Bordia 1996, p.90).
	Ex) "which relief agencies donate ait to re: #haitiearthquake? Red Cross?"
Prudent disclaimer statement	"Cautionary statements usually used to qualify what follows as being 'hearsay'. They can be thought of as quarded attempts at avoiding responsibility for what is being sad" (Bordia 1996, p.89)
	Ex)"I have no idea if it's true or not"
Disbelief statements	"Those that believe that the person does not believe in in the rumor" (Bordia 196, p.96)
	Ex) "That's far-fetched..."
Belief statements	"Those that indicate that the person believe in the rumor"
	"yes it is indeed...#haitiearthquake"
Work statement	Statements that "suggest a course of action." (Bordia and DiFranzo, 2004, p.42).
	Ex) "Please RT to help the victims of today's earthquake."
Not Codable	Statements that are not codable

Table 3 -coding scheme [10]

4.5.7 Human and Machine computation

Lately I've been working to convince myself
That everything is a computation.
Rudy Rucker [29]

The social web created fundamental shift in disaster response. Allowing emergency managers, government agencies, and aid organizations to combine their expertise with real-time input data from the public. As of today, most of us are not ready to collect, respond or react to this incoming social data in a timely manner. The use of publicly available data in times or places of crisis raises issues of authenticity, privacy and veracity. Response to this challenge requires the collective input of government agencies, first responders, technology companies, public safety officials and the public.

During analyzing various research reports and articles of recent years, I witnessed hybrid solutions approach, combining human computing and machine intelligence in data processing and validation operation. With humans and experts, the bottleneck is human nature (which is fickle, humans can get bored and make mistakes). Human computation has been defined as "a paradigm for utilizing human processing power to solve problems that computers cannot yet solve"[12]. Application of human computation in the crisis realm, is to recruit and utilize remote crowd workers. This approach is found in Haiti Earthquake aftermath, in conjunction with Mission #4636 and the Ushahidi crowdmap [40], where translation of SMS messages from affected individuals to the language of responders was performed. Machines, on the other hand, do not suffer from boredom and can work on menial algorithmic tasks with high throughput and no error. Machines

29 https://en.wikiquote.org/wiki/Rudy_Rucker

can utilize well-crafted algorithms for various problems, whose solutions can be exactly defined step by step. However, for many problems, the machine learning approach – which is based on learning from data – is appropriate.

In humanitarian technologies, there is a need to combine the wisdom of the crowd with the efficiency and automation of artificial intelligence and machine learning. Machine learning is especially important since it can lead to automated processing and extracting useful information from big crisis data. The most potent approach to big crisis data is to leverage both human and machine intelligence. Crowd are better at finding patterns, while machines can process faster than humans (and even crowds). Quinn and Bederson [68] have proposed "hybrid human-machine computation" as an extension of the emergent field of human computation.

In this sub-chapter, machine computational approach was only related to data processing technique as an additional contribution to the main human working efforts.

Let me go through analysis data of processing evolved in Nepal and Haitian earthquakes. P.Gupta et al. [36] article outlines study of tweet messages in Nepal quake, hereby performing machine learning techniques. This technique includes learning Subjective and Objective sentences, executed by a Rule-based method. The rule-based subjective classifier categorizes a sentence as a subjective if it includes two or more strong subjective clues. They use Subjective Precision, Subjective Recall, Subjective F measure, Objective Precision, Objective Recall and Objective F[30] measure for the analysis. Gupta and his colleagues focus his attention on sentence level, to examine whether the sentences are objective or subjective and to categorize the polarity (the state of having two opposite or contradictory tendencies, opinions, or aspects) of the sentences to positive or negative

30 http://www.kdnuggets.com/2017/04/10-free-must-read-books-machine-learning-data-science.html

sentiment. This categorization includes positive and negative sentiments to the category of opinion analysis approach. Figure 15 [36] shows the procedure used in order to identify opinions from twitter in calamity situation of Nepal. As you can observe from this figure, it is conducted in 8 levels which are as follows: Data Collection, Data processing, Data Analysis, Model Creation, Feature extraction and reduction, Training and model evaluation further concludes into Classification Results in data storage.

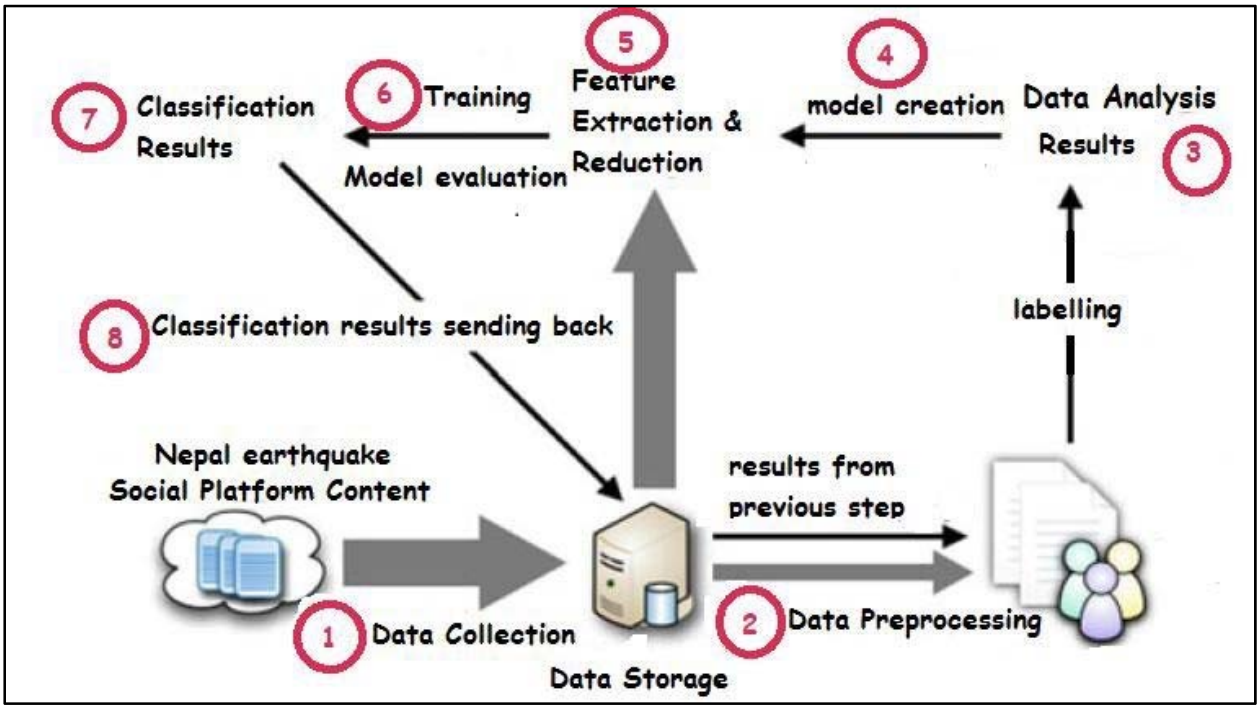

Figure 15- Procedure for Opinion Analysis for Tweets in Nepal [36]

Based on Gupta's and other scholars [36] research work, let me establish a brief overview of roles of each of these processing stages of twitters covering Nepalian earthquake.

1) Data Collection. In this level data is gathered from social platform i.e. Twitter for the duration of 2 months by using twitter Application program interface using hashtags #earthquake, #nepal and #nepal earthquake. 10,000 tweets were gathered from which 3,000 were found to be impertinent. Therefore, only 7,000 tweets were taken into consideration
2) Data Pre-Processing. In this level the gathered data is pre-processed as it includes vast amount of irrelevant data which is in the form of misspelling, repetition of alphabets, slang words etc. in order to make it consistent & eliminate the irrelevant words which do not impact any opinion in the drafted text. The Nepal earthquake dataset also includes huge tweets which are in Hindi i.e. translated into English by using Google Translate API. So, following steps are taken in order to pre-process the dataset:
   a) In order to make the data set consistent all the tweets are transformed into lower case.
   b) All twitter user names and internet addresses mentioned in the twitter tweets are substituted with a constant string.
   c) All Hash tags are eliminated that is all #words are substituted with word, e.g. #Nepal earthquake are substituted with Nepalearthquakes.
   d) All irrelevant white spaces, punctuations, special symbols and alpha-numeric characters are eliminated.
   e) Common Stop words are eliminated.
   f) All the repeating characters mentioned in a word are eliminated. E.g. verrry is substituted with very.

3) Data Analysis. In this level the pre-processed data is further labeled with three major emotion classes: positive, neutral & negative
4) Model Creation. A prototype is designed which is a fusion of N gram and stemming technique (machine learning algorithms).Feature Extraction and Reduction. For attribute reduction String to word vector filter is utilized that is to elect a subset of important attributes to be utilized for prototype construction.
5) Model evaluation and Training. We can see that 90% of tweets are utilized as training data set, while only rest 10% are utilized as testing dataset.
6) Classifiers. Bagging classifier, is one of the ensemble techniques which are used to enhance the accuracy of the system.
7) Classifications Outcomes. As an outcome, Gupta et al. determine that Bagging outperforms best by using Multinomial Naïve Bayes classifier with overall accuracy.

In the study case of Haiti, C.Caragea et al. [11] developed a reusable information technology infrastructure, called Enhanced Messaging for the Emergency Response Sector (EMERSE). The components of EMERSE are: 1) an iPhone application; 2) a Twitter crawler component; 3) machine translation and 4) automatic message classification. While each component is important in itself and deserves a detailed analysis, Caragea with his colleagues focus on the automatic classification component, which allowed to classify and aggregate tweets and text messages about the Haiti disaster relief, so that they can be easily accessed by non-governmental organizations, relief workers, people in Haiti, and their friends and families. The EMERSE system architecture is presented in Figure 16.

Now let us move to the component of our main interest-the automatic classification component of Haitian calamity.

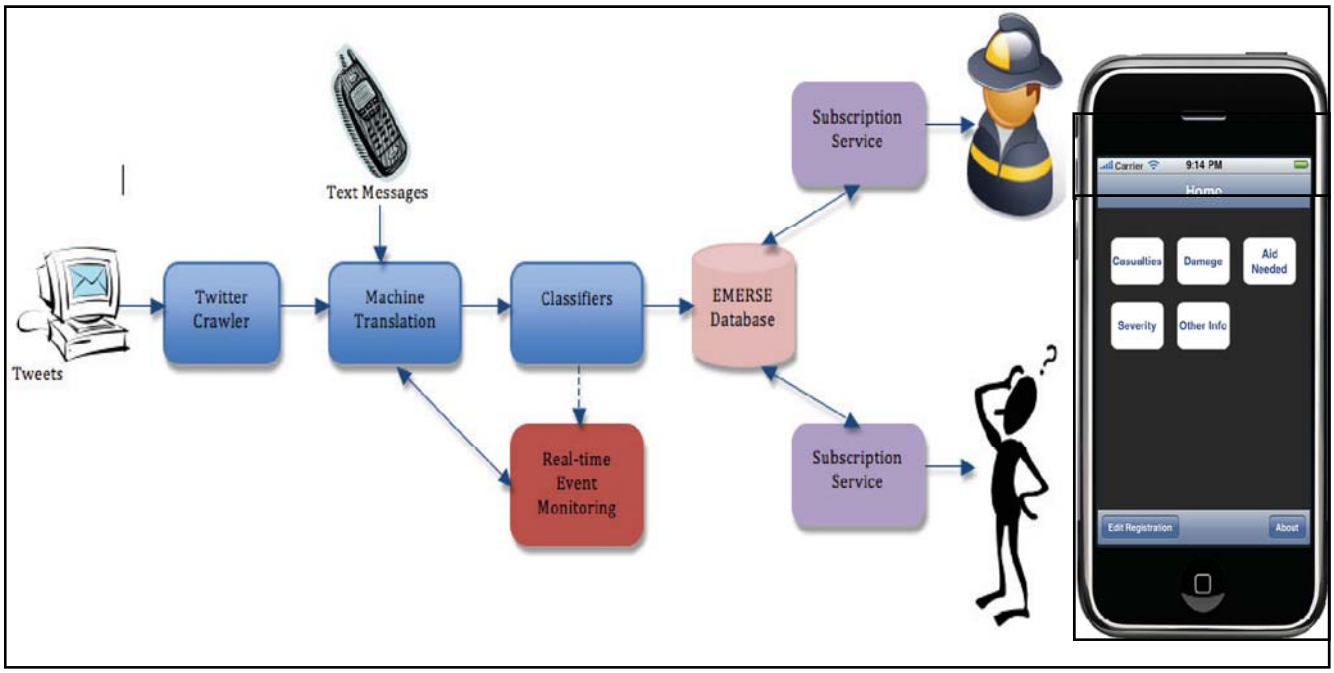

Figure 16 – EMERSE Architecture and the Iphone Application in Haiti [11]

Scholars described four methods, which particularly produce feature representations that are used as input to machine learning algorithms: (1) the bag of words (BoW) approach; (2) feature abstraction; (3) feature selection and (4) Latent Dirichlet Allocation (LDA). The reason why scholars chose these four methods was that they were successfully used for text document modelling and classification. Whereas the (1) BoW approach is commonly used for text classification; (2) feature abstraction methods reduce a model size by grouping 'similar' features into clusters of features; (3) feature selection methods attempt to remove irrelevant or redundant

features in order to improve classification performance; and (4) LDA are designed to discover clusters of semantically related words that co-occur in a collection of documents. It shall be mentioned here, that Ushahidi text message was considered for automatic classification components. Moreover, two different ways for performing classification were introduced: classification by keywords and classification by Support Vector Machine (SVM), which is a machine learning algorithm. Classification by keywords identified a set of keywords as follows: the words were sorted from the vocabulary based on their frequency of occurrences in the messages. Classification by SVM was designed to explore what feature representations of short text messages, result in best classification performance. To enable learning SVM classifiers on the Ushahidi text messages data set, four types of feature representations were introduced:

- A bag of words representation, stemming and removing stop words, and words with document frequency less than 3 (i.e., words that occur in less than 3 messages).
- A bag of *m* words chosen in using the Relief feature selection method.
- A bag of *m* abstractions, where m-size partition of the vocabulary obtained by grouping words into m abstract terms based on the similarity between the class distribution that they induce.
- A bag of *m* topic words output by LDA.

So, now we may say that twitter, as a networking source, has become important for real time and understanding of the need and concern of affected people in Haiti and Nepal earthquakes'. Scholars introduced various methods, in order to solve problem of data analysis of two earthquakes, but it is very complex to declare which method will give optimal results as every method has its own advantages and disadvantages. Exploring the

relationship between human and machine based computation, we get an understanding of interlinking mutual collaborative work of people (human) and machine learning technique, where the capacity of outperforming work in need of urgent response and data allocation cannot compete with human automatic capabilities.

This sub-chapter performs a complementary approach to the computational solutions recently put forward by P.Gupta et al. [36] and C.Garagea et al.[11]. Evidence of 2010 Haiti and 2015 Nepal earthquakes suggest that machine learning classifiers will need training and re-training across event types and event stages, therefore output of machine algorithms will need human validation and interpretation to be suitable for decision-making in safety critical situations.

Conclusion

As the world gets connected with technology in rushing speed, the opportunity for crowdsourcing also rises. This thesis work explored the role of crowdsourcing through the analysis of data during natural calamities, i.e. 2010 Haiti and 2015 Nepal earthquakes, 2010-2010 Queensland flooding in Australia and 2012 Hurricane Sandy in United States. Data quality is a vital issue. Validation of crowdsourced data have been the major concern of this thesis.

From a practical perspective, data validation approaches, as means for filling data/information gaps, do not just contribute, but also accomplish the Relief Effort Goals in post disaster work. Hence when resources are scarce, crowdsourcing or citizen science data is better than no data at all, as nobody should remain invisible for policy and decision makers. 2015 Nepalian post-quake calamity introduced such knowledge of the local crowd, originated from those suffered regions being a good alternative in data collection and validation process. Where more specific information could contribute more clear data as a part of crowdsourcing and citizen science.

Role and impact of digital volunteering groups in assistance if tracking, geolocating, mapping, mapping, data cleaning, translation and social networks monitoring was an evidence of 2010 Port-au-Prince quake of 2010 Haiti and 2012 Sandy of US. Witnesses of ICT benefits have been met in all four calamities of my thesis. Qualitative adaptation of various information communication technologies in post-disaster calamities, proved to play major role in communication and data collection, further providing the adequate data processing through IT applications. Major influence of ICT

applications were met in Nepal and Haiti, revealing a great importance of technologies in poor and low-income countries, rather than in 2010-2011 Queensland and 2012 US states. Through theoretical and empirical analysis, scholars outlined that various information technology techniques permitted to resolve data accuracy problems.

Variation of data translation techniques in non-English speaking countries like Nepal and Haiti allows me to presume that the aspects like language barriers shall be investigated in pre-disaster management works. Because enormous amount of data inflow is always a triggering aspect of fake and false information development. Which more frequently met in post-hurricane Sandy. Another interesting way of data validation involved human and machine computation techniques. Here, data validation revealed some variations in terms of approaches and methods. Correlation of variations were met in Nepalian and Haitian cases, where machine computation assets played the role of additional assisting and helping approach, rather than main approach of data evaluation, while human computation was given more priority.

My thesis work was dedicated to analyze the role which crowdsourcing plays in data validation process of devastating natural calamities. On the light of scholars' investigation, I would like to presume that preference should be granted to wisdom of the crowd - in collection, processing and evaluation stages of post disaster events.

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