Understanding the Gap between the United Nations World Food Programme Crisis Mapping Operations and Crowdsourcing Technology

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Abstract

There is increasing pressure from the crisis mapping community for United Nations agencies to adopt crowdsourcing technology as part of existing United Nations crisis mapping, emergency response operations. Whilst United Nations agencies such as the World Food Programme are in support of crowdsourcing initiatives, it is imperative that the technology be assessed before it can be adopted as part of the existing crisis mapping operations. It is frequently argued in theoretical scientific papers that during a crisis situation, the limitations associated with crowdsourcing technology are outweighed by the benefits of its use. However, it can also be argued that in crisis mapping operations, crowdsourcing technology is not of sufficient maturity at present to provide adequate benefits. To understand the capability of crowdsourcing technology for crisis mapping, this was tested by evaluating a number of existing crowdsourced applications. Results of this research indicate that crowdsourcing technology is in its infancy and current applications do not meet the expectations required by the World Food Programmes' crisis mapping operations.

1 Introduction

It has been estimated that by 2050 the number of people affected by crisis events will rise to 2 billion (Aten 2011, pp. 16-20). With this in mind new and emerging technologies such as crowdsourcing must be well understood by the World Food Programme (WFP) for crisis response. Whilst there is increasing pressure from the crisis mapping community for WFP to adopt crowdsourcing technology, the technology can only be adopted if it is of benefit to crisis mapping operations. Assessment based purely from a theoretical scientific perspective, determines that despite numerous limitations associated with implementing this technology, the benefits surpass these limitations when used in support of crisis response (Goodchild & Glennon 2010, pp. 231-241). However, in practice the hypothesis that crowdsourcing technology currently available in the crisis mapping arena is of benefit to existing United Nations (UN) World Food Programme (WFP) crisis mapping operations, needs to be explored. Therefore this hypothesis was tested through a research project. Within this paper the investigation of existing crowdsourcing technology applied to recent crisis events is presented. The degree of benefit associated with the application of crowdsourcing technology to current WFP crisis mapping operations, was determined by evaluating against an identified set of criteria representing the data requirements of these operations.

1.1 Crowdsourcing the geovisualisation production process during emergency response

The term crowdsourcing can be described as 'giving a task for a crowd to execute, instead of executing it oneself' (Vivacqua & Borges 2011, pp. 189-198) suggesting that crowdsourcing is a 'further development of outsourcing' (Hirth, Hoßfeld, & Tran-Gia 2012, n.p.). Within this paper the term crowdsourcing in relation to crisis mapping refers to the outsourcing of geospatial tasks to a large crowd of citizens and volunteers in the production of a geovisualisation. This research is focused on crowdsourcing the Geovisualisation Production Process (GPP), a process commonly used for crisis mapping operations such as those used within WFP. The GPP can be broken

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down into four stages involving the data: generation, acquisition, processing and publication. During a crisis situation where time is of a premium, all or some of the GPP stages may be crowdsourced by a large crowd rather than be completed by a small team of professionals.

Crowdsourcing for Emergency Response (ER) can be described as the outsourcing of GPP tasks to volunteers and citizens located either in the affected area or at a location anywhere in the world. The volunteers and citizens are recruited by publicising the crowdsourcing needs via an appeal on social networking and internet sites. During the ER to a crisis situation large volumes of crisis data are generated. Geovisualisation and web mapping provide a rich environment to manage and aggregate data and allow user communities to collaborate (Li, Veenendaal & Dragićević 2011). This is especially important at a time when maintaining strong communication channels, between ER officials, volunteers and citizens within the crisis affected area, is 'extremely difficult'(Aten 2011, pp. 16-20).

Through the completion of a literature review as part of this research, a number of technological benefits and limitations were identified. The theoretical benefits associated with crowdsourcing technology for crisis mapping situations include achieving success in a small amount of time, reduced costs to perform geovisualisation tasks, being able to harvest local knowledge and permitting acquisition of collaborative knowledge. There were also several theoretical technological limitations discovered including; positional and attribute accuracy limitations, large volumes of data or big data issues and limitations relating to extracting actionable data. As these are theoretical benefits and limitations, practical research was conducted to understand the full capability of crowdsourcing technology.

1.2 Voluntary and involuntary crowdsourcing

There are two forms of crowdsourcing; voluntary and involuntary crowdsourcing. As the term suggests, voluntary crowdsourcing involves the voluntary participation by the crowd with crowdsourcing technology resulting in volunteered geographic information (Goodchild & Glennon 2010, pp. 231-241). An example of voluntary crowdsourcing is a crowd member who typically is a volunteer actively participating in generating crisis data through a crowdsourcing platform such as OpenStreetMap.

Involuntary crowdsourcing involves acquiring data from social networks such as: Twitter, Flickr, YouTube, Facebook, Blogs and wikis, whilst the original creator of the crisis data is unaware that the data will be used in a crowdsourcing application. An example is Ushahidi which is a popular Web 2.0 platform that has been deployed in more than 30 countries (Greenwald 2010, pp. 43-47). Whilst there is increasing popularity to harvest knowledge from social networking sites in the ER to a crisis situation, this form of involuntary crowdsourcing does present its challenges (Rutsaert et al. 2013, pp. 84-91). Data acquired through involuntary crowdsourcing methods typically result in a large, complex dataset which requires intensive data management to extract the actionable and relevant information. The reliability of the acquired data is also an issue as often the source or metadata is unknown.

2 The World Food Programme

The World Food Programme (WFP) 'is the world's largest humanitarian agency fighting hunger worldwide' (WFP 2013a). Operations conducted by WFP relate to promoting food security through sustainability and the provision of food aid to over 75 countries. These countries are typically developing countries that have the 'most vulnerable populations' (WFP 2012a).

In the ER to a natural disaster or shock event, WFP provides the affected population with access to food aid. WFP responds to a variety of food security crisis situations that 'may last several years' (UNFAO 2006, pp. 24-25). A food security crisis can be described as 'extreme food insecurity, when the main danger is widespread loss of access to food, perhaps leading to famine' (UNFAO 2006, pp. 24-25). A food security crisis like other crisis situations can be defined as either slow or a sudden-onset crisis situation. A sudden-onset food security crisis situation is 'associated with natural disasters triggered by climatic hazards, such as floods or hurricanes' (UNFAO 2006, pp. 24-25) and occurs with little to no warning. A slow-onset food security crisis situation is different in that this type of crisis will 'arise when people who are chronically food-insecure are faced with recurrent or persistent external shocks such as drought' (UNFAO 2006, pp. 24-25). A slow-onset crisis situation will emerge over a longer period of time and may be seasonal or predictable in nature.

2.1 The World Food Programmes' crisis mapping geospatial data needs

WFPs' geospatial data needs required in the ER to a crisis situation relates to humanitarian access, the location or movement of population (including refugees and internally displaced people) and food security. These geospatial data needs were gathered as part of this research, and are presented in Table 1.

Data relating to humanitarian access, the location of population and food security must be rapidly acquired to support WFPs' crisis mapping operations in response to sudden onset crisis situations, as well as sustained data acquisition for slow-onset crisis situations. During crisis mapping operations, WFP need to acquire local knowledge that is relevant to their crisis mapping geospatial data needs to ensure a true and accurate representation on the crisis situation and affected population is mapped. As WFPs' crisis mapping products affect decision making, the data acquired must be of high accuracy and reliable.

Table 1: The World Food Programmes' Crisis Mapping Geospatial Data Needs

Geospatial Data Need	Specific Geospatial Data Need
Humanitarian access	Roads, rail, navigated waterways, ports, airports, airfields, heliports, air routes, tunnels, bridges, dams, barrages, levees, ferries, humanitarian corridor, entry points/border crossing points, distance matrix between main points of interest, elevation data, slope, access to markets, obstacles and checkpoints.
The location or movement of population	Populated places, classification of populated places (national/provincial/district capital), refugee camps, population figures or population estimates of each populated place.
Food Security	Agricultural areas, grain storage facilities, bakeries, hospitals, schools, colleges, stadiums, built-up areas, location of existing services (water, power, waste), oil and gas wells and communication facilities.

2.2 The World Food Programmes' crowdsourcing application requirements

The degree of benefit associated with the application of crowdsourcing technology to current WFP crisis mapping operations was determined in this research by evaluating applications against a number of criteria related to WFP's requirements. These criteria are identified as: time, local knowledge, collaborative knowledge and crowd participation, positional accuracy, attribute accuracy, big data (spatial data handling potential), actionable data and meets WFPs' geospatial crisis data needs.

Table 2 outlines WFPs' crowdsourcing application requirements in relation to these eight criteria and was identified together with the Emergency Preparedness and Response Branch at the WFP headquarters in Rome, Italy. This research determined crowdsourcing application requirements in relation to data accuracy for decision making, flexibility to support slow and sudden crisis situations and data acquisition to meet WFPs' needs. Research relating to the UN crowdsourcing for crisis mapping examples determined the need for spatial handling capability and accuracy for decision making.

Table 2: WFPs' crowdsourcing requirements

Criteria	WFP Crowdsourcing Application Requirement
Criteria 1: Time	The application would need to be able to support the continual and rapid crisis mapping timeframes for the ER to both slow and sudden-onset crisis situations respectively.
Criteria 2: Collaborative Knowledge (Crowd Participation)	The application would need to have a high level of crowd participation to ensure that crisis mapping tasks are completed within typically limited timeframes. Crowd participation would need to be constant and sustained to support both the slow-onset and sudden-onset crisis situations. The resultant collaborative knowledge needs to be a true representation of the whole affected population.
Criteria 3: Local Knowledge	The application would need to be accessible and useable by the affected population in all countries in which WFP has a presence, despite the countries' level of economic development.
Criteria 4: Attribute Accuracy	Not only would the application need to achieve a high degree of attribute accuracy, but it would also need to have attributes which do not delay crisis mapping operations. E.g. long textual comments associated with each observation or attributes containing uncertainty will delay critical crisis mapping operations and are not practical.
Criteria 5: Positional Accuracy	The application would need to achieve a high degree of positional accuracy and need to generate reliable crisis data. Million dollar food aid decisions need accurate and reliable location information.
Criteria 6: Spatial Data Handling Capability (Big Data)	In the typically time-constrained crisis mapping operations, the application would need to support ease in spatial data handling in order to permit further manipulation of the geospatial data.
Criteria 7: Actionable Data	The application would need to define and extract actionable geospatial data with ease to permit timely assessment of food security and factors affecting food aid decision making.
Criteria 8: Meets WFP Spatial Data Needs	The application would need to be suited to support WFP's geospatial data needs as outlined within this chapter.

3 Study: recent crisis situations and utilisation of crowdsourcing technology

A number of crowdsourcing applications deployed on the Internet in response to two crisis events were selected and investigated for this research. The crisis events were chosen because the WFP undertook crisis mapping operations in the ER to these events during the research period of November to December 2012. The selected crisis events include the November 2012 Gaza crisis and the December 2012 Philippines Typhoon Bopha crisis. For each, the available web-based crowdsourcing applications were discovered and information was obtained on the extent and amount of mapped data, platform used, methods of capture, distribution of data sources and range of useable data. These are identified in the following subsections.

3.1 Gaza Crisis

Israeli–Palestinian violence began in the Palestinian Territory, Gaza Strip on Saturday 10th November 2012. On the 14th November this violence escalated. A cease-fire between Israel and Hamas was agreed upon on 21st November 2012. This crisis is a slow onset crisis situation resulting from conflict and therefore requires ER and crisis mapping operations from WFP for a sustained period of time. With over 2.5 million people affected (UNOCHA 2012a) by this crisis, the magnitude of this crisis situation is great. Two crowdsourcing applications were discovered in relation to this crisis situation; the Palestine Crisis Map crowdsourcing platform (Ushahidi 2012a) and the Tracking Social Media from Israel and Gaza crowdsourcing platform (AlJazeera 2012). The crowdsourcing applications were analysed and evaluated over a period of 10 days. The 10 day period was determined based on the period from when the November violence began (10/11/2012) until when the WFP crisis mapping began (19/11/2012).

3.1.1 Palestine Crisis Map crowdsourcing platform

The Palestine Crisis Map crowdsourcing platform (Ushahidi 2012a) attracted 39 responses over a 10 day period via a web form in order to identify data that may be useful in the ER. The map in Figure 1 illustrates the overall data and categories that were crowdsourced using the Ushahidi platform (Ushahidi 2012a). Of the responses over that 10 day period, only 17.9% contained data about food security, population movement, refugee camps and humanitarian access that was useful to the WFP.

The crowdsourced data obtained was limited and hence the platform was not utilised further as part of WFPs' crisis mapping operations for the November 2012, Gaza crisis situation. Platform analysis results show that this may be due to the following limitations:

a) The low volume of data geovisualised with an average of 3.90 data records geovisualised per day,
b) The low level of spatial data handling capability typically required for time poor crisis mapping operations as there is no data download function available on this platform,
c) The low degree of crowd participation and resultant collaborative knowledge,
d) The low degree of useful data which meets WFPs' geospatial data needs with 82.1% of the 39 data contained crisis information that would be of no benefit to WFPs crisis mapping operations and
e) The low degree of local knowledge and actionable data. This platform acts more as a news article aggregator rather than a harvester of local knowledge for decisions and actions.

3.1.2 Israel and Gaza Tracking Social Media crowdsourcing platform

The Tracking Social Media crowdsourcing platform for Israel and Gaza (AlJazeera 2012) is based on Ushahidi and was able to source data via both web forms and twitter feeds (Figure 2). Of the resulting data captured over the same 10 day period as for the Palestine Crisis Map, 23.3% (as identified through a random sample) were useful to the WFP. This platform (AlJazeera 2012) was not used as part of WFPs' crisis mapping operations for the November 2012, Gaza crisis situation due to the following summary of limitations:

a) The low level of spatial data handling capability. Whilst a large volume of crisis data was geovisualised within a small timeframe (an average of 36.40 data records geovisualised per day), this crowdsourcing platform did not have capability to download or easily acquire the data,
b) 199 of the 364 data could not be verified. The unverified data contains a level of uncertainty,
c) The large portion of data which did not meet WFPs' geospatial data needs. A low level of actionable data crowdsourced through this platform with 76.6% of the 73 sampled data of no relevance to WFPs' existing crisis mapping operations. Low positional accuracy of this data also results in a low level of actionable data, as the geographic locations are not specific enough for accurate delivery of food aid.
d) Low positional accuracy was observed as some of the data was attributed with multiple locations. E.g. One point has the geographic location within the Gaza Strip on the platforms' geovisualisation, however the point was attributed with the textual location of London.

Crowdsourcing Application Summary	
Platform:	Web 2.0 Ushahidi platform
Crowdsourcing Method:	Voluntary and Involuntary crowdsourcing through; iPhone and Android applications, email and the Ushahidi web form.

Crowdsourced Crisis Data Analysis Summary

Analysis Period (days)	# of Crowdsourced Data Records	Average Daily Crowdsourcing Rate	Web Form	SMS	Email	Twitter	Food Security (%)	Movement/Location Population (%)	Refugee Camp (%)	Humanitarian Access (%)	Verified	Unverified
10	39	3.90	39	0	0	0	2.56	2.56	10.26	2.56	38	1

Figure 1: Summary of the Palestine Crisis Map crowdsourcing platform

Crowdsourcing Application Summary	
Platform:	Web 2.0 Ushahidi Crowdmap platform
Crowdsourcing Method:	Voluntary and Involuntary crowdsourcing through; SMS, iPhone and Android applications, email and the Ushahidi web form.

Crowdsourced Crisis Data Analysis Summary

Analysis Period (days)	# of Crowdsourced Data Records	Average Daily Crowdsourcing Rate	Web Form	SMS	Email	Twitter	Food Security (%)	Movement/Location Population (%)	Refugee Camp (%)	Humanitarian Access (%)	Verified	Unverified
10	364	36.40	213	0	0	151	2.74	0.00	1.37	19.18	165	199

Results reflect analysis performed on a 20 % random sample of total data records.

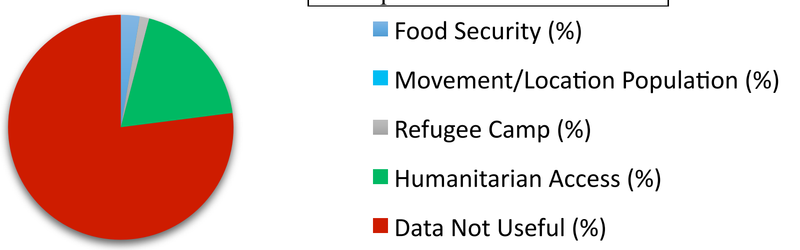

Figure 2: Summary of the Israel and Gaza Tracking Social Media crowdsourcing platform

3.2 Philippine Typhoon Bopha

Typhoon Bopha hit the Philippines on the evening of the 3rd December 2012 and caused a crisis event affecting a great proportion of the population. This crisis situation is a sudden onset crisis situation resulting from a natural disaster and therefore is required to be sustained to a high degree over a short period of time. With 6.2 million people in the Philippines affected (UNOCHA 2012c) by Typhoon Bopha, the magnitude of this crisis situation is great. At the time of conducting this research, four crowdsourcing applications were discovered in relation to this crisis situation including; the Philippine Disaster Watch (Ushahidi 2012b), the Super Typhoon Pablo (Ushahidi 2012c), the Typhoon Pablo Google Crisis Map (Digital Humanitarian Network 2012) and DOST Nationwide Operation Assessment of Hazards (Philippines Government 2012). The analysis period for each application was determined based on the period from which Typhoon Bopha hit the Philippines (03/12/2012) until when the last crowdsourced record was generated at the time of compiling this research.

3.2.1 Philippine Disaster Watch crowdsourcing platform

The Philippine Disaster Watch crowdsourcing platform (Ushahidi 2012b) was based on the Ushahidi system and utilised during the period when the disaster struck (Figure 3). The 10 responses received were obtained via web forms and provided information on population movements; 90% of the data was useful. However, an analysis of the limitations for use in the WFP crisis mapping operations reveals the following:

a) The low positional accuracy suggested by the data is attributed with multiple locations. E.g. One point has the textual location of Bislig City Airport (BPH), Bislig, Philippines but the geographic location of Mangagoy, Philippines. This creates uncertainty in the data.
b) The low volume of data geovisualised with an average daily crowdsourcing rate of 5 data records geovisualised per day,
c) The low degree of relevance of this data in meeting WFPs' geospatial data needs with 0% of crowdsourced data relating to food security, refugee camps or humanitarian access,
d) Despite the geovisualised data having a high degree of actionable data, due to the low level of attribute accuracy (in the form of accurate metadata) this actionable data is not reliable.
e) Most data was able to be captured by other means and hence crowdsourcing was largely redundant.

The majority of the crisis information crowdsourced through this platform were extracted from the National Disaster Risk Reduction and Management Council (NDRRMC) reports. WFP is aware of the NDRRMC reports and already uses these reports during existing WFP crisis mapping operations. As the NDRRMC reports are published every 6 hours, there is a high probability that more up-to-date information is available and this crowdsourced data is potentially redundant.

Crowdsourcing Application Summary	
Platform:	Web 2.0 Ushahidi platform
Crowdsourcing Method:	Voluntary and Involuntary crowdsourcing through; iPhone and Android applications, email, social media and the Ushahidi web form. Twitter (via a specified hashtags).

Benefits and Limitations Summary

Analysis Period (days)	# of Crowdsourced Data Records	Average Daily Crowdsourcing Rate	Web Form	SMS	Email	Twitter	Food Security (%)	Movement/Location Population (%)	Refugee Camp (%)	Humanitarian Access (%)	Verified	Unverified
2	10	5.00	10	0	0	0	0.00	90.00	0.00	0.00	10	0

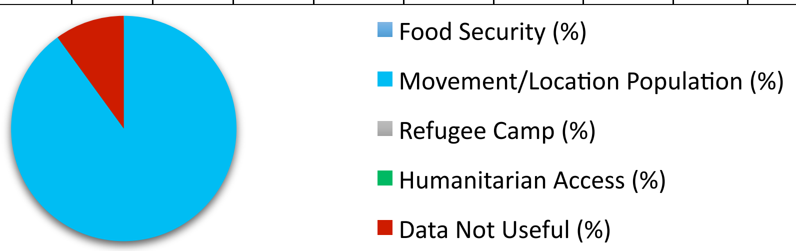

Figure 3: Summary of the Philippine Disaster Watch crowdsourcing platform

3.2.2 Super Typhoon Pablo Crowd Mapping crowdsourcing platform

Through use of the Super Typhoon Pablo crowdsourcing platform (Ushahidi 2012c) 27 responses were crowdsourced through Ushahidi web maps (Figure 4). Of the responses capturing a range of ER data, 85.2 % was considered useful. An analysis of this data in the context of this Philippines disaster identified the following limitations;

a) Whilst the spatial data handling capability associated with platform is of benefit (data downloadable in csv and kml formats), the low volume of data geovisualised through crowdsourcing methods is a limitation. With an average of 9 data records geovisualised on a daily basis, the 9 data records is not a large enough measure to aid in developing accurate situational awareness for such a large-scale sudden onset crisis situations.

b) Of the 8 geovisualised crisis data responses relating to location or movement of population, 5 of these were attributed with data extracted and copied directly from the NDRRMC reports. As previously indicated, the NDRRMC reports are published every 6 hours with a high probably of more up-to-date information being available and hence this crowdsourced data is potentially redundant.

c) Whilst this crowdsourcing platform shows potential in crowdsourcing geospatial data to meet WFPs' geospatial data needs, the low volume of data meant that this platform is of no direct benefit to WFPs' existing crisis mapping operations. Only 14.8% of the 27 data records contained information that was not relevant to WFP crisis mapping operations.

d) Only 7 of the 27 data contained local knowledge. E.g. one point included mentions local weather conditions and the possibility of flooding near the banks of the Agusan River (e.g. a local reference).

3.2.3 Typhoon Pablo (Bopha) Google Crisis Map crowdsourcing platform

The Typhoon Pablo Google Crisis Map (Digital Humanitarian Network 2012) was generated using a Google Map platform (Figure 5) and generated 101 crowdsourced responses over a 4-day period. On 5th December the Digital Humanitarian Network (DHN) was activated by UNOCHA following the impact of Typhoon Bopha which impacted the Philippines on the evening of 3rd of December 2012. The Standby Volunteer Task Force (SBTF) which consists of a crowd of volunteers was activated at this time, as SBTF is part of the DHN. Twitter was determined by UNOCHA as a source of crisis information. Through involuntary crowdsourcing methods, the task outsourced to the SBTF was to acquire and process video and photo crisis data from Twitter and publish this data to a Google Crisis map to assess the damage caused by Typhoon Bopha. The SBTF crowd was required to geo-tag, categorise, generate and attach metadata and time stamp the acquired crisis data.

Crowdsourcing Application Summary	
Platform:	Web 2.0 Ushahidi platform
Crowdsourcing Method:	Voluntary and Involuntary crowdsourcing through; iPhone and Android applications, email, social media and the Ushahidi web form. Twitter (via a specified hashtags).
Crowdsourced Crisis Data Analysis Summary	

Analysis Period (days)	# of Crowdsourced Data Records	Average Daily Crowdsourcing Rate	Web Form	SMS	Email	Twitter	Food Security (%)	Movement/Location Population (%)	Refugee Camp (%)	Humanitarian Access (%)	Verified	Unverified
3	27	9.00	27	0	0	0	3.70	29.63	0.00	51.85	26	1

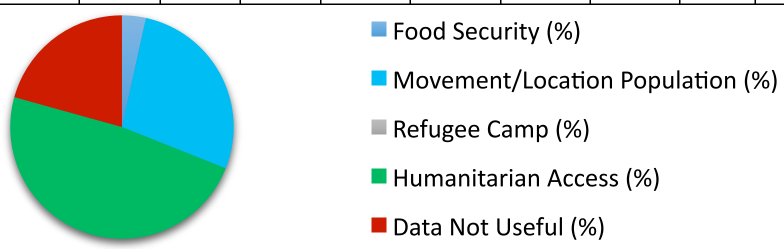

Figure 4: Super Typhoon Pablo Crowd Mapping crowdsourcing platform

The following limitations were identified:

a) The platform geovisualised a large volume of crisis data over a short period of time (with an average of 25.50 data records geovisualised per day) and has high degree of spatial data handling capability. However the crowdsourced data was not downloaded in this instance due to the low degree of relevance of the data to WFPs' crisis mapping operations and geospatial data needs. 64.71% of the 101 data records were not of any use to WFPs' crisis mapping operations. For example, only 7 data records were relevant to food security. WFP cannot accurately make decisions based on 7 data records as there is high probability that this is not a true measure of the entire population affected by the crisis event.

b) The 101 data records crowdsourced through this platform were photo and video multimedia data extracted by the SBTF from news websites, Twitter and YouTube. It would not be practical for WFP to view all the photo and video links during crisis mapping operations due to time constraints. This platform has the potential to be of benefit in giving a broad overview of the crisis situation. However to analyse the data at a more detailed scale, (such as viewing the multimedia) would be impractical during the critical time dependent crisis mapping operations.

c) Positional accuracy could be improved since some of the crowdsourced data records were inaccurately geotagged. E.g. a point with obvious low positional accuracy is a point containing the attributes 'Large scale housing damage' which was located within the Bohol Sea instead of on land.

Crowdsourcing Application Summary	
Platform:	Web 2.0 Google Crisis Map platform by Google Crisis Response
Crowdsourcing Method:	• This application is an example of where involuntary crowdsourcing is used to outsource the data generation stage of the Geovisualisation Production Process. • Voluntary crowdsourcing has also been used to complete the data processing stage of the Geovisualisation Production Process. The United Nations Office for the Coordination of Humanitarian Affairs (UNOCHA) employed the Digital Humanitarian Network to curate, process and publish the crowdsourced multimedia crisis data from social networking sites. • There are no functionalities which allow the crowd to voluntarily participate with the crowdsourcing application in generating crisis data, as there is no availability of a platform web form.

Crowdsourced Crisis Data Analysis Summary

Analysis Period (days)	# of Crowdsourced Data Records	Average Daily Crowdsourcing Rate	Other (including News websites)	YouTube	Twitter	Food Security (%)	Movement/Location Population (%)	Refugee Camp (%)	Humanitarian Access (%)	Verified	Unverified
4	101	25.50	50	26	26	6.86	15.69	0.00	16.67	No verification	

Figure 5: Summary of the Typhoon Pablo (Bopha) Google Crisis Map crowdsourcing platform

3.2.4 DOST Nationwide Operation Assessment of Hazards crowdsourcing platform

Figure 6 shows the crowdsourced map of the DOST Nationwide Operation Assessment of Hazards platform (Philippines Government 2012) implemented using Web 2.0 technology. Only a small number of responses were received over a 2-day period with 62.5 % of them providing useful data. However, the information was not considered appropriate for the WFP's crisis mapping operation due to the following limitations:

a) The very low crowd participation and resultant collaborative knowledge with an average of 4 data records geovisualised per day. For the magnitude of this crisis, the low volume of crisis data would not add any extra benefit to existing WFP crisis mapping operations. However this platform has spatial data handling capability with the crowdsourced data can be downloaded to json format. The crowdsourced data records once downloaded are attributed with the coordinates, date, time and with a numerical value which corresponds to specified flood heights e.g. ankle high.

b) Five of the 8 responses contained potentially actionable crisis information, as they contained information relating to flood heights and therefore humanitarian access. However none of the 8 data met WFPs' geospatial data needs in terms of food security, movement or location of population or refugees.

Crowdsourcing Application Summary	
Platform:	Web 2.0 platform
Crowdsourcing Method:	• Originally suspected as a crowdsourcing application due to the Twitter feed present on the Google maps API. However, on closer inspection it appears that the Twitter feed contain Tweets which are tweeted by two official organisations rather than a large crowdsourcing crowd. • Whilst this application is focused on the disaster management aspect of emergency response, there is a function on this platform which allows for crowdsourcing the data generation task of the GPP. • Within this platform there is an application which allows the crowd to generate flood crisis data through voluntary crowdsourcing methods. • This function allows the user to search for and pinpoint a geographic location where the flood event is occurring and submit this flood event location.

Crowdsourced Crisis Data Analysis Summary

Analysis Period (days)	# of Crowdsourced Data Records	Average Daily Crowdsourcing Rate	Web Form	SMS	Email	Twitter	Food Security (%)	Movement/Location Population (%)	Refugee Camp (%)	Humanitarian Access (%)	Verified	Unverified
2	8	4.00	8	0	0	0	0.00	0.00	0.00	62.50	0	0
				No SMS, Email or Twitter functionality							No verification information	

Figure 6: Summary of the DOST Nationwide Operation Assessment of Hazards crowdsourcing platform

4 Study results and discussion

A total of six crowdsourcing platforms involving the November 2012 Gaza and the December 2012 Philippines Typhoon Bopha crisis situations were assessed in this study. None of the six crowdsourcing platforms were used for the crisis mapping operations undertaken by WFP. Each of the crowdsourcing applications was evaluated in terms of the following criteria: time, local knowledge, collaborative knowledge and crowd participation, positional accuracy, attribute accuracy, big data (spatial data handling capability), actionable data and whether or not the data meets WFPs' geospatial data needs. This criteria was determined following a literature review on the technological limitations and benefits of crowdsourcing for crisis mapping.

Figure 7 summarises the benefits and limitations of the six assessed crowdsourcing applications with regards to these criteria. Given that timeliness of appropriate data at the ER phase of a crisis event is crucial, it is not surprising that most applications did not provide sufficient data in a timely manner. Only the Tracking Social Media from Israel and Gaza (AlJazeera 2012) and the Typhoon Pablo (Bopha) Google Crisis Map (Digital Humanitarian Network 2012) crowdsourcing applications produced data that were timely. However, the data that was acquired through these applications was of a low level of relevance to WFP's crisis mapping, geospatial data needs. The one platform of the six analysed that did meet WFP's geospatial data needs (Ushahidi 2012c) did not geovisualise enough data to make this application of use, with only 27 data records generated over a three day period. Applications such as the Philippine Disaster Watch crowdsourcing platform (Ushahidi 2012b) and the Super Typhoon Pablo Crowd Mapping crowdsourcing platform (Ushahidi 2012c) had a low degree of attribute accuracy with no metadata associated to the crowdsourced data content. This lead to uncertainties and made the data unreliable.

Even if simply considering the overall number of benefits and limitations across the six applications, the total of 34 limitations outweighs the 14 benefits identified. It must be noted here that this is one simplistic view and that the analysis presented within this paper was based purely on one situation; WFPs' crisis mapping operations. The results reflect the analysis performed in association with the requirements of WFPs' emergency response crisis mapping operations. Assessment of the eight criterion used in this study will vary in the number of benefits and limitations based on the crisis mapping situation that the crowdsourcing application is assessed against. A weighting could be applied to each of the eight criteria to reflect the level of requirement of the criteria in relation to the crowdsourcing application, and the crowdsourced outcome to the crisis situation.

Figure 7 shows that five of the six crowdsourcing platforms that geovisualised geospatial data do not meet WFPs' geospatial data needs (Criteria 8). This is a major limitation. The attribute and positional accuracy of the crowdsourcing platforms is also a main limitation with five of the six analysed crowdsourcing platforms containing uncertainties. Analysis of the six crowdsourcing applications determined that Criteria 6 showed the highest degree of benefit with three of the six crowdsourcing platforms having a high degree of spatial data handling capability. This is not consistent for similar platforms (such as the Ushahidi platform) where a data download functionality appears to be added based on the individual or organisations preference during creation and deployment of the platform. For the Google Crisis Map crowdsourcing platform (such as the Digital Humanitarian Network (2012)) a data download functionality appears to be a standard feature of the platform.

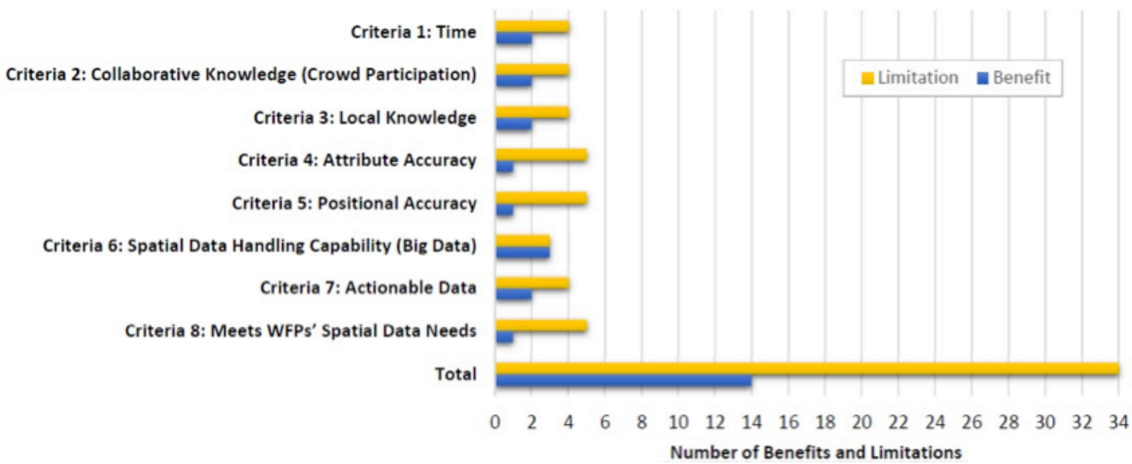

Figure 7: Limitations and benefits resulting from the analysis of different crowdsourcing platforms

5 Conclusions

A number of crowdsourcing applications were investigated in order to determine the benefit of crowdsourcing to the World Food Programmes' (WFP) existing crisis mapping operations. For each application, details regarding the crowdsourced information were extracted and recorded. This information was evaluated in regards to criteria that define the essential requirements for WFP's crisis mapping operations. As WFP responds to a variety of both slow and sudden-onset crisis situations in over 75 countries in which the most vulnerable populations are located, crowdsourcing technology needs to be highly flexible in order to be adopted by WFP. Thesis research identified WFP crowdsourcing capability requirements including; acquisition and sustainability of crowd participation, acquisition of local knowledge (despite a countries level of economic development), achievement of a high degree of attribute and positional accuracy, spatial data handling capability, being able to extract actionable data and to acquire data that meets WFPs' geospatial data needs.

The outcomes of this investigation demonstrate that the limitations outweigh the benefits of applying current crowdsourcing technologies to WFP's crisis mapping operations. This is primarily due to the inability of current crowdsourcing techniques and systems to capture required data in sufficient quantities and of sufficient quality in a timely manner. Crowdsourcing technology appears to be in its infancy at present and will need to develop further before it will be adopted as part of WFPs' existing crisis mapping operations.

Despite not discovering an immediate crowdsourcing solution to be adopted by WFP, this work will lead to further research and development which will be of greater benefit to humanitarian, crisis mapping operations. The limitations associated with crowdsourcing technology as highlighted in this research will steer future technological developments. For example, highlighting countries where WFP has a presence and the related degrees of information and communication vulnerability will steer technological development in the direction of advancement for developing countries. It is hoped that this research will lead to technological development in terms of a crowdsourcing application that meets; critical time frames for both slow and sudden-onset crisis situations, sustained and consistent crowd participation, affected population participation (which is not dependent on a countries economic development), practical and accurate attributes, accurate positional accuracy, effective spatial data handling capability, an ease in extraction of actionable information and an application which meets the geospatial data needs required for humanitarian crisis mapping operations.

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