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# Collaboration among Humanitarian Relief Organizations and Volunteer Technical Communities: Identifying Research Opportunities and Challenges through a Systematic Literature Review

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## ABSTRACT

Collaboration is the foundation to strengthen disaster preparedness and for effective emergency response actions at all levels. Some studies have highlighted that remote volunteers, i.e., volunteers supported by Web 2.0 technologies, possess the potential to strengthen humanitarian relief organizations by offering information regarding disaster-affected people and infrastructure. Although studies have explored various aspects of this topic, none of those provided an overview of the state-of-the-art of researches on the collaboration among humanitarian organizations and communities of remote volunteers. With the aim of overcoming this gap, a systematic literature review was conducted on the existing research works. Therefore, the main contribution of this work lies in examining the state of research in this field and in identifying potential research gaps. The results show that most of the research works addresses the general domain of disaster management, whereas only few of them address the domain of humanitarian logistics.

## Keywords

Volunteer Technical Communities, Response Agencies, Disaster Management, Decision-Making, Humanitarian Logistics.

## INTRODUCTION

Large scale disasters such as 2010 Haiti Earthquake or 2013 Philippines Typhoon caused high losses in terms of human lives and property damage in recent years (Harvard Humanitarian Initiative, 2011; Vieweg et al., 2014). In the aftermath of such disasters, timely information is needed in order to contribute to situational awareness. Especially for logistics operations information on the condition of required infrastructure and resources such as roads or airports is critical (Horita et al., 2014).

In the last years, the spread of information and communication technology (ICT) has enabled affected people to directly contribute to situational awareness; for example, by reporting blocked roads or destroyed airports (IFRC, 2013). However, humanitarian organizations often do not have the resources to handle this emerging flow of information (Harvard Humanitarian Initiative, 2011). Therefore, volunteer groups stepped into the evolving information space by monitoring and filtering the new information flow in the aftermath of disasters (Capelo et al., 2012). In this regard, the 2010 Haiti Earthquake was important for the raising of several volunteer technical communities (VTCs) (Starbird & Palen, 2011). By offering information on affected people and infrastructure, VTCs provide timely and valuable information products for relief operations.

Although VTCs are important actors in nowadays humanitarian response and offer a high potential to support relief operations, “the challenge lies in enabling humanitarian organizations and V&TCs to better understand each other and to develop opportunities for collaboration that harness the full potential of the resulting partnership” (Capelo et al., 2012). Issues of trust, reliability or integration of data are exemplary obstacles to collaboration between these volunteer groups and the traditional actors in humanitarian response (Harvard Humanitarian Initiative, 2011).

Several research works have provided specific insights of collaboration problems and suggested possible ways forward. Within these works, Haworth (2016) identifies and addresses obstacles such as missing trust of emergency managers in volunteer information or perceived legal concerns. Gralla et al. (2015) give an overview of the decisions to be made after disasters by emergency managers through a framework for such decisions and information requirements. However, to best of our knowledge, no literature reviews have been carried out to summarize the collaboration between VTCs and formal humanitarian organizations.

Therefore, the main goal of this work is to provide an overview of the existing literature by conducting a SLR on the collaboration among formal organizations and VTCs. An SLR “involves both the identification of high quality papers and the evaluation of their applicability to the study” (Vom Brocke et al., 2009). Thus, this study examines the following research question:

*RQ. How can formal humanitarian organizations and VTCs collaborate to support decision-making with crowdsourced geographic information?*

The remainder of this work is structured as follows: Section 2 presents the basic concepts used in the paper. Section 3 describes the research methodology regarding the SLR. Section 4 contains an analysis and discussion of the state-of-the-art of the collaboration among humanitarian organizations and VTCs. Eventually, Section 5 concludes with a summary and future works.

## BACKGROUND

A disaster is defined by UNISDR (2007) as “a serious disruption of the functioning of a community or a society involving widespread human, material, economic or environmental losses and impacts, which exceeds the ability of the affected community or society to cope using its own resources”. Disaster management aims at lessening the impact of such disasters by use of plans and arrangements to coordinate and guide involved humanitarian organizations in their response to emergency needs (IFRC, 2016; UNISDR, 2007). Within disaster management, humanitarian logistics represents the sub domain of “planning, implementing and controlling the efficient, cost-effective flow and storage of goods and materials, as well as related information, from the point of origin to the point of consumption for the purpose of alleviating the suffering of vulnerable people” (CSCMP, 2016; Thomas & Kopczak, 2005). Thomas & Kopczak (2005) identify humanitarian logistics as an essential sub domain of disaster management due to its relevance for effectiveness and speed of overall relief operations.

Accurate and up-to-date information is essential for supporting the tasks of disaster management, especially in humanitarian logistics, owing to its characteristics. Crowdsourced Geographic Information (CGI) – user-generated information that is crowdsourced and relies on collaborative web platforms, specific web applications and/or mobile phone apps (Goodchild, 2007) – has emerged as an important source of information for disaster management (Albuquerque et al., 2017). However, humanitarian organizations often do not have the resources

to handle this emerging flow of information (Harvard Humanitarian Initiative, 2011). Therefore, Volunteer Technical Communities (VTCs) emerge as an important mechanism to support humanitarian organizations. VTCs can be defined as volunteer-based, virtual communities that “apply and leverage their technical skills in collecting, processing and managing data in support of response efforts for disasters” (Liu, 2014). Thereby, they provide information-related services such as aggregated and mapped social media streams to actors involved in disaster management. VTCs consist of members of different backgrounds, most of them keen on innovative technologies (Capelo et al., 2012). Main differentiating factors of VTCs from formal humanitarian organizations are their open-source ideology, their flexible structure, the altruistic nature of their motivation as well as their enthusiasm for partnership (Capelo et al., 2012).

This paper deals with the collaboration of the aforementioned types of actors: response agencies and VTCs. Collaboration shall be defined as a “mutually beneficial and well-defined relationship entered into by two or more organizations to achieve common goals. The relationship includes a commitment to: a definition of mutual relationships and goals; a jointly developed structure and shared responsibility; mutual authority and accountability for success; and sharing of resources and rewards” (Mattessich & Monsey, 1992). Collaboration is a fundamental component of any emergency response (Waugh & Streib, 2006). However, it is a complex topic because it requires analysis from different perspectives for the efficient design and development of tools and technologies to support collaborative work.

## RESEARCH METHODOLOGY

For addressing the research question on the collaboration among VTCs and formal humanitarian organizations a Systematic Literature Review (SLR) has been conducted. Vom Brocke et al. (2009) introduce an SLR as a means of rigorously conducting literature reviews and searches in the Information Systems (IS) domain. It helps to reveal potentially open research gaps (Vom Brocke et al., 2009). In order to do so, they presented an iterative review process consisting of the following phases: (i) the definition of review scope, (ii) the conceptualization of topic, (iii) the literature search, (iv) the literature analysis and synthesis, and (v) the formulation of a research agenda.

For the first phase, the taxonomy of Cooper (1988) gives guidance on how to scope the review. The literature review underlying this paper is aimed at specialized scholars and based on research outcomes and applications. Goal of the review is to identify central issues of the topic and to evaluate the state of literature based on potential research gaps. The next phase, *conceptualization of topic*, has already been addressed through the definitions in Section “Background”.

The objective of the *literature search* is to capture the largest possible number of paper, and remove those which do not meet the criteria defined (Okoli, 2015). It consists of certain sub phases: *journal search*, *database search*, *keyword search*, *in-/exclusion criteria* and *back- / forward search* (Vom Brocke et al., 2009). Journals from the domains of IS and the domain of disaster management serve as indicators for the selection of appropriate databases. Thus, the three databases Scopus, ACM Digital Library and Web of Science have been chosen for conducting the review.

**Table 1. Search string structure**

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((“disaster management” OR “emergency management” OR “crisis management” OR “disaster response” OR “emergency response” OR “crisis response” OR “response agenc\*<sup>1)</sup>” OR “relief organization”) OR (“humanitarian logistics” OR “disaster logistics” OR “emergency logistics” OR “crisis logistics” OR (“humanitarian aid” AND “logistics”) OR (“disaster relief” OR “emergency”) AND (“logistics” OR “supply chain\*<sup>1)</sup>”))) AND (“volunteer techn\* communit\*<sup>1)</sup>” OR “VTC” OR “volunteer\* geographic information<sup>1)</sup>” OR “VGI” OR “crowdsourc\*<sup>1)</sup>” OR “crowdtask\*<sup>1)</sup>” OR “microblogging” OR “digital humanitarian\*<sup>1)</sup>”)

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<sup>1)</sup> The asterisk-symbol allows for minor variations such as singular and plural forms

For the *keyword search* the search string has been derived from the conceptualization of the topic and the research question (Table 1). The following inclusion criterion (IC) was defined to ensure that only papers contributing to the research questions are selected:

IC-1: The paper integrates the topics of disaster management / humanitarian logistics and of VTCs, it is especially concerned with collaboration of VTCs and response agencies.

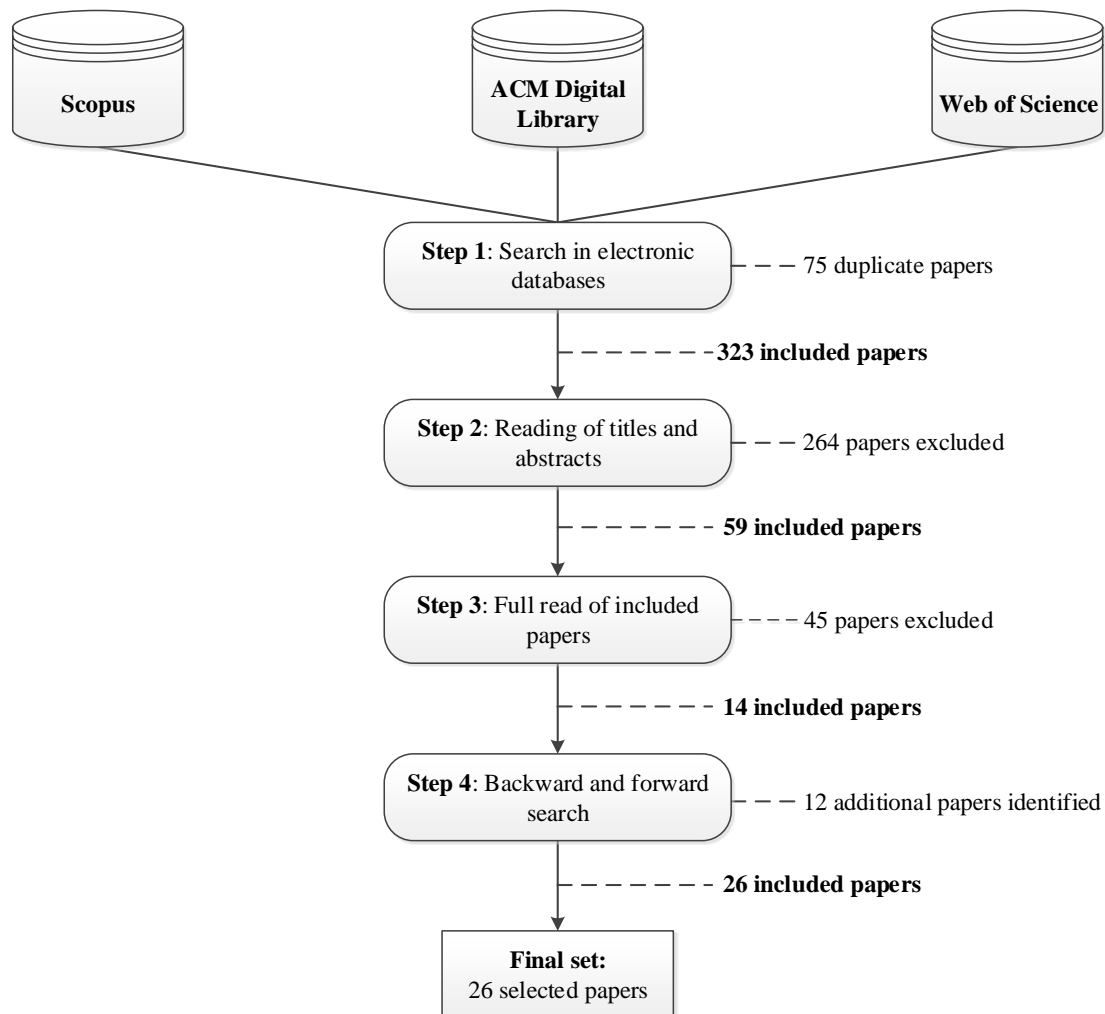
Accordingly, a set of exclusion criteria (EC) was specified:

EC-1: The paper is not electronically available on the web through institutional subscriptions that the authors currently have.

EC-2: The paper is not presented entirely in English.

EC-3: The data entry does not refer to a peer-reviewed scientific paper.

After primary study selection based on these criteria a back- and forward search has been conducted based on all primary studies' citations. The overall process of the literature search, which was conducted in May 2016, is visualized in Figure 1. During the literature search a high number of papers did not meet IC-1 since they do not deal with the behavioral aspect of collaboration among response agencies and VTCs, but are more concerned with technical aspects such as crowdsourcing platforms.



**Figure 1. Literature Search Process**

As a result of the literature search, 26 papers were selected as a basis for the analysis and discussion (Table 2).

Table 2. List of selected papers

Year	Conference (ID/Ref.)	Journal (ID/Ref.)	Workshop (ID/Ref.)			
2016	C01	Hellmann et al. (2016)	J01	Haworth (2016)		
	C02	Horita et al. (2016)				
2015	C03	Gralla et al. (2015)	J02	Becker & Bendett (2015)		
	C04	Kaminska (2015)	J03	Hughes & Tapia (2015)		
	C05	Link et al. (2015)				
	C06	van den Homberg & Neef (2014)				
2014	C07	Cobb et al. (2014)	J04	Liu (2014)		
	C08	Horita et al. (2014)	J05	Tapia & Moore (2014)		
	C09	Meesters & van de Walle (2014)				
	C10	Soden & Palen (2014)				
	C11	van Gorp (2014)				
	C12	Vidolov (2014)				
	C13	Vieweg et al. (2014)				
2013	C14	Starbird & Palen (2013)	J06	Kerle & Hoffman (2013)		
2012	C15	St. Denis et al. (2012)				
2011	C16	Chamales & Baker (2011)	J07	Barrington et al. (2011)	W01	Ortmann et al. (2011)
	C17	Gao et al. (2011)	J08	Ghosh et al. (2011)		

After conducting the literature search, information was extracted from the papers in a concept-oriented way (Webster & Watson, 2002) based on four extraction dimensions. The first extraction dimension identifies the domain addressed in the selected papers, either disaster management or its sub domain of humanitarian logistics acknowledging its high criticality for any relief operation (Blecken, 2009). The following extraction dimensions examine the focal point of collaboration between humanitarian organizations and VTCs to answer the research question. The initiation direction of the information flow between the two actors, following Meesters & van de Walle (2014), is contained in the second dimension. Information on different types of disaster management interfaces, following Liu (2014), is extracted using the third extraction dimension. The fourth extraction dimension identifies different types of collaboration practices used by response agencies and VTCs (Vidolov, 2014).

## RESULTS AND DISCUSSION

This section contains the analysis and discussion of the 26 selected papers. Figure 2 shows the distribution of these papers classified by year and their publication venue. The distribution of publication years of the papers is limited to the range from 2011 up to now with a peak in 2014. This rise in literature after 2010 seems reasonable due to the rise of VTCs' engagement during 2010 Haiti Earthquake (Zook et al., 2010).

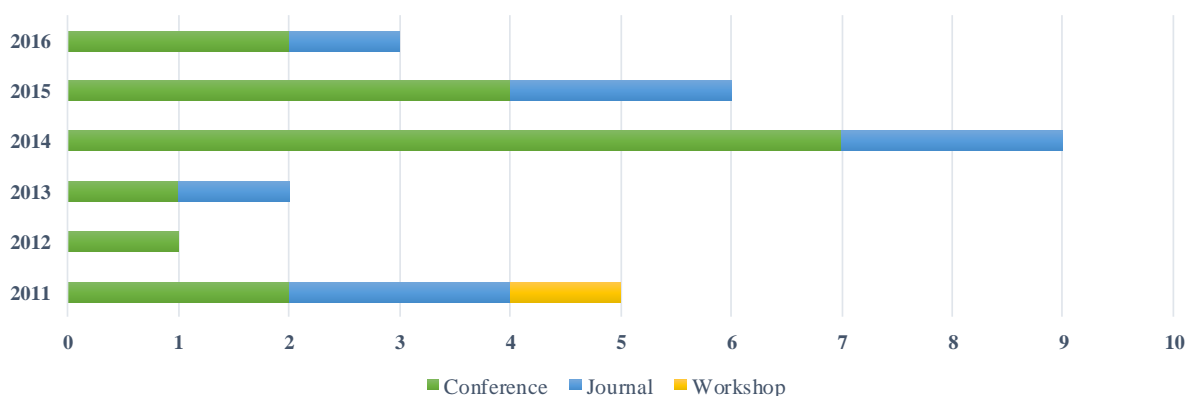


Figure 2. Paper Distribution by Year and Publication Type

### Addressed Domain

Most of the selected papers (23 of 26 papers) are concerned with the general domain of disaster management (Table 3). Gao et al. (2011) developed a platform that facilitates coordination of emergency requests and response efforts of humanitarian organizations. Another example of studies on collaboration in disaster management is Vieweg et al. (2014). The authors use interviews with the Office for the Coordination of Humanitarian Affairs' (OCHA) staff to assess the potential contribution of classified twitter data which has been classified by VTCs such as MicroMappers.

Three of the 26 selected papers specifically address the sub domain of humanitarian logistics (Table 3). Horita et al. (2016) present the observation-aware Decision Model and Notation (oDMN) which connects tasks, decisions, information and data sources of actors in emergency management. They apply their notation specifically to a logistics context in the aftermath of 2015 Nepal earthquake and thus pay attention to specifics of this domain such as infrastructure conditions or resource constraints, whereas Vieweg et al. (2014) use a case study of Typhoon Yolanda without focusing on a specific domain.

**Table 3. Classification of addressed domain**

Attribute	Paper
Disaster Management	C01, C03, C04, C06, C07, C09, C10, C11, C12, C13, C14, C15, C16, C17 J01, J02, J03, J04, J05, J06, J07, J08 W01
Humanitarian Logistics	C02, C05, C08

Within the 26 selected papers the sub domain of humanitarian logistics is rather poorly covered concerning the collaboration among formal humanitarian organizations and VTCs. However, some special characteristics of humanitarian logistics raise the need for such research: The logistics function is distinguished from general relief operations by its strong dependency on physical infrastructure (Blecken, 2009). The existence and condition of roads, airports or the availability of fuel can mean the difference between successful and failed operations (Kovács & Spens, 2007). Especially for providing such infrastructure-related information, VTCs could be used as valuable collaboration partners (Blecken, 2009).

Another distinction criterion is the privatization of logistics operations (Van Wassenhove, 2006). An “outsourcing of logistics services to third parties” (Blecken, 2009) is apparent within humanitarian logistics. One implication of this is that additional to response agencies also private companies have to be coordinated within humanitarian logistics (Cozzolino, 2012). Thus, it is necessary for future research to examine for example the influence of privatization on collaboration in the disaster management environment.

### Information Flow Initiation Direction

Many of the provided information products of VTCs are generated without specific request of response agencies, thus the information flow between response agencies and VTCs is initiated bottom-up (Table 4). There are rather generic information products such as maps which show where help is needed by supplying textual or visual information (van Gorp, 2014). These provide basic information which addresses the information needs of several response actors. In contrast, there are also more specialized products generated by VTCs such as Event Diaries in which specific information such as location and capacities of nearby hospitals is synthesized during disasters. For using such specialized products, response agencies have to be educated by the providing communities (Starbird & Palen, 2013).

Several papers also introduce examples and concepts of top-down initiations of the information flow (Table 4). For example, networks of volunteers such as GEO-CAN for building damage assessment are based on specific information needs of response agencies. If the volunteers are not aware of these information needs “it remains unclear precisely what information is required by individual responders and decision-makers” (Gralla et al., 2015). However, top-down initiations require a lot of clarification of information requirements short after or even prior to a disaster.

**Table 4. Classification of information flow initiation direction**

Attribute	Paper
Bottom-Up Initiation	C09, C10, C11, C14, C16, C17 J01, J05 W01
Top-Down Initiation	C03, C04, C05, C07, C08, C09, C13, C15 J06, J07, J08
Bidirectional Initiation	C01, C02, C06 J02, J03
Not Addressed	C12 J04

A bidirectional connection of the decision-making process of humanitarian organizations and the data collection of VTCs is more rarely found in the 26 selected papers (Table 4). One way to handle a bidirectional information flow between the actors is the use of information brokers or mediators. These brokers “function as boundary spanners, demonstrating insight into each individual domain of the collaborative effort” (Hellmann et al., 2016). Hellmann et al. (2016) report on a rather traditional form of brokering activities in which individuals act as information brokers by providing contact lists or data inventories. In contrast, Hughes and Tapia (2015) point out that also whole networks such as the Digital Humanitarian Network (DHN) can serve as such intermediaries and that they tend to employ new, innovative processes as part of the brokering activity.

To date mainly large organizations such as the United Nations OCHA or the World Bank collaborate with VTCs (van Gorp, 2014). The analysis of the information flow initiation direction provides one possible reason for this fact: Top-down initiations such as the use of closely tied networks of volunteers are no good option for small response agencies due to their lack of resources for coordination (van Gorp, 2014). Furthermore, information products which are generated bottom-up by VTCs will often not meet the information requirements in case of specialized small agencies. Therefore, bidirectional mechanisms are required for small agencies to assess the value of provided information products against the background of their specific information needs. Hughes & Tapia (2015) suggest an “a-la-carte system where digital volunteers can advertise services and emergency responders can then order the services they need”. As indicated by the selected papers of the review there is only a small number concepts for bidirectional information flow initiations available in literature. This poses the need for further concepts for matching information requirements and volunteered information, thus enhancing the use of such information as decision-support for emergency managers (Albuquerque et al., 2017).

### Interface Type

Concerning social interfaces, ten of the 26 selected papers elaborate on concepts such as trust or organizational culture (Table 5). Through interviews Haworth (2016) recognizes for example that the traditional, procedure-driven top-down power structure of emergency management is disrupted by the spontaneous, unstructured nature of VTCs’ information products. Similarly, Hughes & Tapia (2015) state that the “key difference between professional response organizations and digital volunteer groups is their approach to information as either closed or open”. Whereas VTCs use open and transparent processes and standards to handle information, traditional agencies clearly define ownership and intellectual property rights of information.

Seven papers discuss the interfaces between VTCs and response agencies from a technological perspective (Table 5). The main challenge from this perspective is the integration of VTCs’ systems into the highly proprietary systems used by response agencies for day-to-day operations (Tapia & Moore, 2014). One way to address this challenge is Linked Open Data presented by Ortmann et al. (2011) which offers a common exchange format. In their approach information provided by VTCs is transferred into RDF-triples by volunteers who can then be integrated into response agencies’ systems.



**Table 5. Classification of interface type**

Attribute	Paper
Social Interface Type	C09, C10, C11, C12, C14, C15, C16 J01, J03, J05
Technological Interface Type	C01, C06, C08, C13, C17 J05 W01
Organizational Interface Type	C01, C02, C04, C05, C07, C13, C15 J02, J03, J07, J08
Political Interface Type	C16 J01
Not Addressed	C03 J04, J06

Organizational interfaces are also often discussed in the selected papers (Table 5). The concept of information brokers among VTCs and response agencies is part of this organizational perspective: These brokers often use contact lists and data inventories “in order to promote connecting the right people to achieve a given goal” (Hellmann et al., 2016). Examples for such brokers can also be networks such as GEO-CAN which are used to reach a high number of experienced volunteers (Barrington et al., 2011; Ghosh et al., 2011). One possibility for researching organizational interfaces issues could be the conducting in-depth cases studies with the aim of advancing understanding on the role of brokers among VTCs in collaborative mapping activities and response agencies (e.g. the Humanitarian OpenStreetMap Team and the Missing Maps Project).

Political interfaces between VTCs and humanitarian organizations are the only type of interfaces which are sparsely represented in the selected papers (2 of 26 papers) (Table 5). Haworth (2016) recognizes the threat of accountability and legal complications due to decisions based on to some extent unreliable information provided by VTCs. Improved legal protections are required for allowing agencies to base their decision on such information. Chamales & Baker (2011) elaborate on necessary protection of individuals’ identity against malicious groups in addition to legal protection of response agencies.

Perceived legal concerns of response agencies for example of being considered responsible for unverified information by VTCs can pose hindrance to collaboration with such volunteer groups (Haworth, 2016). Therefore, on the one hand governments are challenged to improve legal protection for response agencies which are basing their decisions on information provided by VTCs (Haworth, 2016), on the other hand researchers are challenged to further research the impact of faulty information and issues of accountability on VTCs’ and response agencies’ collaboration. Quality assessment is an important step in all CGI sources since the information comes from unknown sources and with unknown quality (Albuquerque et al., 2017). Thus, works that propose a framework of the methods used to assess the quality of CGI in absence of authoritative data are really required.

### Collaboration Practice

Collaboration practices can be classified into reconfiguring and fusing ones. Reconfiguring practices refer to transformational processes at either response agencies or VTCs in order to prepare for new collaboration relationships (Vidolov, 2014). Fusing practices are defined as the construction of a collaboration network between a response agency and a VTC including defined roles and responsibilities (Vidolov, 2014). Of the 26 selected papers, 19 elaborate on fusing practices and six on reconfiguring practices (Table 6).

**Table 6. Classification of collaboration practice**

Attribute	Paper
Reconfiguring Practice	C03, C09, C10, C11, C12 J01
Fusing Practice	C01, C02, C04, C05, C06, C07, C08, C11, C12, C14, C15 J02, J03, J04, J05, J06, J07, J08 W01
Not Addressed	C13, C16, C17

Concerning reconfiguring practices, five papers deal with reconfiguring the VTCs' side. Soden & Palen (2014) for example take the Humanitarian OpenStreetMap Team (HOT) as an example of how a volunteer community that emerged out of disaster response formalized in the following years. Vidolov (2014) states that by formalization of VTCs these groups can overcome potential problems of reliability and trust perceived by formal response agencies. In contrast to Soden & Palen (2014) who focus on examining VTCs, Vidolov (2014) underlines the necessary reconfiguration of both collaboration actors: They state that in order to prepare for using voluntarily contributed information, formal humanitarian organizations need to become more open and flexible in comparison to their current bureaucracy. For example OCHA has recently introduced structural changes concerning de-centralization, flattening of hierarchies and openness (Vidolov, 2014)

The fusing collaboration practices can be classified according to Majchrzak et al. (2012): Centralized, traversing fusing practices include making knowledge bases of and dependencies between the actors explicit in advance to disasters (Harvard Humanitarian Initiative, 2011). The local, transcending approach "concerns the emergence of local collaborations between various traditional and non-traditional actors that are developing a collaborative ordering through 'learning-by-doing'" (Vidolov, 2014).

14 of the 19 fusing practices mentioned in selected papers are on central, traversing fusing practices. For example the TIDES program of the US Department of Defense is a central fusing practice. Such networks which are not related to a specific disaster make knowledge bases of the involved groups explicit by interagency field experiments in between disasters (Becker & Bendett, 2015). Such training and education efforts in between disasters are also proposed by Starbird & Palen (2013) and van Gorp (2014). Another part of the literature on fusing practices is of local, transcending nature (6 papers). Networks such as GEO-CAN that have been established in direct response to a specific event include ad-hoc collaboration efforts (Barrington et al., 2011; Ghosh et al., 2011). Tapia & Moore (2014) state that such initial, ad-hoc collaborations, which have often been conducted in the past years, can create trust in the long term.

Local fusing practices represent ad-hoc collaboration efforts in a specific disaster context and thus represent collaboration of actors who have not worked with each other before. These local collaboration practices can actually be seen as the basis for central fusing approaches since in practice collaboration often emerges out of initial courses of interaction (Vidolov, 2014). Accordingly, starting directly with central fusing practices is no easy task for emergency environment actors if they did not experience this initial courses of interaction. Both types of fusing practices are apparent in literature but the question remaining unsolved is how to use local fusing practices as concrete basis for collaboration agreements and central fusing practices. Thus, future research should examine concepts of community-centeredness in disaster management in order to prepare for enhanced long-term collaboration of VTCs and response agencies.

## CONCLUSION

This paper has presented the results of an SLR on the collaboration of formal humanitarian organizations and VTCs. Concerning the initial research question, different approaches for collaboration have been identified in the 26 selected papers of the literature search, using four extraction dimensions. The biggest benefit of this work thus lies in examining the state of research in this field and in identifying potential research gaps indicated by the selected papers.

Through this SLR, it has been realized that most of the selected papers address the general domain of disaster management, whereas only few of them address the specific domain of humanitarian logistics. Future work needs to research for example the influence of privatization on collaboration as this is one special characteristic of humanitarian logistics. Furthermore, concepts are required for quality assessment of possibly faulty volunteered information in order to protect response agencies against legal consequences. Especially small organizations need to be assisted in integrating such information by researching concepts for matching their

information requirements and the provided volunteered information. In addition, the field of community-centeredness in disaster management is an important one in order to enhance long-term collaborations of volunteers and formal actors.

Thus, future work should be done to address the research gaps, which have been pointed out in Section 4. Moreover, future research in that direction will allow humanitarian organizations and VTCs to better understand each other and to develop opportunities for collaboration, allowing to seize the opportunities offered by resulting partnerships. One limitation of this work can be seen in the selected set of extraction dimensions since additional extraction dimensions can potentially identify further gaps during future work. Furthermore, within this SLR exclusively scientific studies regarding the collaboration of humanitarian organizations and VTCs have been reviewed. In future works, interviews with practitioners will be carried out aiming at identifying promising areas of future research.

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