Designing Disaster Information Management Systems 2.0: Connecting communities and responders

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ABSTRACT

Information and supporting information systems is a key element in an effective emergency response. From creating situational awareness to informed decision making, information enables responders to optimize their decisions and operations. Today, with the increased availability of information technology around the globe, a new active player in the field of information management is emerging as communities are becoming increasingly active in the field of information gathering, analyzing and sharing.

However, communities may have specific requirements and approaches to using information systems in crisis situations. Moreover, connecting information systems between communities and responder pose specific challenges due to the different information needs, capacities and incentives to use them. In this paper we build on the DERMIS premises and explore through a case study if and how these principles apply to inclusive information systems. We present the initial findings of this work of designing information systems involving both communities and formal responders.

Keywords

Information Systems, Community Engagement, Participatory Systems, Systems Design, Inclusive Systems

INTRODUCTION

It has long been recognized that information plays a pivotal role in the response to disasters (Comfort et al. 2004; IFRC 2005). Information and communication technologies have fundamentally changed the availability and exchange of information before, during and after a crisis. Since the Haiti earthquake marked the beginning of disaster relief 2.0 (Crowley et al. 2010), there is a surge in information systems specifically designed for disasters (Neef et al. 2014; Piccolo et al. 2018; Streefkerk et al. 2014). Equally prominent is the use of platforms such as Twitter, Facebook, WhatsApp and other social media and instant messaging systems during disasters. In recent events, such as the Sulawesi earthquake/tsunami in Indonesia and the 2015 Nepal earthquake (Basu et al. 2017), WhatsApp was extensively used by both responders and the affected communities. In these and other disasters, WhatsApp became a critical information sharing platform in which a plethora of groups were formed for various coordination groups (Debnath et al. 2016; Meesters 2014; Sebastian et al. 2017).

The increased availability of information and the expanded reach of information networks bring about new challenges: information is gathered and shared across a wider network, a more diverse audience, and with more speed than ever before (Comfort et al. 2004; Gralla et al. 2013). As such, the requirements for systems that support effective information management also change. For example, systems need operate in a more distributed manner, allowing different user(groups) to connect, share and use information (Baharmand et al. 2016; Nespeca et al.). In addition, communities and individuals play a more prominent role. While these groups have long been recognized as the pivotal in effective disaster response (Twigg 1999; Weiss 1999), the increased profusion of mobile technology, digital literacy, and accessibility of ICTs have also opened up opportunities for them to directly engage in information processes (Comes 2016c; Harbers et al. 2014; Meier 2014; Munro 2012; Okolloh 2009).

All the more it is important that information systems in the Disaster 2.0 era are designed to provide the right information, at the right time to the right person. Turoff, Cumer and Van de Walle in their seminal paper "The design of a dynamic emergency response management information system (DERMIS)" examine requirements and design principles for information systems to be used during crisis response and emergency management

(Turoff et al. 2004). The DERMIS principles and premises have provided an important frame of reference for both the design of information systems themselves, as well as for the academic studies around those systems.

The focus of these design premises is on information systems used by formal emergency responders operating in an official or mandated capacity. Premises such as the 'need for training' or 'free exchange of information' are based on the analysis of information systems and processes in use by organizations and individuals with a formal role in the crisis management operations. In short, the scope of the DERMIS premises are the emergency response systems that are being designed, established and used by responding organizations.

The above-mentioned trends of the increasingly active role of communities in the information management during crisis response along the emergence of various day-to-day communication platforms show a fundamental shift in the design and use of information systems in crisis response. As information systems open up, 'common' applications are being used, and new actors enter the information eco-system, a re-examination of the DERMIS design premises is warranted.

In this paper we present the findings of an exploratory field study on today's use of information and information systems in crisis response and disaster management. The aim of this research is to uncover the explicit and implicit requirements of inclusive information system. Using the DERMIS premises for information systems design as an analytical lens, we examine how these premises manifest themselves in information systems with active participation of communities in the gathering, analyses and sharing of information during crisis response.

In the remainder of this paper we outline the methodology used, specifically focusing on our approach to revise the requirements and premises laid out in DERMIS to include community groups. Subsequently, we present a revision of the DERMIS principles to include the role of communities based on literature and interviews. Subsequently, we test and revise these adopted premises using a qualitative case study approach.

RESERCH APPROACH

This study combines theoretical and empirical work, as highlighted in Figure 1. The starting point was the development of a theoretical framework by mapping the DERMIS principles against the requirements brought about by the wide diffusion of ICT. These requirements were elicited through a literature review as well as through interviews with professional responders and digital volunteers. From there, we designed a first set of principles.

In a second step, we tested and revised the new principles in a field research case study in Jakarta / Indonesia. The study area was chosen because the population is frequently exposed to floods and crises. At the same time, there are active local communities that use digital tools to self-organize and improve their resilience, for example through community driven risk mapping or self-designed disaster preparedness measures. Our interviewees were selected to be representative for the main actors (communities, NGOs and public authorities). Throughout the field work 70 respondents were reached through 11 interviews, 2 focus groups and 3 workshops.

To focus on key drivers of change since the original DERMIS principles were published, we rooted our research in theories of coordination; information sharing; decision-making and resilience. The interviews aimed at investigating three main points: situations faced, and decisions made, information management (collecting, analysis and sharing), and the tools used to facilitate information exchange and communication. In combination with this semi-structured approach, we included open questions in an exploratory approach to investigate the priorities and requirements that of the actors identified based on their own experience with disasters. All details of the approach and interview guidelines are documented in the Deliverable 2.1 of the European Project COMRADES[1]. This interview protocol is centered around decisions and decision making processes, the use of information in these processes, and the information tools and methods to obtain and share this information (Lipshitz et al. 2001). To complement this approach for eliciting requirements for new technologies, we also used an Ushahdi-based[2] instance for crowd sourcing to demonstrate the possibilities of crisis mapping in hands-on tutorials in workshops. The workshops aimed at triggering critical thinking about the current situation compared to the platform capabilities and receive feedback from the actors on the platform design. The data gathered from the interviews and the workshops was then analyzed to update and revise the integrated DERMIS principles.

The data collected from the various interactions and observations, such as interviews, field visits and workshops has been recorded in a case-study based field research approach. The collected recordings and notes have been transcribed and subsequently tagged using the adapted -integrated- DERMIS premises, serving as example design and implementation elements of information systems that contribute to a more integrated information system between communities and formal responding organizations.

[1] https://www.comrades-project.eu
[2] https://ushahidi.io

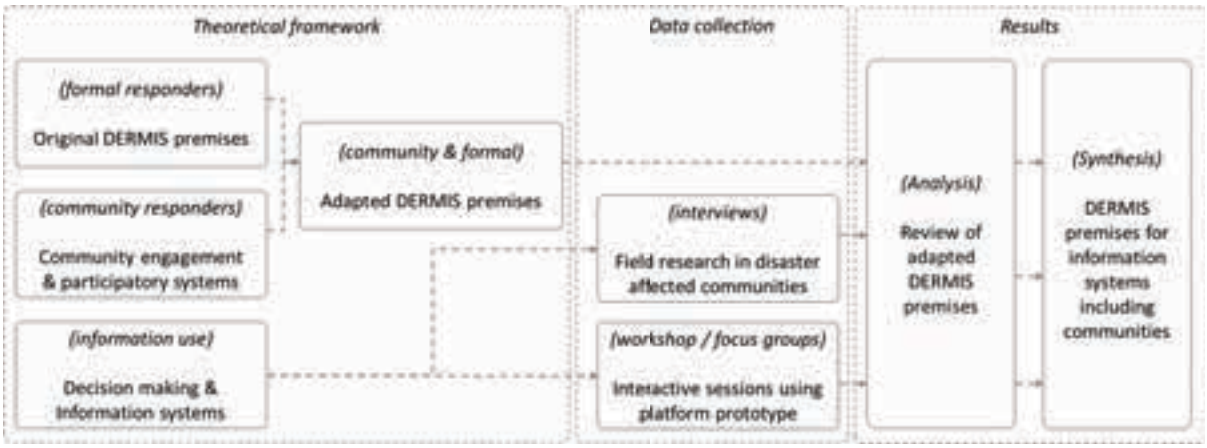

Figure 1: Research methodology

DESIGNING INTEGRATED DERMIS PREMISES

Building on the existing DERMIS premises, we examine how information systems emerge, are designed and used during emergency response in which the affected communities play in active role in the disaster preparedness and response. For this we design the DERMIS premises to be integrated with the existing literature on decentralized coordination, decision making and the use of information systems in such contexts.

Decentralized coordination and decision-making

In the following, we highlight three characteristics of the decentralized coordination and decision-making in disaster relief 2.0 that need to be considered in designing principles for information management: (i) the lack of formal decision support; (ii) the fragmentation and poly-centricity; and (iii) the need to embrace emergence and to design for the context.

(i) Particularly at community level, the decision-making processes for decisions established via analytical models or optimization are often too rigid, too consumptive in terms of resources and cognitive capacity, or simply ineffective. As a result, operational decision-makers typically find themselves engaged in intuitive forms of decision-making (Comes 2016b). Such naturalistic decision-making (Lipshitz et al. 2001) and the connection between sensemaking and decision-making (Gralla et al. 2016; Muhren et al. 2008) or sensemaking and coordination (Van de Walle et al. 2016) have not been translated yet into formalized guiding principles that help design decision support or information sharing taking into account the conditions and requirements of the field.

(ii) A key feature of crisis situations is the multiple agents and units who will perceive themselves, rightly or wrongly, to be in a leadership position or a vital element in the formal chain of command. Dave (2012) in his assessment of ICT for disaster risk reduction in India highlights for example the complex web of government institutions that are involved in handling disasters. Similar phenomena have been observed for different instances of crisis response in Europe (Noori et al. 2016). More recently, Wolbers et al. (2018) introduce the idea of fragmentation in crisis response, highlighting the need for decentralized and local decision-making even for professional responders.

(iii) Frustration with tools owing to lack of coverage and access, complicated interfaces or language barriers will lead communities of reporters, but also professional responders and volunteer & technical communities to revert back to the simplest possible means of communication, particularly in the immediate response (Altay et al. 2014; Comes et al. 2015; Landgren et al. 2007; van den Homberg et al. 2014). The design of information systems must take into account how workflows and processes emerge in the field rather than striving to change patterns that are deeply rooted in cultural and behavioral structures.

DERMIS premises & adaption to decentralized coordination

In the paper by Turoff et al. (2004), based on the various requirements and design approaches, the authors present 9 premises that have been found to be key considerations in the design of information systems used in management of a crisis response. For each of these 9 premises we consider how they can be adapted to reflect the three characteristics of decentralized coordination and decision making listed above.

Premise 1 - System Training and Simulation: "A system that is not used on a regular basis before an emergency will never be of use in an actual emergency."

The operational circumstances of an emergency will allow little room for users to acquaint themselves with a new system. Therefore, authors state that if a system is not used frequently, it will likely not be used during an emergency as users may not be or no longer are familiar with the system. The adoption of systems by communities is driven from different motives then those of formal responders. Where formal responders can be trained in certain systems and processes, or exercise with them during exercises, communities need to rely on different approaches for the adoption of systems (Craig et al. 2002). As communities and community members will not have access to or infrequently use bespoke systems for crisis management, systems that are part of the 'daily life' in communities will be used.

> *Adapted Premise 1:* "Community information systems during crisis response build on systems used in daily (normal) life."

Premise 2 - Information Focus: "Data and information needs to relate to the users dealing with the disaster."

Information systems need to include operationally relevant information. This information needs to be easily accessed, retrieved and represented in a useful format. This includes interactive approaches and dynamic maps, in which users can customize the information they see. Information streams generated to support professional response are currently dominated by advocacy and programming decisions (Comes 2016a). However, information should be relevant to the end-users, as this generates an incentive for user to keep contributing information. It is important to consider activities in communities and examine how these could be strengthen or improved through information. In other words, information in the platform has to be relevant and tailored to a specific user, for example agriculture information may only be relevant to farmers, whereas weather information (alerts) is relevant to the wider community (Paulus et al.).

> *Adapted Premise 2:* "The resilience platform needs to subscribe to the principles of reciprocity and make relevant information available to users at community-level"

Premise 3 - Crisis Memory: "Learning and understanding what actually happened before, during, and after the crisis is extremely important for the improvement of the response process."

A culture of continuous learning should be implemented. This includes a culture of collective mindfulness, and the willingness to learn from past failures (Weick et al. 1999). There are too few reflections and lessons learned due to the reactive nature of crisis interventions and lack of professionalization and training at local level, as well as the lack of an easy to use platform that tracks and monitors events and actions as they unfold over time. Moreover, communities have significant and relevant knowledge about their community, including risks and opportunities related to their resilience (Mayunga 2007). Systems could enable communities to make this knowledge explicit and accessible to both the community and external stakeholders. Communities can also serve as the institutional memory due to their continued presence, the past experiences, and local knowledge.

> *Adapted Premise 3:* "Support the communities in knowledge capture and create an institutional memory which can be shared with other stakeholders."

Premise 4 - Exceptions as Norms: "Almost everything in a crisis is an exception to the norm."

Systems need to be able to adapt to the respective context, in terms of language(s) or pictograms; coverage and network; key issues and needs in the crisis; expertise, skills, and time available of the user. Crisis response information systems rely on standardized products and tools, resulting in the (relatively) rapid and predictable production of e.g. maps, reports, contact lists. Information tailored to the specific context of a disaster, however, is typically not produced, and only available by direct requests. Information systems need to become flexible and agile to adapt to the respective context, in terms of language(s) or pictograms; coverage and network; key issues and needs in the crisis; expertise, skills, and time available of the user (Streefkerk et al. 2014). Furthermore, the systems should also be able to scale up and down, in crisis situations. This is for example an increased flow of information and data, but also multiple (different) users, such as international agencies who can 'plug into' the platform and integrate their systems, making the platform a bridge between the community and other stakeholders (Muhren et al. 2008).

> *Adapted Premise 4:* "Any system developed needs to be able to adapt and be a good fit and tailored to the local context with relevant connections with other systems."

Premise 5 - Scope and Nature of Crisis: "People, authority, and resources need to be brought together at a specific period of time for a specific purpose."

Platforms should support joint data collection and sharing. Despite discussions on interoperability and joint efforts, NGOs and agencies alike are still being asked to fill in different data collection forms across communities. Multiple assessments take place in some areas and no assessments in others; data is collected in different formats by different agencies; and information is not being shared effectively. Information and communication technologies enable contributions from remotely working experts and volunteers. However, with the increasing intervention of people not familiar with the context, control and "ownership" of a crisis may shift towards remote levels. At the same time, communities can contribute important information but require other information to support their decision-making process and maintain their own ownership (Tran et al. 2009).

> *Adapted Premise 5:* "While working on and contributing to a shared set of information, a system can serve different stakeholders each with their own information needs."

Premise 6 - Role Transferability: "It is impossible to predict who will undertake what role. The actions and privileges of the role need to be defined in the software, and people must be trained for the possibility of assuming multiple or changing roles."

Processes and procedures need to be established that give authority to collect and process information to specific roles. Particularly tacit privileges, norms and codes of conduct need to be made transparent through better training and good governance, bringing together tools and practices. At the same time communities undergo changes, so a system should be transferable and aligned with community structures, rather than individual persons. Moreover, the platform should also be able to adopt incoming stakeholders and provide them with the correct role and acces to a system, as well as the information management practices in the community (Smith et al. 2000).

> *Adapted Premise 6:* "Communities undergo changes, so the platform should be transferable and to ensure sustained adoption the platform should fit into community structures and processes."

Premise 7 - Information Validity and Timeliness: "Establishing and supporting confidence in a decision by supplying the best possible up-to-date information is critical to those whose actions may risk lives & resources."

Information cycles need to become predictable and transparent, such that decision-makers can deliberate if the information is sufficiently reliable to decide, or if it is worthwhile to wait for more. This requires that data about the time of the information collection, and its inherent uncertainty, as well as potential implications in terms of humanitarian needs is clearly represented and communicated. Standardized products are available in a relatively short time, though sometimes at the cost of not fulfilling specific information requests. For more specific information needs, it typically takes a longer time to collect, compare and process information. A system should support not only single updates but support a continuous information management process to support forecasting (Kapucu 2008; Thompson et al. 2006).

> *Adapted Premise 7:* "Enabling users to continuously exchange information will add a temporal factor to the information, allowing users to identify trends and developments over time"

Premise 8 - Free Exchange of Information: "Crises involve the necessity for hundreds of individuals from different organizations to freely exchange information, delegate authority, and conduct oversight, without the side effect of information overload."

Shifting formats and the use of different languages hamper access to information, particularly for local actors and emerging actors that do not comply to international humanitarian norms and rules (Harmer et al. 2005). In conflicts, information is often not shared, not even with partners or within the same organization. Standardization and inter-operability of tools and platforms need to be improved, enabling easy access, and offline-modes of work. Common Operational Datasets (CODs) and other information need to be made commonly available and updated at community level. Clear protocols and procedure for sharing information need to be established.

> *Adapted Premise 8:* "Standardization and inter-operability of procedures, tools and platforms are critical, enabling easy access, and offline-modes of work."

Premise 9 – Coordination: "The crux of the coordination is that the exact actions and responsibilities of the individuals cannot be pre-determined."

Research has shown that decisions for disaster coordination are mainly facilitated through organizational structures, collaborative decision processes, and the contribution of advanced information and decision-support systems, all of which are highly interdependent (Chen et al. 2008). While exact actions cannot be predetermined, coordination relies on feedback on the prevalent situation. Response plans are therefore subject to constant change and updates as new information becomes available. Policies that will be developed here will therefore take into

account this flexibility, in order to avoid "threat rigidity", i.e., people following pre-defined, rigid responses while not taking into account the reality of new threats in the crisis situation (Staw et al. 1981). Communities are actively working on their own resilience and have developed structures to support themselves and each other in disaster situations. Rather than supporting a complete or fixed resilience building process, the platform should provide various bits and pieces that communities can use, integrate and apply as they see fit.

> *Adapted Premise 9:* "Any system should not be directive in nature, but rather be flexible to adopt to the structures and process of a community and support self-developed process and goals of the community."

CASE STUDY

To validate the above-mentioned adapted DERMIS premises, with the inclusion of community participation, a case study has been conducted as part of a larger research project related to development of community driven information systems and approaches. The case study is centered around Jakarta, Indonesia, home of 10 million people and it is considered as the fastest sinking city in the world (Chaussard et al. 2013). It has the Java Sea and about 13 rivers running through the city, this continuous influx of water, compounded by the rapid and dense urbanization of the city the capacity of the city makes the city prone to flooding (Abidin et al. 2011).

The study was conducted in November 2018, shortly following the Sulawesi Earthquake and Tsunami and amidst the ongoing efforts of local, national and international agencies to provide assistance to the affected communities in Palu. While our research did not focus on the Sulawesi disaster, the presence of many international agencies and coordinating bodies provided unique opportunities to evaluate the use of information systems in real-time and reflect on the use of information and information systems in these events with the interviewees.

Interviews & Observations

Overall a total of eleven interviews were conducted within two communities in different regions of Jakarta. One situated in Marunda, a frequently affected coastal area which faces both tidal and riverine flooding. And the second in Kampung Melayu, affected by frequent riverine flooding. The interviewees included community leaders of both areas, various community members from diverse backgrounds, including teachers, (factory) workers, youth, families, and elderly people. The interviews took place in the neighborhoods themselves, using a semi-structured approach following the above introduced interview protocol centered around the topics of decisions and decision making, the related information required for these decisions (sources, availability, reliability etc), and the information management approaches and technologies used to facilitate this information exchange.

Figure 2: Location of the case studies

Focus Groups & Workshops

In addition to the interviews, the case study also involved focus group sessions with members from (previously) affected communities and formal responders. One focus group was held with five members of a community group actively mapping hazards and risks in their area using the Ushahidi-based COMRADES platform. The second focus group involved a 'Community Coordination Team' responsible for enhancing community disaster preparedness and response.

Furthermore, three workshops were held with members from the V&TCs and affected community to assess and reflect on the usability of an information system designed to exchange information with communities. One workshop was with members of Humanitarian OpenStreet Map, an experienced actor in the field of open mapping for enhancing humanitarian action and community development. A second one was with organized at Pulse Lab Jakarta, a joint initiative of international and national governmental agencies with expertise in the field of big-data and real-time analytics. The final workshop was organized with students from the University of Indonesia. While the first workshops provide insight from experts, which are generally equipped with the required knowledge and skills for information systems design, the latter provided the perspective from local community members.

RESULTS

Using the results from the interviews, workshops and focus groups we review the adapted DERMIS premises. In the following section we review each of the premises and examine if they can be identified in information management approaches and information systems used by communities in the response to crisis situations. Additionally, we look for examples in information systems that are used to exchange information with communities to further if and how these design principles can be manifested in specific examples.

Adapted Premise 1 - Integration into 'daily'' information systems.

The approach of gathering relevant information, according to different community members, is highly personal. Young adults may use social media networks like Twitter or Facebook to search for information while elders rely on their personal knowledge or obtain information from traditional media such as TV. Nevertheless, communication between community members is performed through WhatsApp where they are connected through different groups to family members, community leaders, and in some cases, government officials. The interviews illustrated that in emergency situations, there is usually neither time nor capacity to implement unfamiliar mechanisms. Systems need to be adapted to local the context and capacities and should thus be developed in close collaboration with local partners and integrated in regular and commonly used information systems.

Nov 6, 2018 - Marunda, North-East Jakarta, Indonesia, a community Leader is showing WhatsApp on his mobile phone:

"When flooding occurs, we use mobile phones to inform and be informed by the people in our community. WhatsApp and Facebook are our most important communication tools"

Figure 3: WhatsApp groups used in the community during flooding

Adapted Premise 2 - Reciprocity and offer relevant information

The interviews illustrated that people require specific meaningful information to actively use in decision-making. For instance, the mention of an expected flood holds limited value for a community member, unless the height of the water at the flood gate is mentioned too, as this is used by individuals to assess the likelihood of being affected. At the same time various responders noted that their content is not designed to specifically meet the needs of the affected communities but rather about compliance with standard operating procedures or accountability. With the increased availability of information during crisis situations, one of the challenges is to ensure relevant information is identified and presented to the communities. For this active consideration of the information needs of other information users is needed. While these needs differ between communities and crisis, the ability for a system to support addressing specific information needs should be a key design consideration.

Oct 30, 2018 – South Jakarta, Jakarta, Indonesia, Humanitarian OpenStreetMap team Indonesia

"COMRADES and the new services helps us to better understand unstructured information and find relevant information for different users"

Figure 4: Humanitarian OpenStreetMap using the platform for analyzing community provided reports

Adapted Premise 3 - Support the communities in knowledge creating and capture

The interviews illustrate that there is a vast amount of tacit knowledge developed through past crises on which communities rely to identify and assess the potential impact of crisis or hazard. Information systems can make this tacit local knowledge available to other key stakeholders to identify important of information about the local context. Vice versa, systems can support the community members in effective use of their local knowledge when the right information is delivered. An example thereof, mentioned by community members, is the lack of information regarding possible secondary effects. During recent floods for example, additional rises in the water level occurring after the first flood event were not known to the community, although this did happen in the past. If information about the water levels was continuously provided, community members would possibly make different choices such as evacuation as they had done in previous longer lasting flooding events.

Nov 4, 2018 – South Jakarta, Jakarta, Indonesia, Community Member illustrating floods

"We know what water levels are normally expected when a flood is announced, and we have taken measures to deal with these. However, we don't always have the information to determine if this is going to be worse or not"

Figure 5: Community member illustrating the height of previous floods

Adapted Premise 4 – Tailoring to local context

The communities in our case study are regularly affected by small floods, and therefore not every flood may be cause for alarm or a larger scale response. This example illustrates the need for an information system to be tailored to a local context. Building on the other points of ensuring that information systems are relevant and integrated into community structures, information systems should be able to deal with a range of expectations: the next disaster can fit the regularity of past ones, but it can also be a lot more destructive. In other words, the systems need to be designed in a way that they address frequent emerging information needs in the local community. This enables people to become familiar with information systems and sharing approaches throughout the community.

Nov 4, 2018 – South Jakarta, Jakarta, Indonesia, Community Leader

"It is difficult for me to manage the community response because everyone was doing their own thing without sharing information, eventually leading to a lack of information for decision making."

Figure 6: Community leader along with several community members

Adapted Premise 5 – Tailored presentation and analytics for different stakeholders

Interviewees indicated that allocation of people, authority and resources in case of disasters are a combination of predefined protocols and roles, but also on-the-fly adaptation. In each disaster and community, different people may fulfill a certain role, for example community leaders may share information with community members and/or mediate within other communities and government agencies. Formal responders indicated it would be valuable to identify specific roles of community members in a response, for instance to collect and share information on community needs as this allows the design of information systems to support these roles. However, flexibility in this approach is required since relations and roles differ greatly between communities and disasters. Therefore, a tailored information provision approach, designed for a specific role or decision-making process, is needed.

Nov 4, 2018 – South Jakarta, Jakarta, Indonesia, Community Leader

"We have risk and flood maps provided to us by government agencies, but not everyone has access to the map, knows how to read them or understands what is means for them."

Figure 7: Risk map of community on display in community hall

Adapted Premise 6 - Fit into community structures and processes

The interviews portrayed strong community structures that play a crucial role during emergencies, for example community leaders play an important role in the coordination and exchange of information. In one community a youth group was tasked to use Ushahidi to collect data on risks and hazard in the community. This newly formed group was formed by the community and support by the information system to execute their task. To ensure sustained adoption the system should fit into and support the community structures. The technical complexity of an information system however, requires certain capacities not present in the community themselves, but could be provided by technical volunteers, NGOs or government agencies.

Nov 6, 2018 – North Jakarta, Jakarta, Indonesia, Youth Risk Mapping Group:

"We are using (mobile) technology to continuously asses the risks in our community and use that information to update our disaster preparedness plans"

Figure 8: Youth Risk Mapping group during a focus group discussion

Adapted Premise 7 - Enabling users to continuously exchange information

Interviewees indicated the need of people to have real-time information. An interview with an NGO specialized in the mapping of data for increased resilience indicated furthermore that only real-time usage of data prevents misinformation or information overload. Information provided should focus on the information required for decision-making in that situation. A professional responder with vast experience also indicated that beneficiaries should not be kept in the dark when information is unknown. Information systems should support communities in not only once-off sharing of information but rather managing a continuous stream of information to and from other stakeholders, including other communities' members, NGOs and government agencies.

Nov 7, 2018 –Jakarta, Jakarta, Indonesia, University of Indonesia. A student assuming the role of community leader during a simulation:

"During the simulation it was difficult to maintain an overview as messages from our community members keep coming in via WhatsApp, the situation was constantly changing"

Figure 9: Students building a situational overview during a simulation

Adapted Premise 8 - Standardization and inter-operability of tools and platforms are critical

Communities have information that is relevant to various other stakeholders, such as experiences from previous crisis events, information about the local context and knowledge on their capacities and vulnerabilities. This local knowledge, while valuable, can be disconnected from the formal response. As communities are increasingly also active in the gathering of data as multiple interviewees indicated. A system should assist communities in the connecting their own information management approaches to formal responses. Vice versa, information available to formal responders and their agencies should be shared back to communities.

Nov 9th, 2018 –Central Jakarta, Jakarta, Indonesia. After a demonstration of connecting to the Facebook Messenger and the Humanitarian Data Exchange:

"By connecting to Facebook and the Humanitarian Data Exchange, COMRADES show how to bridge gaps across communities and international organizations"

Figure 10: Demo sharing data via Facebook Messenger with the Humanitarian Data Exchange

Adapted Premise 9 - A system should not be directive in nature

Communities are actively working on their own resilience and have developed structures to respond to disaster situations, often with already set actions and responsibilities and communication channels. However, specific approaches are dependent on the disaster and cannot be fully predetermined. Agency of decision-making lies with community members and complexity increases when information is not available. A system can assist in coordination of non-predetermined actions and responsibilities by informing users on who is doing what and provide checks for accountability. In both the response and preparedness, the information provided serves as trigger and support the decision-making process. I.e. the information provided does not prescribe a certain action but rather supports the user in making informed decisions.

Nov 4, 2018 – South Jakarta, Jakarta, Indonesia, Sunday school Teacher

"Based on the information and support we have received on the risks (flood maps) in our community we have designed our own evacuation routes that we maintain ourselves"

Figure 11: Community designed & maintained evacuation routes

DISCUSSION

The results show that the various DERMIS premises and considerations are relevant and important to the design of information systems in which communities are an active stakeholder and user. Nevertheless, with the existing DERMIS premises mainly focused on the design of information systems for formal responders, the involvement of communities requires a revision of these design principles. While the results above are based on a limited case study through anecdotal evidence, the adapted premises are recognized among both communities and formal responding agencies. Moreover, the results highlight the importance of reconsidering the design principles when involving communities directly in the gathering, analysis and exchange of information. Even though these collected data needs to be closer examined, and the findings further validated, these initial results indicate important considerations for the design of information systems that recognize the role of communities in the information management process.

DERMIS premises applied to community-included information systems

The inclusion of communities as a key stakeholder requires the re-examination of the design principles. The results show that the while the initial ideas of the DERMIS principles still hold true, there are additional implications to be considered. Aside from the above listed results for each of these premises, we found that throughout the interviews, workshops and focus groups several discussions were recurring.

In the design of information systems for community involvement trade-offs have to be made. In contrast with formal responding agencies, communities have other concerns, priorities and core activities (Mayunga 2007; Paton et al. 2001). As such the design, use and maintenance of information systems designed for emergency response management has to be contrasted with these other activities. This requires a balancing trade-off in investments (time, financial, resources) with the prospected benefits of such as system (Liu et al. 2004).

Adoption & Reciprocity

These considerations are closely linked to the adoption of a system. Throughout the interviews and other interactions various other design elements that have proven to be crucial for ensuring an effective information exchange between communities and formal responders have been identified. Finding partners and the embedding of an information system in the community is a key aspect to ensure that these systems are adopted by communities. This applies to communities even more than formal responders, as there is no often mandated need, formal procedure, or ‘pressure’ to force communities to adopt and use a certain system or information sharing approach (Kapucu 2008; Neef et al. 2014). Nevertheless, there are several measures that can be taken to lower the adopting barrier. First and foremost, building on existing systems, familiar concepts, and in line with existing capacities reduces the need for training and capacity building (Butler et al. 2002).

The recurring and key elements throughout all our interviews however is the engagement and reciprocity of a system. Ensuring that a system provides an added value for the community, ideally on a regular basis and in frequent recurring activities in contrast to systems designed to be used solely during exceptional events. Furthermore, to establish this reciprocity, information systems should cater to the different information needs of users and stakeholders (Janssen et al. 2010).

Emergent nature & adaptive design

Designing information systems for crisis response and disaster management with the inclusion of communities is challenging. First, communities across the globe have different characteristics, not only in terms of the hazards faced or their resilience to withstand them, but also in their capacities and capabilities to provide, use and maintain information and information systems. In short, different disasters affect different communities differently, and due to the volatile and unpredictable nature of disasters the exact requirements of these systems cannot be pre-determined (Kapucu 2008; Maguire et al. 2007). Secondly, at the same time technologies and their use in communities also rapidly change. All these factors combined make it difficult to plan and design information systems for the inclusion of communities ahead of time. Rather it requires deployers of information systems to tailor to the specific requirements of one or more communities before but even during an emergency response.

Although including communities in the design of information systems requires a significant amount of flexibility, adaptability, and resources of information systems and their users, the return of these investments are not only the improved information flows which in turn support the decision-making process. They also support the creation of a more comprehensive and inclusive information system in which different stakeholders -not in the least the communities themselves- have access to and the ability to update relevant information (Craig et al. 2002). Finally, we note that an information system should *trigger* community engagement on response, recovery and long-term

preparedness, but not necessarily organize these efforts in the long term as this often done by communities themselves using their own knowledge, structures, capacities and capabilities. In other words, a system should not be directive or prescriptive but rather provide input, feedback and support into community-based decision-making processes (Almedom 2008; Mayunga 2007).

CONCLUSION

The critical role of communities in disaster response and emergency management is increasingly recognized by various agencies and initiatives. Even when affected themselves, communities have the potential make a valuable contribution to effective disaster response for example by providing access, resources or local knowledge. Today, communities, more than ever before, have options to actively engage and exchange information with responding agencies and the wider public (Crowley et al. 2010).

As information and communication technologies become increasingly more common throughout the world, more and more people gain access to new opportunities to collect, analyze and share information. These developments are supporting the increased democratization of information, not in the least during emergency responses. An increasing number of platforms, initiatives and projects emerge that support and encourage new and old players to participate in information management processes in the response to a disaster.

These increased trends of active participation in the decision making and information processes of communities, require a re-examination of the design and approach used in information management systems. When properly designed information systems not only facilitate the information exchange between different groups such as communities, formal agencies and volunteer organizations, but contribute to a more efficient and effective response by actively addressing information gaps, transforming data into actionable information and presenting relevant information to empower different users in their decision-making processes (Comes et al. 2017; Kapucu 2008).

Limitations & Future research

The work presented in this paper reveals the initial results of the ongoing work for community inclusive information systems design for crisis response and management. Building on the DERMIS premises for the design of information systems for emergency response, we have re-examined these design principles in light of the developments of increased participation of communities in information management processes and activities.

The results presented in this paper are based on a single case study conducted in Indonesia in the wake of 2018 Sulawesi Tsunami. Future work would not only focus on strengthening these results by verifying these findings in multiple studies including different contexts, but also extend beyond the current DERMIS principles. The scope of the planned future work includes the identification of possible additional principles, some of which -such as reciprocity- are highlighted already in the discussion. Future study would there focus on a more grounded approach towards identifying critical design elements and success factors for inclusive information systems. Additionally these studies would also examine the trade-offs between various design principles as well as the fit with local circumstances, capacities and resources in particular in the aftermath of a disruptive event.

While this single case-study and the preliminary results do not provide a comprehensive review of the DERMIS design principles in light of community inclusion, the results do indicate important findings that warrant further examination. Especially in light of the ongoing democratization of information and information systems, with more and more communities gaining access to and the ability to share information during disaster responses.

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