NOVA IMS Information Management School

DOCTORAL PROGRAMME

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Specialization in Geographic Information Systems

Enhancing geospatial preparedness for disaster management through the work of development organisations

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Abstract

Depending on the complexity of a disaster and the local capacities, international organizations and multidisciplinary response teams might be involved in the response. Geographic Information Systems (GIS) are used for coordination and information sharing. However, geospatial preparedness is necessary: reliable up to date geodata, tools, and people with the knowledge to use those tools. In least-developed countries the lack of geospatial preparedness, particularly geospatial pre-disaster information, hinders disaster response. In those places, the United Nations Office for the Coordination of Humanitarian Affairs creates a framework for cooperation with the Coordinated Data Scramble Initiative where Information Management Officers (IMOs) from different organisations are supported by volunteers and technical communities to provide ad-hoc datasets and infrastructure to use GIS. Nevertheless, long-term solutions are needed. Before the disaster, Non-Governmental Organizations (NGOs) might already be using GIS to implement development projects. Based on the theoretical concept of disaster management and development as a learning circle, this investigation proposes the engagement of development NGOS working in disaster-prone areas to enhance geospatial preparedness. The research was based on a multi-method approach including the study of the body of literature, authoritative reports, and repositories and databases, monitorization of the tools used during responses to real emergencies, and semi-structured interviews to IMOs. Finally, the study concluded with an online survey with a worldwide sample of more than 200 development NGOs. The result show that disaster response requires reliable and up to date geodata which is not always the case. Humanitarian missions often rely on OpenStreetMap as a source of information to overcome this limitation. Therefore, improving OpenStreetMap would improve geospatial preparedness. Many development NGOs use digital geographic information, mostly open-data. They could indeed improve geospatial preparedness allowing community empowerment while conveying relevant pre-disaster datasets to the humanitarian missions. This bottom-up approach would allow for the inclusion of information relevant to the community in the disaster response decision-making process. There is, however, a limitation; most of these development NGOs are not familiar with the platform used by the humanitarian community (i.e., OpenStreetMap). Therefore, the sustainability of this synergic approach requires further harmonization between development and humanitarian organizations working for the wellbeing of the same communities.

Keywords: GIS, disaster response, geospatial preparedness, OpenStreetMap, open-data, inequity

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1. Introduction

1.1. Research background and problem definition

Communities are inextricably linked to the environment creating an economic and cultural dependency. This interaction with the surrounding environment may increase the pressure in already fragile ecosystems becoming more vulnerable to hazards[1] and changes. In addition, long-term affecting factors (i.e. socioeconomic factors, climate change, etc.) also affect this balance. Communities are exposed to natural hazards (i.e. earthquakes, hurricanes, tornadoes, floods, tsunamis, sea level rise, landslides and avalanches) or induced by human processes (environmental degradation and technological hazards). This exposure might lead to disastrous situations depending on the vulnerability[2] of these communities. When local authorities cannot cope with the consequences of a disaster[3] the UN intervenes to support the coordination of the international aid.

Geographic Information Systems (GIS) are a tool commonly used for disaster response coordination. Nevertheless, there are some requirements for GIS to be effective. In countries with adequate disaster mitigation strategies there are databases with up-to-date information readily available to organize the response, there are tools to use and share that information and people with knowledge to use those tools. It may be referred as geospatial preparedness (DHS 2004). In this context, availability of reliable pre-disaster data is paramount to geospatial preparedness (National Research Council. 2007). In those places, public and private sectors use GIS for their daily operations therefore geospatial data is abundant, reliable and maintained up-to-date.

Around the world, however, there are different levels of vulnerability, preparedness and response. The level of geospatial preparedness varies greatly and, in some cases, does not exist at all. In those cases where international support to the disaster response is necessary,

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[1] Hazard: *"A potentially damaging physical event, phenomenon or human activity that may cause the loss of life or injury, property damage, social and economic disruption or environmental degradation. Hazards can include latent conditions that may represent future threats and can have different origins: natural (geological, hydrometeorological and biological) or induced by human processes (environmental degradation and technological hazards)"* (UNISDR 2005) (also referenced at http://www.unisdr.org/we/inform/terminology)

[2] Vulnerability: *"The characteristics and circumstances of a community, system or asset that make it susceptible to the damaging effects of a hazard."* http://www.unisdr.org/we/inform/terminology

[3] Disaster: *"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."* http://www.unisdr.org/we/inform/terminology

Information Management, including GIS, needs to be built ad-hoc by the emergency response teams. Different organizations (i.e. UN institutions, private sector, NGOs and the international community of volunteers) work together to create datasets "on the spot". It takes precious time to make this information available to the decision-makers that coordinate the response. Part of the data is disaster-related but there is also need for pre-disaster information (just because it does not change with the disaster or to be used as base-line for recovery).

These issue is especially acute for least-developed countries and small islands (UNISDR 2015). In these cases, there is an acute need for information to coordinate the international support to disaster response. As the Sendai Framework for Disaster Risk Reduction 2015-2030 (Sendai, Japan, 14-18 March 2015) indicates *"[…] it is important to (a) Promote the collection, analysis, management and use of relevant data and practical information. Ensure its dissemination, taking into account the needs of different categories of users, as appropriate […] (f) Promote real time access to reliable data, make use of space and in situ information, including geographic information systems (GIS), and use information and communications technology innovations to enhance measurement tools and the collection, analysis and dissemination of data;"* (UNISDR 2015) (p. 9/24). Promoting geospatial preparedness in least-developed countries is an effective disaster risk reduction strategy, and pre-disaster data collection is fundamental to this task.

Frequently, there are Non-Governmental Organizations (NGOs) implementing development projects in disaster prone areas. Disaster management and development projects can be considered as part of a learning cycle to improve human wellbeing in changing environmental and socio-economic conditions (Desai and Potter 2002). Therefore, it is possible to explore the synergies between development NGOs and disaster responders (San Martin 2014). *Development NGOs* may use GIS to plan, monitor and evaluate their projects. The information standards and formats used for development projects and humanitarian aid might be different but in many cases they cover similar topics. The main focus of the present research is to study a possible synergic approach to the use of GIS for development that could improve geospatial preparedness for disaster management in least-developed countries. The present research aims to explore the possibilities of using these development NGOs to make reliable up-to-date data available to humanitarian aid missions.

1.2. Relevance

In the aftermath of a disaster, when major decisions are taken, there is a high demand for and low supply of information. In this context, the lack of geospatial preparedness hinders disaster response coordination. Information Management Officers lose precious time to obtain basic geospatial pre-disaster data necessary to make information available to the decision makers. The origin of the problem is that local authorities might lack the capabilities to gather and/or to share that data. Geospatial preparedness is, however, and area that has not being habitually addressed by academic research in this context.

In many cases, these countries lack institutions to provide all the services needed by the society. Often, development programmes are implemented not by the authorities but by NGOs with funds from international donors. For many, including most donors, these organizations have become the centre of civil society. NGOs have become service providers and reliable partners for governments and international institutions (Lewis and Kanji 2009). NGOs, including development organizations, cover the needs that the official institutions cannot satisfy. In addition, development NGOs that face this task through participatory approaches could address other needs highlighted by the Sendai Framework for Disaster Risk Reduction considering the integration of traditional and local knowledge and the collaboration among people at local level (UNISDR 2015). Community implementation contemplates the inclusion of socio-economic factors in the information management system, while the development of technological skills empowers the community and provides ownership of the project. This approach allows empowering the community while bringing long lasting benefits to development and humanitarian organizations and the communities at the centre of their work. Regardless of the benefits, even fewer researches might be found in the potential use of participatory approaches to improve geospatial preparedness. Considering the consequences of lack of information during disaster response, the outcomes of this research might be significant to the wellbeing of the communities.

1.3. Definition of the research questions and objectives

The objective is to find a methodology that allows addressing the geospatial preparedness inequity issue, providing vulnerable communities with a tool that might allow improving geospatial preparedness and facilitating the coordination provided by the UN disaster response system. In this context NGOs working in development projects are considered the representatives of the local communities and reliable partners for the international humanitarian community.

Therefore, the main research question could be definite as:

> Is there a practical approach that might allow local communities to improve geospatial preparedness in line with the UN disaster response system requirements?

In order to answer this question, there are other questions that should be addressed:

1. How is the UN disaster response information management procedure?
2. Which datasets required by this system can be considered geospatial preparedness? Is this information readily available everywhere?
3. Are UN information needs “compatible” with the development NGOs information management needs and methodology?
4. Is it possible, and useful, for the development NGOs to gather and use this data?

In line with these questions, the research should define a data gathering methodology that allows the communities in least-developed countries to provide data suitable for development projects management while improving geospatial preparedness for disaster response.

From this general objective more specific objectives can be identified:

1. Understanding UN needs regarding geospatial data for disaster response with especial focus on those that can be fulfilled improving geospatial preparedness. The objective is to consider what data used by responders can be prepared well in advance and the availability of that data;
2. Understanding the actual and potential use of GIS for the planning, monitoring and evaluation of development projects with especial focus on the data previously identified;
3. Studying the possible synergies of both communities.

1.4. Contributions

Research related to the Disaster Management – Development learning cycle should be multidisciplinary since disasters are multi-causal and development is a complex process. The amount and characteristics of the information, the type of analysis, the number and diversity of stakeholders, crosscutting issues and uncertainties require the use of well-defined procedures to reach conclusions and facilitate the decision-making process. Cost-effective solutions can be developed through a common approach and common tools. One of the main relations in this learning cycle is "geography". Geography is a complex reality full of synergies between space, ecosystem, society, culture and economy. Disaster management and development should be produced from the community related to this geography. A holistic and dynamic approach is required. The different actors and factors have to be studied considering space, time, interactions and feedback-loops.

The present research should confirm that investment in geospatial preparedness could improve information management during the response to a disaster. This is commonly accepted by the disaster response community in developed countries. Nevertheless, the confirmation of this general point is a prerequisite for this research and a contribution to the academic work in this area of knowledge.

The geographic data necessary to improve geospatial preparedness could also be relevant for the implementation of development projects. This hypothesis should be justified by the application to this particular case of the *Boundary object theory* which justifies the use as a common "object" useful to the UN disaster response system and to development organizations. In addition, the geospatial data defined should be not only suitable for the tasks realised by development NGOs but its management should also be within their capabilities. Thereby, development NGOs would be willing to gather and maintain information that can be useful to the community during development projects while improving disaster preparedness. The application of the *fit-viability theory* is central to support this statement.

Therefore, the present research aims to make a contribution to knowledge providing a base for the integration of geospatial preparedness to the work of development NGOs. This integration would be based in the identification of a boundary object common to the humanitarian disaster response community and the NGOs working in development projects. In addition, other contributions are linked to the study of the relevance of geospatial preparedness for the information management of humanitarian missions and the study of geospatial information management by NGOs working in development projects in least-developed countries.

1.5. Research strategy and methodology

"*Good research requires good design*" (Murray and Overton 2014) (p.19). Moreover, development research has peculiarities that require a careful planning.

This research has been approached with a *mixed-methods* (also referred as multi-method) strategy. The research design needed to be flexible to adapt the changing circumstances and findings. This problem-driven approach permits the use of different methods sequentially to "triangulate" the findings and develop the analysis providing different perspectives. The methods implemented in this case were the analysis of documents and databases, interviews and questionnaires. The analysis of the results was a combination of both qualitative and quantitative approaches. This is a pragmatic approach that tries to provide a complete picture of the issue (Denscombe 2014). This approach was necessary to quantify a subjective concept such as "usefulness" or "reliability" of information. The different steps of the research and their results are shown in Figure 1.

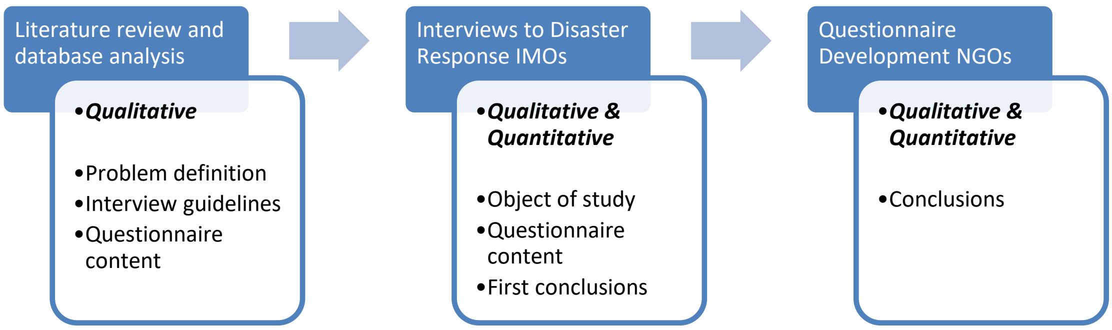

Figure 1. Methodology flow-chart describing the phases of the research and main outcomes

The research was initiated with the review of literature related to the use of GIS for the coordination of humanitarian aid, development projects and the synergies between both. In addition, the information management system and datasets created within this context were studied. In order to focus the study, the research considers a period of no more than 5 years from the beginning of the research (which covers the main development in the organization of GIS structures within the UN).

The next step was the study of GIS within the coordination tools used by the UN, the datasets necessary and the "utility" (i.e. usefulness) of having those datasets readily available. The study of humanitarian community working standards was accomplished through the qualitative and quantitative analysis of a selection of interviews to responsible persons within the UN institutions and collaborating organizations. The study participants were selected using a purposive sampling technique to identify key informants, followed by a snowball sampling to increase the sample (Denscombe 2014). The participants were evaluated base on their experience as IMOs working for UN institutions and/or volunteering for NGOs involved in disaster response humanitarian operations on-field and/or supporting remotely. The semi-structured interviews were conducted in 2016 and beginning of 2017. The selection of key informants was focused on providing a representation for on-field and remote supporters of the main stakeholders UN institutions and NGOs. In addition, the range of interviewers provided an insight vision of UN at local, and headquarters level and NGOs from volunteers to management level. Interviews were recorded, transcribed and coded manually following an inductive approach. The analysis considered seven a priori codes for topics directly introduced in the interviews. In addition, grounded coding identified eleven topics of common reference that occurred across interviews.

The results of the study were crosschecked with the tools used for the coordination of remote support to on-field IMOs. These tools were monitored during the actual response (i.e. Hurricane Matthew in Haiti on October 2016) and "a-posteriori" (i.e. Cyclone Winston in Fiji on February 2016 and Ecuador Earthquake on April 2016). They include an array of technical solutions including Skype room, Google Docs and Trello boards. The Skype room for the response to Hurricane Mathew was monitored daily from 14 October to 4 November (the historic of the chat was studied from its creation on 4 October). Trello board, documents shared through Google Docs and datasets uploaded to the Humanitarian Data Exchange repository (HDX[4]) were followed in parallel. It should be noted that 4 of the participants in the Hurricane Matthew disaster response team were also part of the study. The response to Cyclone Winston and Ecuador Earthquake were studied through the Trello boards and the datasets uploaded to HDX.

The next step was to determinate whether these outcomes are consistent with the information management needs and procedures of development NGOs. This part of the research was based in a survey to development NGOs. The online questionnaire was the result of previous research, the outcomes of the literature review described, and a semi-structured interview with an OpenStreetMap representative.

The research was conducted globally to avoid country or culture related biases. Purposive sampling techniques were used to identify organizations from several databases. In the second stage other networks and partners of the initial sample were used to identify further organizations within the target population. The resulting sample of 2684 organizations was

[4] *https://data.hdx.rwlabs.org/group/nepal-earthquake*

contacted by email or contact forms on the organization's websites, with a description of the study and a link to the questionnaire. In order to increase the size of the sample, the invitation to participate in the study requested to cascade the call to include further organizations within the target population. From 383 responses to the questionnaire (over 14% of the number of NGOs contacted), partial replies were disregarded and only completed replies were considered for analysis. The analysis of the Internet Protocol (IP) address of the device used to complete the questionnaire lead to dismissing further answers to avoid duplications. The final sample was therefore 204 answers. This sample was considered representative of the target population in view of the characterization of the participants and their geographical location. The quantitative analysis of the results was focused, not only in the "utility" of using GIS but in the "feasibility" within the capabilities of the different development NGOs. The proposal is providing a low-cost solution with the inclusion of the local community to provide ownership of the project and ensure long-term viability.

1.6. Literature review overview

Each individual article described in the following chapters includes a literature review in the particular topic. Therefore, in order to avoid duplication, this section aims to provide an overview of references relevant for the overall research that were not included in the independent articles. In addition, it includes an update in the state of the art already presented. The search subjects considered for those articles were: GIS data and analysis for disaster management, GIS data and analysis for Development and the synergies between both. The references found in the databases (i.e. web of science and google scholar) were filtered based in their relevance to the subject considering subsequently the title, abstract, and full content.

During the disaster management response phase information is needed to optimise the decision-making process. Geospatial data is needed to use those tools. In least-developed countries there is a gap between information needs and information availability. Pre-disaster data preparedness is needed to close that gap (Marc van den Homberg, Monné, and Spruit 2018).

A wide range of geospatial software is freely available to be used during the different phases of disaster management (Leidig and Teeuw 2015). Projects such as Missing Maps using open platforms (i.e., OpenStreetMap) for humanitarian assistance and disaster risk reduction has proven a great success (Scholz et al. 2018). The term "Collaborative mapping" might be better to describe the use of crowdsourced geospatial information to fulfil the collaborative edition of web-based interactive maps such as OpenStreetMap. The importance of this tools for disaster management is however limited by the use of remote volunteers during crisis mapping which is reflected in the quality of the data (de Albuquerque et al. 2016). Indeed, the usefulness of Volunteered Geographic Information (VGI) and the use of this information by the authorities are limited by the trust of the users (B. T. Haworth 2018). Therefore, collaborative mapping using remote VGI and WebGIS gains importance when integrates local volunteers. Missing Maps work in combination with local NGOS and communities can improve different phases of the disaster management cycle (Scholz et al. 2018).

In least-developed countries is common to find NGOs working in development projects. However, the possibility of Non-Governmental Development Organizations (NGDOs) improving geospatial preparedness has not been considered by the researchers. There are few studies in the use of geospatial information by the development community and those studies not always consider the use of free and open-source geospatial software. Only the need to integrate disaster risk management into sustainable development projects has been considered by studies focused on geospatial information. Earth observation, ground-based observation networks, crowdsourcing, WebGIS, and other tools can be used for this purpose. It has been remarked that these projects should consider the end users of the data products (Miyazaki, Nagai, and Shibasaki 2015). The information needs of the communities should be reflected in the projects. It is also important to consider the possibility of these tools supporting different aspects of sustainable development not only integration of risk management.

The study of Information and Communication Technology for Development (ICT4D) requires a transdisciplinary approach (interdisciplinary research with stakeholders involved in all phases) linking the academy to practitioners (Blake and Garzon 2012). Moreover, a “capability approach” focus to ICT4D through participatory, people-centred approaches is needed to ensure that human capabilities, not ICTs, are central to the development process (Blake and Garzon 2012). ICT4D gains a new meaning with the widespread use of mobile phones and internet connection in developing countries. This new meaning should consider technology, people and institutions (Heeks 2018). Therefore, ICT4D research should not have a top-down approach bringing “solutions” to “beneficiaries”. Researchers need to adopt a transdisciplinary and open approach allowing for engagement with users and practitioners (Walsham 2017).

The motivations behind the participation of the individuals in ICT4D projects based in open content differ from developed to least-developed countries. Individuals in least-developed countries might be more prone to contribute and work for free motivated by the overall development of the community (Pal 2017). The non-participants in this crowdsourced projects might be limited by lack of technical skills or linguistic barriers (Carraro and Wissink 2018). Nevertheless, the participation in itself would eventually empower the individuals and promote development from within the community.

In general, VGI should be considered as a complex social practice. Within VGI, community-based mapping is able to offer a more local and cultural approach (B. T. Haworth 2018). It is a tool that offers a great potential for development integrating the knowledge of the local communities into development projects, while providing empowerment and a sense of ownership (Sala and Dendena 2015). A question to consider is how this form of VGI is affected by digital divide which may produce the exclusion of parts of the community (B. T. Haworth 2018). In addition, the inherent temporality of the tools used for crisis mapping has been found as one of the main limitations (Brandusescu, Sieber, and Jochems 2016).

The need for an integrated interoperable approach to the use of GIS for sustainable development in Africa was already noted in 2002. This need has not changed and it could be extended to other least-developed areas. Dataset maintenance and continuity to achieve long-term GIS projects instead of one-time demonstrations were also pointed out as some challenges to consider. This achievement is linked to capacity building at human, organisational and societal level (National Research Council 2002). Therefore, it is important that the community find these GIS useful so the temporality is avoided obtaining long term empowerment and capacity building. Community-based projects such as Map Kibera are a great example of how this motivation might work and the benefits that the community can obtain in the process (Hagen 2017).

Development, particularly the monitoring of the Sustainable Development Goals (SDG), has a strong geographic component. The three factors of sustainable development (economic, social and environmental) within this geography should be integrated into the information management flow with a holistic approach (Scott and Rajabifard 2017). GIS are indispensable to manage sustainable development. Data gathering is one of the main points to consider for the implementation of GIS for development. Also the integration with other data and information is fundamental (Sala and Dendena 2015). Specialist in geographic information management should be involved to integrate this information into the development process (Liverman 2018). In this approach, one of the issues that should be considered is the number of actors involved in development projects; government, international and local NGOs, individuals and the community. Each actor has different visions, data sources and information management strategy using different software solutions. This limits data sharing (Marc Van Den Homberg and Susha 2018). National authorities might be the best option to lead that approach but many countries risk being left behind due to the "digital divide" (Scott and Rajabifard 2017). Research should consider whether that gap can be closed from within the communities themselves applying a bottom-up approach instead of the traditional top-down.

Within this context NGOs working in development projects are the logic partner to represent the local communities but some limitations need to be surpassed. NGDOs importance to channel the funding to development projects has been continuously increasing (Aldashev and Navarra 2018). Both, international and local NGOs are intermediaries between the donors and the local communities. There are information asymmetries in this relation that might create situation of inequity and unfair distribution of funding (Aldashev and Navarra 2018). Therefore, the empowerment of the local community allowing the direct transmission of information to the outside world is needed to avoid these situations. In this context, an important limitation to conduct research is the lack of studies to characterize the NGO sector in terms of labour composition and relation with the local communities (Aldashev and Navarra 2018).

From the update of this literature review, it might be concluded that there is need for research in geospatial preparedness for disaster response particularly in least-developed countries. The possibility of organisations working in development projects to improve geospatial preparedness using open-sourced freely available tools has not been considered by the researchers. Moreover, there are no studies in the level of adhesion to these tools by NGOs working in development projects neither in the possibility of these organisations working to improve geospatial preparedness.

1.7. Theoretical basis

Economic theories (*human development theory* and *technocratic approach*) showing different approaches to the development-disaster management cycle are the seminal justification for the overall research presented in this thesis. The *boundary object theory* applied to information management explains the selection of OpenStreetMap as focus of the implementation. Finally, an information management theory (*fit-viability*) is the base for the validation of the results.

The study of development and disaster management as part of a unique learning cycle has been considered by several authors (Weichselgartner 2002; Desai and Potter 2002). *Human development theory* and *technocratic approach* may be used to justify the disaster-development learning cycle. This holistic approach validates the consideration of the synergies between disaster management and development for the design of common tools. The use of GIS may be considered a particular case within this context as it was stablished by the author in a paper previous to this research (San Martin 2014).

The use of OpenStreetMap is justified by the *Boundary object theory* as the "lowest common denominator" of an "object" that can be used by different social worlds/communities of practice (UNOCHA for the coordination of humanitarian aid and development NGOs for the planning, monitoring and evaluation of development projects). If the results are considered, it could be included within the "repository" type. Simultaneously it would be a "standardized form" type if the information acquisition method is considered (Star and Griesemer 1989). Taking the theory a step further OpenStreetMap could be considered as "standardized package" (Fujimura 1992). The use of OpenStreetMap by organizations working in development projects and the UN institutions would improve the "convergence" of two communities of practice and their "information artefacts". Thereby, the convergence of two "information worlds" that are working for the benefits of the same social community (Star, Bowker, and Neumann 2003).

Fit-Viability theory is considered to assess the suitability of this tool to the task and organizational structures of the development organizations. A good level of fit-viability is necessary so the organizations may be interested in the implementation. Development organizations should find the final product fit for the task (development projects). In parallel, the requirements and cost of the data gathering should be assumable by the organization (Liang et al. 2007). It should cover their information management needs without representing an unbearable burden.

1.8. Document outline

The dissertation constitutes a compendium of scientific articles about the different phases of the research. Consequently, there is a natural overlap, especially in the introductions. The document contains an introduction defining the research topic, together with an update of the literature review, a description of the methodology, and the theoretical basis for the research. The document follows with the text of the publications described below and closes with the overall conclusions and suggestions for further research.

1.8.1. Publications

A first article, "Inequity and development in geospatial preparedness" was presented at the 22nd Annual International Sustainable Development Research Society Conference. This article identified the geospatial inequity problem and justified the relevance of the research.

The next two articles presented the outcomes of the interviews to IMOs: "Geospatial preparedness: empirical study of the joint effort to provide geospatial support to disaster response" published in Transactions in GIS; and "Geospatial preparedness: empirical study of alternative sources of information for the humanitarian community" published in Journal of Homeland Security and Emergency Management.

A final article, "Addressing geospatial preparedness inequity: a sustainable bottom-up approach for Non-Governmental Development Organizations" published by the Journal Sustainability, describes the analysis of the survey presented to development organizations.

The Table 1 presents the contribution of the different authors to each article.

Table 1 List of articles references and authors contribution

Article	**Roberto San Martin**	**Marco Painho**	**Frederico Cruz-Jesus**
San Martin, R.; Painho, M. Inequity and development in geospatial preparedness. In Proceedings of the 22nd Annual International Sustainable Development Research Society Conference Rethinking Sustainability Models and Practices: Challenges for the New and Old World Contexts; 2016; Vol. 3, pp. 12–24.	Conceptualization Methodology Investigation Writing-original draft	Methodology Supervision Writing-editing Review	
San Martin, R.; Painho, M. Geospatial preparedness: empirical study of alternative sources of information for the humanitarian community. *J. Homel. Secur. Emerg. Manag.* **2019**, DOI: 10.1515/jhsem-2018-0046.	Conceptualization Methodology Investigation Writing-original draft	Methodology Supervision Writing-editing Review	
San Martin, R.; Painho, M. Geospatial preparedness: empirical study of the joint effort to provide geospatial support to disaster response. *Trans. GIS* **2019**. DOI: 10.1111/tgis.12537	Conceptualization Methodology Investigation Writing-original draft	Methodology Supervision Writing-editing Review	
San Martin, R; Painho, M.; Cruz-Jesus, F. Addressing geospatial preparedness inequity: a sustainable bottom-up approach for Non-Governmental Development Organizations. *Sustainability* **2019**. DOI:10.3390/su11236634I	Conceptualization Methodology Investigation Writing-original draft	Methodology Supervision Writing-editing Review	Validation Writing-editing Review

The figure represents how the results of the first article were used to design the interviews. The analysis of the interviews was the base for the two articles that were used to design the questionnaire that originated the last article and the overall conclusions of the research.

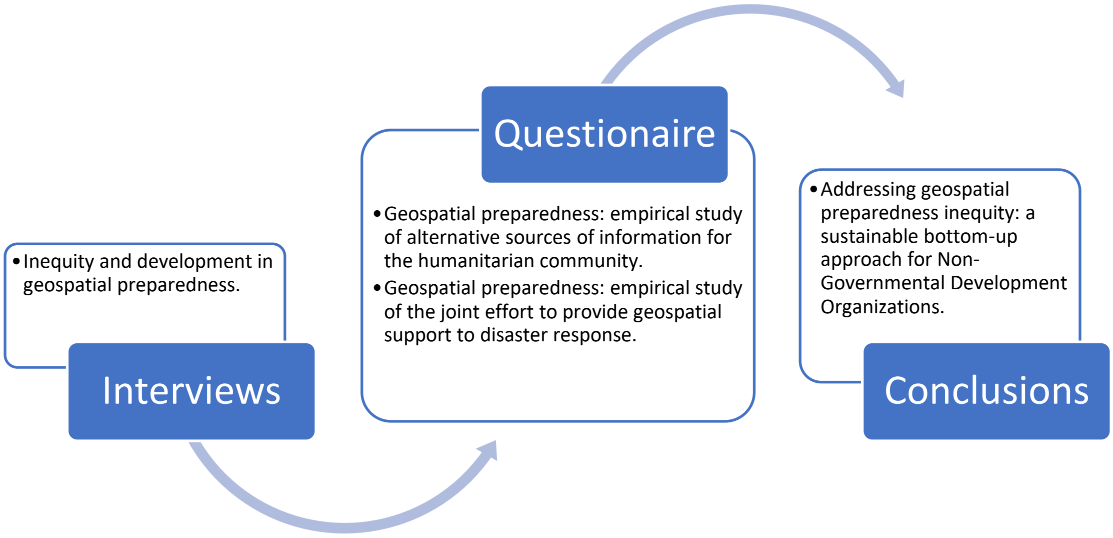

Figure 2. Relation of articles and the different phases of the research

2. Inequity and development in geospatial preparedness[5]

Abstract

Depending on the complexity of a disaster and the capacities of the local response, national and international organizations and multidisciplinary response teams might be involved in the response. Coordination and information sharing become paramount. Geographic Information Systems (GIS) are among the tools used to improve the coordination and facilitate the decision-making process through all phases of disaster management, especially during the disaster response. The use of GIS is based on geospatial preparedness: reliable up-to-date geodata, tools, and people with the knowledge to use those tools. The level of geospatial preparedness varies greatly, however, and in some cases does not exist. In developed countries geodata is abundant and there are means to use it. In least-developed countries the lack of geospatial preparedness, particularly geospatial pre-disaster information, hinders disaster response coordination. Based on the body of literature, other authoritative reports covering areas not studied by the academic world and the study of repositories and databases, this paper provides examples that illustrate the geospatial preparedness inequity issue and explores the tools that emergency responders use to overcome the problem. International institutions (UN) supported by Non-Governmental Organizations (NGOs), volunteers, and technical communities provide ad-hoc infrastructure to use GIS and create datasets in the aftermath of a disaster. Nevertheless, long-term solutions are necessary. Based on the theoretical concept of disaster management and development as a learning circle, the main contribution of the present work is to propose a new model to mitigate geospatial preparedness inequity. Our approach is based on the engagement of organizations working on development projects in disaster-prone areas to enhance geospatial preparedness. It is necessary to develop a public participatory GIS methodology for the engagement of development organizations and the local community to provide that information. Based on participatory methods this bottom-up approach allows community empowerment while conveying relevant pre-disaster datasets readily available to the humanitarian aid community. Nevertheless, there are challenges to overcome: development organizations, especially smaller players, might face a lack of technical and human resources to implement this approach. Finally, the perception of reliability by the

[5] First published as San Martin, R.; Painho, M. Inequity and development in geospatial preparedness. In Proceedings of the 22nd Annual International Sustainable Development Research Society Conference Rethinking Sustainability Models and Practices: Challenges for the New and Old World Contexts; 2016; Vol. 3, pp. 12–24.

emergency responders of the datasets provided through participatory approaches is also a question to be considered.

2.1. Introduction

Communities are exposed to hazardous situations. These hazards may be natural (i.e. earthquakes, hurricanes, tsunamis, sea level rise, tornadoes, drought, landslides, and avalanches) or induced by human processes (i.e. environmental degradation and technological hazards). Hazardous situations occur with different consequences. There are different levels of vulnerability, preparedness, and response. In the aftermath of a disaster, situation, needs and response capabilities are assessed. Depending on the complexity of the disaster and local capacities, international and multidisciplinary response teams might be involved. Coordination and information sharing become paramount to implement an adequate response.

Geographic Information Systems (GIS) are among the tools used to improve coordination and to facilitate the decision-making process through all phases of disaster management. GIS provide the spatial dimension mainly as a cartographic tool for information sharing, resource allocation, planning and logistics. But it is also used for crisis simulation, environmental planning, hazard management, vulnerability assessment, risk reduction, map population densities and displacements, and investigation of infectious disease outbreaks (Kaiser et al. 2003; Shorbi and Wan Hussin 2015).

There are, however, requirements that must be pre-fulfilled to undertake these tasks. These are referred to as *Geospatial Preparedness*. This concept is described by the United States (US) Department of Homeland Security (DHS) as: *"… the level of overall capability and capacity necessary to enable all levels of the Department to use geospatial data, geographic information systems software and hardware, and geospatial applications to perform essential functions such as prevention, detection, planning, mitigation, response, and recovery in order to minimize loss of life and property…*" (page 3, (DHS 2004).

The implementation of geospatial technologies for disaster management requires political support and regulations to create institutions with tools and trained people to gather and use geodata. The level of geospatial preparedness differs across the world; it is significant in many countries while inexistent in others. This inequity hinders the coordination of disaster management. The lack of information, more particularly the lack of geospatial pre-disaster information, delays the coordination of disaster response. The goal of this paper is to illustrate through examples the geospatial preparedness inequity issue, and to consider how it is being addressed. Ultimately, the main objective is to introduce a new model to improve geospatial preparedness based on the work of development organizations in synergy with international institutions. It is out of the scope to provide a comprehensive inventory of geospatial preparedness, or to establish causal relationships between development and the use of technology.

2.2. Methods

The research is based on a literature review and the study of open databases. Researchers agree on the difficulties to perform a comprehensive literature review on GIS application to disaster management since in this multidisciplinary environment GIS is just one tool amongst others. Moreover, when considering the application by international institutions, much of the knowledge is not accessible or does not meet scientific standards (Verjee 2007). This research is based mainly on the analysis of peer-reviewed journals and conference proceedings, in addition to other authoritative reports and online information for topics not considered by formal research. This paper might be considered a preliminary work that should lead further research using a multi-method strategy (qualitative and quantitative methods sequentially to "triangulate" the findings and develop the analysis) (Denscombe 2014).

The first part of the paper explores the use of GIS for disaster, followed by comparative examples of geospatial preparedness to illustrate the inequity issue. It closes with a reflection on the mechanisms in place to close this gap and the introduction of a new model.

2.3. Results and discussion

2.3.1. Use of GIS in Disaster Management

Disaster management is approached as a cycle divided into phases as illustrated in Figure 3. GIS are coordination tools used throughout the cycle. Academia, institutions, NGOs, and software providers have different, but complementary, opinions about GIS capabilities. A holistic approach is needed to cover this topic: local governance considered in conjunction with international institutions and interaction between institutions, strategy with in-field operations, "basic" applications with spatial analysis.

Geography is a complex reality full of synergies between space, ecosystem, society, culture and economy. The use of GIS evolved to provide this geographical perspective to disaster management. The examples provided by the Joint Board of Geospatial Information Societies shows its flexibility, integration and economic impact (JBGIS 2010). Applications, initially limited to technological solutions, become holistic and participative. Overviews on this application from the late 1990s (Cova 1999; Kaiser et al. 2003) as well as current publications (Kawasaki, Berman, and Guan 2013a) recognize GIS as a fundamental tool to deal with hazards. It is used at different levels of complexity including a wide range of analysis and modelling capabilities. In humanitarian work GIS' main use is as a cartographic tool for situational awareness and information sharing. Optimization methods, problem solving, and decision support tools (e.g. route and resource allocation) are of especial interest for in-field operations. Additionally, modelling capabilities are used during rescue operations and for prevention and early warning (Shorbi and Wan Hussin 2015). Other "trendy" topics in developed countries are: 3D mapping, cloud computing, and web-based GIS (Kawasaki, Berman, and Guan 2013a).

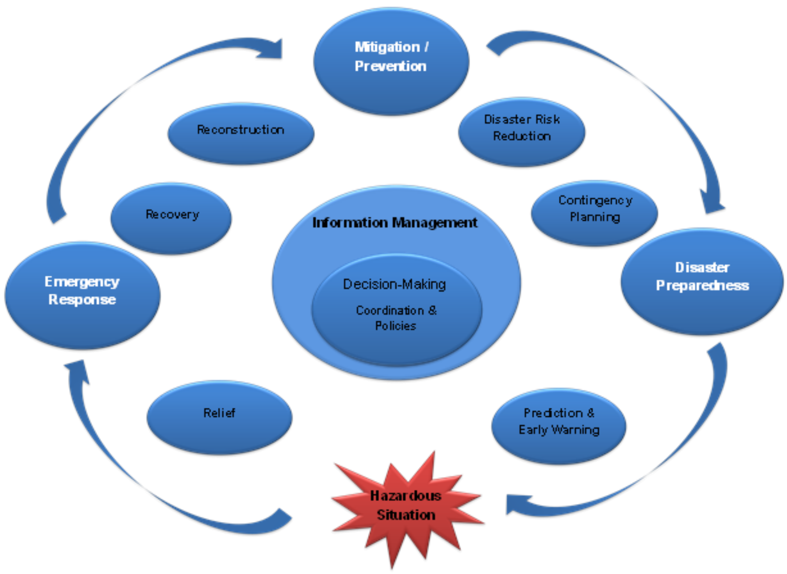

Figure 3. Disaster management cycle.

Nevertheless, the advantages of using GIS for disaster management depend on the level of geospatial preparedness. In countries with adequate disaster mitigation strategies there are databases with reliable up-to-date information readily available to organize the response, there are tools to use and share that information and knowledgeable people to use those tools. Availability of reliable spatial data is especially important, including geodata related to the area of study, the community in that area, and the hazards to which they are exposed. In this regard, well-populated geospatial databases and spatial data infrastructures (SDI) are considered an essential precondition for the use of GIS (Köhler et al. 2006). In the aftermath of a disaster, the International Association of Emergency Managers (IAEM-ETC 2013) considers necessary datasets including but not limited to: topography, streets/roads, communications and logistics, administrative boundaries, critical infrastructures, utility lines, health care facilities, socio-demographics (population distribution and population centres), institutions; impact-area modelling; damage and needs assessments: disaster boundaries, etc.

2.3.2. Geospatial preparedness inequity

The fact that investment in geospatial preparedness improves information management during disaster response is commonly accepted by the humanitarian community. Geospatial preparedness, however, is not homogeneous across the world. A country comparison reveals an inequity issue. There are countries where geospatial preparedness is a “political” objective. These countries have institutional structures, tools, knowledgeable users, and an active private sector. As a result, geodata is abundant. On the contrary, in many places the geographical component of the information is not considered, data are not georeferenced and GIS are almost unknown. This inequity jeopardizes disaster response in those places lacking geospatial preparedness. The following paragraphs illustrate this gap.

US geospatial preparedness is described in the DHS Geospatial Concept of Operations (GeoCONOPS). GeoCONOPS, included in the National Incident Management System, is an overview of different actors, tools, and best practices. It coordinates the use of GIS in disaster management and harmonizes political decisions for geospatial preparedness. Many US institutions are involved in geospatial preparedness. There are massive amounts of information originating in public and private institutions. Any institution using GIS creates and maintains geodata available in case of emergency (e.g. Federal Emergency Management Agency, US Geological Survey, Geospatial Multi-Agency Coordination, National Oceanic and Atmospheric Administration, National Aeronautics and Space Administration, US Army Corps of Engineers, US Forest Service, Environmental Protection Agency, and Department of Transportation). The list could be endless due to the ubiquity of GIS in the US. Usually, the information is accessible through web-based tools (e.g. DHS OneView and Portal for ArcGIS, Geospatial Platform database; *Gold* assembled by the National Geospatial-Intelligence Agency, Geospatial Portal, and CorpsMap Viewer). There are also GIS-based modelling (e.g. LandScan USA, Interagency Modelling and Atmospheric Assessment Center HAZUS, and Flood Inundation Mapper) and coordination tools (e.g. DHS Common Operating Picture:

strategic situational awareness application through a web-accessible interface, and DHS Next-Generation Incident Command System) (DHS 2014).

In the US there are multiple organizations, databases and strategic tools for coordination, decision making and information sharing. There are also tools for modelling and other analysis. There is continuous development to improve the information and to improve the tools to use it. In addition, there are new approaches involving public participation through volunteered information and free open data. Taking this level of geospatial preparedness as benchmark we would like to compare the situation in different parts of the world. This is not a comprehensive inventory but just examples to reveal different levels, as shown in Table 2.

Table 2. Levels of geospatial preparedness.

Geospatial Preparedness	Benchmark	Advanced implementation	Initial stages	Basic level
Institutions	Abundant	Abundant	Few	None
Tools	Abundant	Abundant	Few	None
Skilled staff	Abundant	Abundant	Relatively scarce	Scarce or none
Geodata	Abundant & available	Relatively abundant & available	Restricted to most populated areas	Non-existent, not accessible, outdated and/or not reliable.
Overall Coordination	Master plan for geospatial technologies in disaster management	Different projects applied to disaster management without clear overall coordination	Coordination is not essential since there are only a few institutions	Not applicable
Private Sector	Very Active & in close interaction with the institutions	Active and with some level of interaction with the institutions.	Collaboration with the institutions to meet the situation.	Multinationals linked to natural resources (restricted access). Universities/NGOs

Japan is at an advanced level of geospatial preparedness. While the US pioneered the use of GIS for emergency response in the late 1980s, Japan followed in the 1990s. Japan Bosai Platform gathers “know-how” applicable to disaster management. It provides many examples of applications for different types of disaster. It is interesting to see the public-private partnerships in many projects (e.g. Kukusai Kogyo, Panasonic System Networks, Asia Air Survey Co). This symbiotic relationship is at the core of geospatial preparedness in most countries developed on a capital-based model. Other examples of countries at this level of geospatial preparedness are Canada and most European Union (EU) members. There is an enormous amount of geodata in the Canadian Geospatial Data Infrastructure. In addition, Canada's Multi-Agency Situational Awareness System is a common operational picture and communication tool that exemplifies the level of geospatial preparedness of the country that first developed GIS in the 1960s. Another example is the Canadian Disaster Database, which has a geospatial mapping component. EU project INSPIRE aims to facilitate sharing (availability and interoperability) of environmental spatial information through a geoportal. The availability of open geodata is used by companies like IDGIS developing open source software (e.g. Geoide Viewer: a GIS web-based tool for regional disaster management). In the UK there is a 2005 *Cabinet office Guide in GIS applications in Integrated Emergency Management* (MacFarlane 2005) identifying available data (many INSPIRE datasets from Ordnance Survey Digital Map Products). In addition, around the EU there are countless geospatial preparedness initiatives at country level (e.g. Germany VorsorgePlan Schadstoffunfallbekämpfung maps the entire coast as part of a Contingency Planning System and Sensitivity Mapping).

Public and private institutions in these countries have many projects to gather and share information, and as a result reliable geodata is abundant. These institutions have the personnel and tools to use this information. There is not, however, a tool to coordinate these initiatives, such as GeoCONOPS in the US.

In other Asian and American countries geospatial preparedness initiatives are in their initial stages. The amount of information is not as profuse (most regions are mapped but the scale is not always adequate, there is insufficient level of detail, and many thematic areas are not covered). Some countries have developed GIS-based tools for disaster management including numerous examples of common operational picture (e.g. Peru – SIGRID, Chile – SIIE, Argentina - "Sistema Crisis", Colombia – NGRD, Brazil - INDE & S2ID). These tools show different levels of integration with the national disaster management structures.

In many countries geographic information is not considered in the national incident plans. Geospatial datasets are not available. In some cases, it is not even possible to georeference a postal address (e.g. Sudan). Some international private companies may have datasets usually related to natural resources, but the access to this information is restricted.

Finally, it is difficult to evaluate the level of geospatial preparedness in some places. Data are not open to public use due to security concerns (e.g. Venezuela) or are just not available. Regardless of the available academic research, it is difficult to picture geospatial preparedness in places like China due to governmental structures and language barriers that hamper the investigation.

There are extreme differences between the expansion of GIS-based tools in low and high-income countries (Opadeyi 2009). Even if it is not possible to geographically distribute the levels of geospatial preparedness indicated in Table 2, it could be generalized that the implementation is advanced in most western countries and some in Asia. It is just beginning in many countries in Latin America and some in Asia, while a basic level is the standard for Africa and some countries in South-East Asia and Latin America.

Geospatial preparedness inequity is especially problematic for least-developed countries and small islands. There is an acute need for information to coordinate the international support to disaster response. The analysis of the use of GIS during the 2010 Haiti earthquake carried out by Zook, Graham et al. observes *"Particularly challenging to relief efforts was the fact that comprehensive databases of assets, infrastructure, population, and location were minimal[…] Even some of the most fundamental informational needs, like detailed roadmaps and locations of critical assets, were not available"* ((Zook et al. 2010 p. 14).

Geodata is the most significant and costly part of GIS. Lack of pre-disaster data in least-developed countries is an issue (Wang et al. 2012). As we should see in the following point, where the level of income does not allow complex response structures, the attention is given to low-cost and free remote sensing alternatives and the expansion of open-source GIS. Nevertheless, these resources cannot replace sound geospatial preparedness. The matter is especially important since the purpose of the international humanitarian community should not be to replace the national response capacities, but to complement, support, nurture, and build those capacities (Ville de Goyet 2008).

2.3.3. Addressing the inequity problem

Geospatial preparedness inequity has critical consequences during the emergency response. In those cases in which local authorities cannot cope with the consequences of a disaster, international humanitarian aid supports local capabilities and tries to cover information management needs. Disaster response teams arriving on the scene include units to create GIS infrastructure. Various organizations (i.e. UN institutions, private sector, NGOs, and volunteers) work together to create datasets "on the spot". It takes precious time to make this information available to the decision-makers coordinating the response. Some of the data are disaster-related, but there is also the need for pre-disaster information (to be used as a baseline for recovery or because it remains relevant).

2.3.3.1. Institutional International Support: United Nations

When the international community intervenes, the United Nations Office for the Coordination of Humanitarian Affairs (UNOCHA) provides coordination, information management and financing through the *cluster approach*. During the initial stages of the emergency response the intervention is led by UN Disaster Assessment and Coordination (UNDAC) Teams. Within the UNDAC team there is a specific Information Management section that, among other tasks, deals with the use of GIS usually with partner organizations (i.e. MapAction). The initial assessment carried out by the UNDAC team is limited by time and resources. Subsequently, secondary data analysis, particularly “pre-crisis” secondary information, plays a crucial role (MapAction 2011, UNOCHA 2013).

The need for reliable geodata has been acknowledged by the international institutions, particularly by the UN (Peduzzi and Herold 2005; JBGIS 2010; Longhorn 2012). The need to improve geospatial preparedness was initially considered by the UN General Assembly Resolution 59/212 (UN 2005). It was further developed by the Inter-Agency Standing Committee 77th Working Group Meeting Information Management and Preparedness (7-9 July 2010). According to the UN Committee of experts on Global Geospatial Information Management the UN is developing the UNMap: a collection of geo-databases to be used as core mapping layers (international and administrative boundaries, coastlines, drainage, water bodies, roads, railways, airports, populated places, and urban areas). Also, the International Steering Committee for Global Mapping aims to compile fundamental digital geospatial information (transportation, boundaries, drainage, population centres, elevation, vegetation, land cover and land use). There are other UN projects: Inter-Agency Standing Committee Common Operational Datasets (CODs) and Fundamental Operational Datasets (FODs) can be downloaded from the Humanitarian Response repository. CODs (generic) and FODs (cluster specific) have mandatory data characteristics and comply with the “Dublin Core” minimum metadata standards (UNOCHA 2009). UNOCHA Humanitarian Data Exchange consists of a *Repository* where raw data can be uploaded and made openly available. Other UN institutions providing GIS-based products during emergencies are: Second Administrative Level Boundaries project, the UN World Food Program as part of the Logistics Cluster and the UN High Commissioner for Refugees Field Information and Coordination Support Section.

These examples show a complex structure striving to achieve global coverage involving many organizations with overlapping tasks and interoperability issues. The results of these projects are uneven. Further research would be necessary to establish the level of geospatial preparedness achieved.

In countries without proper geospatial preparedness, international support is essential for the coordination of the response during the initial stages of a disaster. It is arguable, however, whether this "reactive" support is as adequate as promoting locally geospatial preparedness would be. Building local capabilities could have long lasting benefits for the community facilitating the task of the international community when that support is needed.

2.3.3.2. Non-institutional International Support: NGOs, Volunteers, and Private Sector

Least-developed countries lack institutions to provide the services needed by the society. NGOs become the centre of civil society, turning into service providers and reliable partners for governments and international institutions (i.e. UN clusters) (Lewis and Kanji 2009).

Some NGOs are global players having GIS structures to respond to their particular needs, while others are exclusively focused on geospatial services. For example, the International Committee of the Red Cross had a GIS unit since 2006 with a centralized web-enabled database that synchronizes with local data storages. *Médecins Sans Frontières* is establishing a framework for application based around "Map Centre" server with data accessible in a webserver. The system is being set up by CartONG, which is a GIS specialized NGO (Laborderie, Lessard-Fontaine, and Soupart 2014).

The work of NGOs and UN institutions is supported by the volunteers and technical communities (V&TCs). The on-line community responds to disasters in different ways. One of the fastest developing methods is to use geospatial technologies; V&TCs provide GIS support in partnership with formal socio-technological networks, data providers, and software vendors. This support is becoming essential to address geospatial preparedness inequity. We are indeed facing a data overload (Carpenter and Snell 2013).

Volunteers are coordinated by organizations like the Urban and Regional Information Systems Association program GISCORPS. The projects undertaken cover a wide range of disaster response activities: mapping as baseline data for humanitarian response, development of post-disaster web maps, damage proxy maps, geo-referencing, and organizing access databases. Volunteers are also field deployed upon request. There are many other organizations covering different areas of work: the Humanitarian

OpenStreetMap Team provides geographic base data with their crowdsourced free and open world map; International Network of Crisis Mappers provides mobile and web-based applications, participatory and crowdsourced maps, aerial and satellite imagery, geospatial platforms, advanced visualization and live simulation; MicroMappers uses volunteers to pre-process disaster data. These and many other organizations are part of the Digital Humanitarian Network (DHNetwor), which is a "network-of-networks" creating a consortium of V&TCs that provides an interface with formal humanitarian organizations. The Standby Task Force established by DHNetwork covers: rapid geolocation of event-data and infrastructure data, creation of live crisis maps, data development, GIS and big data analysis, and satellite imagery tagging and tracing.

Another method to close the geospatial preparedness inequity gap turns to volunteered geographic information (VGI). The concept, coined by Goodchild (Goodchild 2007) covers a wide array of actions that could be interesting for countries with lower economic capacity. Institutional data (usually remote sensing) is complemented by data provided by the affected community giving rise to the concepts "people as sensors" and "collaborative damage mapping". Nevertheless, these concept have limitations due to the lack of well populated SDI with quality data (Maiyo, Kerle, and Köbben 2010), technological knowledge, and restricted internet access. As a result, VGI is mainly considered in developed countries that already have a good level of geospatial preparedness.

The possibilities opened by V&TCs and VGI have also been acknowledged by the institutions. Several initiatives are supporting and funnelling the results of this work. Information (mainly remote sensing) is made freely available to volunteers (e.g. Imagery to the Crowd of the U.S. Department of State Humanitarian Information Unit) and there are initiatives based on the information obtained from this community (e.g. MapGive by USAID, disaster.data.gov, OpenFEMA, and NGA GeoQ by the USA government, UNOCHA initiative The Humanitarian Data Exchange and the open source platform City72 Toolkit).

The private sector also supports humanitarian aid missions. Software and RS providers team up with institutions and V&TCs to provide geospatial services. We could take as examples Esri's Disaster Response Program and Google Crisis Map open source tool from the Google.org Crisis Response team.

The 2010 Haiti earthquake was an inflection point regarding the use of V&TCs in disaster management. For the first time, V&TCs and to some extent VGI, played a fundamental role in the response. Their efforts were the basis for making information available within days of the disaster (Zook et al. 2010) (Harvard Humanitarian Initiative 2011). This change is studied by Kawasaki et al (Kawasaki, Berman, and Guan 2013a) who consider the use of crowd-sourced mapping for the coordination of emergency response. The collaboration of V&TCs changed the structure of the information management teams and the datasets available. The process culminating in the 2010 response was based on technological developments (web-mapping, geodata browsing, web-based data exchange and development, mush-up live editing on the web) and the willingness to open data access from public and private sectors. The result of the study is a positive view of crowd-sourced information for response coordination. The prerequisite is the integration of this source of information in the disaster response plan. It can be concluded that the use of V&TCs and VGI is valuable in conjunction with a good level of geospatial preparedness.

Private sector NGOs and V&TCs are an *ad-hoc* answer to the lack of pre-processed geographical information. These sources of information and know-how seek to bridge the gap in geospatial preparedness. Their work has become necessary but is not sufficient to do so.

2.3.3.3. A new approach: Development organizations

Post-disaster international support can only partially address geospatial preparedness inequity, making a new approach necessary.

The study of development and disaster management as part of a unique learning cycle, as shown in Figure 4, has been considered by several authors (Weichselgartner 2002). Disaster management and development projects are part of this learning process to improve human wellbeing in changing environmental and socio-economic conditions (Desai and Potter 2002). Cost-effective solutions can be developed through a common approach and common tools (San Martin 2014). Development projects and disaster management share a geography. A holistic and dynamic approach is required to produce information from the community related to this geography. The different actors and factors have to be studied considering space, time, interactions, and feedback-loops (Weichselgartner 2002).

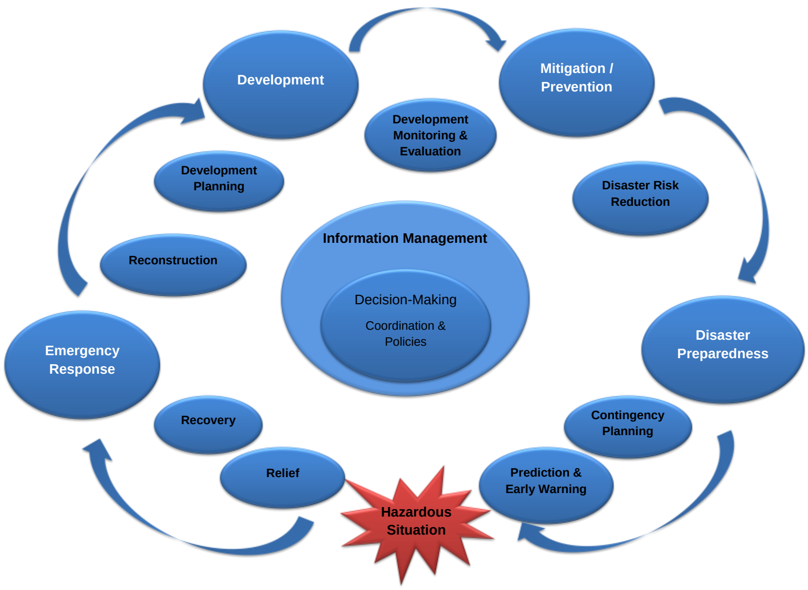

Figure 4. Development and disaster-management learning cycle.

NGOs implement development projects to cover the needs that official institutions cannot satisfy. These *development organizations* often work in disaster prone areas having low level of geospatial preparedness. The value of GIS for planning, monitoring, and evaluation of development projects is widely acknowledged. Development organizations use GIS to base the decision-making process on sound information management, integrating the geographical component in topics such as sustainability, climate change (Stocker et al. 2012) or linked to traditional cultures. Geospatial technology is also associated to land management, vulnerability assessments, and integration of disaster risk reduction strategies into development planning (Guha-Sapir, Rodriguez-Llanes, and Jakubicka 2011).

The *disaster-development learning cycle* concept allows a synergic approach to GIS use to improve geospatial preparedness. The information standards and formats used for development projects and humanitarian aid are different but, in many cases, cover similar topics. It would be necessary to compare the pre-disaster information needs of the disaster response managers with the capabilities of the development organizations to find the common points. As a result, development organizations in partnership with local communities could provide useful pre-disaster information, thereby reducing geospatial preparedness inequity.

Community implementation contemplates the inclusion of socio-economic factors in the information management system, while the development of technological skills empowers the community and provides ownership of the project. In addition, participatory approaches address other needs highlighted by the Sendai Framework for Disaster Risk Reduction considering the integration of traditional and local knowledge and the collaboration among people at the local level (UNISDR 2015).

Public Participatory GIS (PPGIS) (Bunch, Kumaran, and Joseph 2012) and Community mapping are relevant forms of VGI within this framework. PPGIS in development projects is usually associated with land-planning and resources management. It has also been linked to vulnerability mapping and used as a tool to introduce disaster risk reduction strategies in the community (UNCTAD 2012). These applications bring together socioeconomic development and community empowerment. In parallel, they could become instruments to reduce geospatial inequity. These models could be complemented with the support of the V&TCs for data pre-processing.

Nevertheless, there are technological issues related to these applications. Even if free and low-coast techniques are available, know-how is needed to build up the capabilities of NGOs and communities. Limitations are not only technological but socio-economic, and institutional factors also play an important role in the creation of barriers (Badurek 2009). There are also ethical issues related to the ownership of the project. The main limitations, however, could be the perception of quality and reliability of the information provided to the disaster response managers (Devillers and De Freitas 2013).

2.4. Conclusions

The geographic component should be integrated in the decision-making process for disaster management. GIS are a powerful tool to facilitate this integration, especially during emergency response. Implementing a disaster response GIS requires geospatial preparedness: institutions, trained personnel, computing capacity, coordination, and reliable geodata. In addition to lack of skilled staff, the main challenges when building a GIS are lack of data, or data not freely available, and lack of standards and coordination between institutions.

The comparison of geospatial preparedness levels reveals an inequity issue. The difference amongst countries is enormous. In some, government supported institutions and an active private sector are coordinated to generate skilled staff, tools, and reliable geodata. This coordination makes it possible to turn a group of technical solutions into a holistic approach to disaster management. In other countries geospatial preparedness is deficient or does not exist. This issue is especially problematic for least-developed countries, where there is a more acute need for information to coordinate the international support.

The humanitarian aid community works to lessen the consequences of this inequity. International institutions (i.e. UN) and NGOs have acknowledged the need for geospatial preparedness. Main actors in international disaster response have developed the structure and knowledge to handle geodata. International support and public-private sector partnerships are providing vital solutions to coordinate disaster response in places with deficient geospatial preparedness. Institutions are facilitating the work of V&TCs in providing open data and using the outcomes. International institutions, NGOs, the private sector, and V&TCs are the *ad-hoc* answer to the lack of pre-disaster information. In some cases, there is even a data overload. It is interesting to consider this apparent contradiction. The "mass-production" of data in the aftermath of a disaster does not compensate for the lack of pre-disaster data. On the other hand, the escalation of geodata production stresses the importance of data quality and reliability. These reactive sources of information and know-how have become necessary but are not sufficient to replace geospatial preparedness.

The question is whether there are other ways to reduce the gap in geospatial preparedness. Considering development and disaster management as a learning cycle, the work of development organizations can be guided in that direction. Inequity can be contested from the bottom-up. Local communities can improve geospatial preparedness to facilitate the coordination of international humanitarian aid. Usually, NGOs implement development projects in disaster prone areas. These organizations use, or could use, GIS-based tools to plan, monitor, and evaluate project implementation. The information standards and formats used are different, but in many cases cover similar topics. This approach allows empowering the community while bringing long lasting benefits to the development and humanitarian organizations and the communities at the centre of their work.

The use of GIS exploring the synergies between development and disaster management is actually focused on applying disaster risk reduction strategies to development. A new approach should be at the centre of research to contemplate development as a tool to improve geospatial preparedness. It would be necessary to determinate the information needs of the humanitarian community and implement qualitative and quantitative methods to establish the datasets and formats required. Since data input (acquisition and pre-processing) is expensive and time consuming, it is necessary to develop a PPGIS methodology for the engagement of development organizations and the local community to provide that information. In addition, V&TCs can support data pre-processing as they do in the aftermath of a disaster. The current trend in open data availability should both facilitate the task and be the reference for the results. These datasets should not be adequate only for the humanitarian community, but also for the tasks implemented by the development organizations. In addition, the implementation of the data gathering methodology should be in line with the budget and capabilities of these organizations. The concept can only be feasible if they obtain a benefit without an added burden.

There are limiting factors to this approach. The lack of technological capacity and data availability limits the use of GIS-based tools by the development community, especially among smaller organizations, even though some projects (e.g. MapAction RAMP) are trying to solve this issue. In addition, how to engage V&TCs without the pressure of a recent disaster should be considered. Finally, and more importantly, there is a conceptual limitation imposed by the lack of "credibility" of the information provided. It is necessary to establish the perception of reliability of the information obtained by NGOs through participatory approaches, and discover how to improve it.

3. Geospatial preparedness: empirical study of alternative sources of information for the humanitarian community[6]

Abstract

In response to a disaster, the United Nations Office for the Coordination of Humanitarian Affairs creates a framework for cooperation in which Information Management Officers from different organisations can work together to provide decision makers with necessary information. Geospatial data are among the first information delivered. Recently, online mapping, remote sensing and the support of volunteers and technical communities wrought dramatic changes in the use of geospatial information, bringing new challenges to the digital humanitarian community. Information Management Officers are tapping alternative data sources, and institutions are adapting their working procedures to this new reality. The perspectives of these Information Management Officers have been studied through semi-structured interviews and monitoring of the tools used during responses to real emergencies. This study determines the required data and the relation with geospatial preparedness. It also explores the potential and limitations of development organisations, community mapping and social networks as alternative sources of information.

3.1. Introduction and background on the coordination of Information Management in disaster response

In the aftermath of a sudden-onset emergency, the United Nations Office for the Coordination of Humanitarian Affairs (OCHA) provides coordination, information management and emergency funding. The first step is to compare local capacities with the magnitude of the disaster. The Coordinated Assessment Support Section (CASS) within OCHA creates a framework for cooperation of a multidisciplinary team of Information Management Officers (IMOs) from different UN institutions and partner organizations (OCHA CASS 2016). The objective of this group is to share pre-crisis and post-crisis data and information to achieve a joint, multi-sectoral analysis. CASS and the Coordinated Data Scramble distribute tasks and establish a collaboration space (i.e. Skype room, Google Docs,

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Trello board). These IMOs are supported by other organisations together with Volunteers and Technical Communities (V&TCs) working in remote (San Martin 2014; Cutter 2016).

Within this context, Geographic Information Systems (GIS) is a fundamental tool to manage the vast amounts of geospatial information generated. They are crucial for supporting spatial thinking and situation awareness providing a common operating picture necessary for the coordination. The use of geospatial analysis allows evaluating the disaster severity, estimate the needs and optimise the utilisation of the resources (Kaiser et al. 2003; Shorbi and Wan Hussin 2015; Comes and Van de Walle 2016).

In order to use GIS for these tasks some requirements must be pre-fulfilled. These are referred to as *Geospatial Preparedness* and they might be considered within the data preparedness concept (Raymond and Achkar 2017). There is, however, an inequity issue. The level of geospatial preparedness differs across the world; it is significant in many countries while inexistent in others. In many disaster-prone areas, the geographical element of the information is not considered, and GISs are unknown. The lack of information, more particularly the lack of geospatial pre-disaster information, hinders the coordination of emergency response (San Martin and Painho 2016) since international IMOs have to close that gap ad hoc when a disaster strikes.

This context determines the importance of understanding the role of geospatial preparedness for international humanitarian missions. The scope of the empirical study is focused on understanding the process of gathering geospatial data in those places where it is not readily available. The present research aims at answering 2 questions: How do IMOs actually address the lack of pre-disaster information? And, are the proposed alternative sources of information (i.e. social networks, community mapping and development organisations) a feasible option? Ultimately, the information used to address the lack of geospatial preparedness depends not only in procedures and logic but in subjective decisions. Previous studies were missing the perspective of the people deciding which information is used and how it would be used. Therefore, this area of research is addressed from the perspective of those IMOs working within the framework led by OCHA. As a result, this study aims to provide an *inside* practical view in the process leading to the identification and validation of the information that will be used by decision-makers in humanitarian missions. Ultimately, this should be a first step to stablish alternatives to improve geospatial preparedness. It is acknowledged that geospatial preparedness is a more complex concept including institutions and regulations, tools and the people who use them. Nevertheless, providing those would be related to capacity building which is outside the scope of this research.

3.2. Methodology

This research is based on a multi-method strategy (the sequential use of qualitative and quantitative methods to "triangulate" the findings and develop the analysis) (Denscombe 2014). The adopted methodology includes a literature review, the analysis of semi-structured individual interviews with IMOs, and the study of the tools used.

Researchers agree on the difficulties in performing a comprehensive literature review on the application of GIS to disaster management since, in this multidisciplinary environment, a GIS is just one tool among others. Moreover, when considering the application by international institutions, much of the knowledge is not accessible or does not meet scientific standards (Verjee 2007). Thus, institutional documents were considered in addition to the review of academic work related to geospatial preparedness and the use of GIS for disaster management and humanitarian aid.

For the next phase, an interview guide was drafted. The questions included seven topics previously identified. The study participants were selected using a purposive sampling technique to identify key informants from institutions within OCHA's IMOs team, followed by snowball sampling to increase the sample size (Denscombe 2014). The semi-structured interviews were conducted via Skype in 2016 and 2017. From a total of 10 contacts, 8 interviews were completed. This sample size was considered sufficient given the key positions of the IMOs interviewed (i.e. NGO Volunteers, NGO Founder and Director, Coordinated Data Scramble organiser, UN Consultant, UN GIS Coordinator, UN Data Systems Analyst, and UN Head of Unit), the size of the target population (i.e. 9% of the IMOs actively involved in the response to Hurricane Mathew were interviewed) and the overall methodology of the research not relying merely in the interviews. As shown in Table 3, the selection of key informants was focused on providing a representative sample of on-field and remote supporters of the main stakeholder: UN institutions (OCHA and High Commissioner for Refugees) at different levels (Local, Regional and Head Offices) and NGOs (Digital Humanitarians, MapAction and GISCorps). The identities of the interviewers, including details of their specific roles, are not revealed to preserve confidentiality. Furthermore, to ensure the ethical use of data from research participants, they are cited using a “P” followed by the interview number in chronological order, as described in the table below.

Table 3. Characterization of the participants in the study

P1	**P2**	**P3**	**P4**	**P5**	**P6**	**P7**	**P8**
UN	NGO	UN	UN	UN	NGO	UN	NGO
Head office	Volunteer & Manager	Local office	Head office	Local office	Volunteer	Head office	Volunteer& Manager
Field & remote support	Field & remote support	Field & remote support	Field & remote support	Field & remote support	Remote support	Field & remote support	Remote support

Each participant was presented with the same questions, and the outcomes of other interviews were never discussed. Interviews were recorded, transcribed and coded manually following an inductive approach. The analysis of the interviews considered the seven a priori codes for topics that were directly introduced in the interviews.

The results of the study were crosschecked with the tools used for the coordination of remote support. Upon invitation, the Skype room for the response to Hurricane Mathew in Haiti 2016 was directly monitored daily from 14 October to 4 November (the chat history was studied from its creation on 4 October). The Trello board, documents shared through Google Docs and datasets uploaded to HDX and ReliefWeb were followed in parallel. It should be noted that four of the members of the Hurricane Matthew emergency response team had already been interviewed as part of the study. Responses to Cyclone Winston in Fiji in February 2016 and the Ecuador earthquake in April 2016 were studied a-posteriori through the Trello boards and datasets uploaded to HDX.

3.3. Framework and related work

The work of the team described in the introduction should be considered within the framework of the *Multi-Cluster/Sector Initial Rapid Assessment* (MIRA) and the Humanitarian Needs Overview established by the Inter-Agency Standing Committee (IASC). The target is to produce an operational picture from primary (i.e. field data) and secondary (i.e. pre-crises and in-crises data) sources of information. The results are presented in a *Preliminary Scenario Definition* (within 72 hours) and a *MIRA Report* (after 2 weeks). MIRA Analytical Framework establishes the information priorities (i.e. scope and scale of the crisis, conditions of the affected population, capacities and response and humanitarian access)

(Inter-Agency Standing Committee 2015). During this period, when major decisions are taken, there is a high demand for and low supply of information. NGOs use these products for strategy and advocacy, even if their usefulness for decision-making is arguable due to delays in distribution and limited dissemination among local NGOs (Lovon and Austin 2016).

The datasets that define the OCHA needs in terms of geospatial information are the Common Operational Datasets (CODs) and Fundamental Operational Datasets (FODs). CODs are generic (e.g. administrative boundaries, populated places, transportation network, hydrology, hypsography) and FODs are cluster specific (e.g. education facilities, hospitals, wells). CODs and FODs are, among other information, available at the Humanitarian Data Exchange (HDX), which consists of a *Repository* where raw data can be uploaded and made openly available (McDonald, 2010; UNOCHA, 2009).

The practical application of GIS to humanitarian aid is described in institutional documents, but there are few academic works in the area. Tomaszewski et al provide a general view of GIS for disaster response (Tomaszewski et al. 2015). Other papers that study empirical implementations consider local-level implementation in areas where geospatial preparedness is not an issue (Breen and Parrish 2013). The most relevant works specifically related to preparedness are: the Data Preparedness Framework developed by van den Homberg et al, within the Netherlands Red Cross 510 project (Mark van den Homberg, Visser, and van der Veen 2017) and Raymond and Al Achkar work for the Harvard Humanitarian Initiative (Raymond and Achkar 2017). In both works the focus is data preparedness in general even if including a strong geospatial component.

The application of different forms of crowdsourced information, such as volunteered geographic information (VGI) or involuntary volunteered geographic information (iVGI) has been considered in the use of GIS for disaster management (See et al. 2016). Also, depending on the level of control over the VGI contributions a difference exists between “bounded crowd-sourced” project such as those produced by MapAction or GISCorps and “unbounded” such as OpenStreetMap (Payne, Florance, and Shain 2012). The literature review that was carried out by Klonner et al shows that the academic research is more focused on the response phase than on preparedness (Klonner et al. 2016). These studies state the potential, along with its challenges, such as data quality, bias in contributions, data management, and security issues (B. Haworth and Bruce 2015). In addition, Patrick Meier’s book provides an inside view at the first steps of “Digital Humanitarians” work and the integration of that VGI in the institutional system (Meier 2015). These advances in VGI and

WebGIS are influencing the production and data sharing in disaster response, which is becoming more dynamic, transparent, and decentralised. Institutions are not only sources of information but also coordination points between relief agencies and volunteers (Kawasaki, Berman, and Guan 2013b) and private sector supporting the responders (i.e. Esri's Disaster Response Program and Google Crisis Map open source tool from the Google.org Crisis Response team).

In academic research, social networks are also considered as a source for crowdsourcing iVGI to generate crisis maps (See et al. 2016). The possibility of using microblogs, images, and videos that are posted on sites such as Facebook, Twitter, and YouTube is being studied (Huang and Xiao, 2015; Middleton, Middleton and Modafferi, 2014). Although promising, the adoption of this technology is limited by the potential lack of reliability and the struggle to handle the large amounts of data that are generated (Mccormick 2015; Plotnick and Hiltz 2018). Therefore, the latest research trends in this area are related to the verification of the information generated (Mehta, Bruns, and Newton 2016) and, their use to verify information obtained from other sources (Eckle and de Albuquerque 2015; Planella Conrado et al. 2016), together with the application of machine learning (Avvenuti et al. 2016; Ofli et al. 2016) and semantic data mining (Xu et al. 2016) to gather geospatial information overcoming the information overload.

3.4. Findings and discussion

3.4.1. GIS basic datasets for disaster response in humanitarian missions: priorities, features and sources

As one of the participants in the study noted, "*maps are an easy way to tell a complex story"* (P7). The first maps that are created are related to the magnitude of the emergency to help responders understand the impact, most affected areas and key needs. They are followed by the *Who-What-Where* (3W), which provides two components of the *common operational picture:* situation and responders. There are two different audiences: in the first 24-72 hours, it consists of on-the-ground and remote responders; in the second stage, it is also necessary to create products for donors. Usually, shapefiles and tabular datasets can be used for infographics and to merge other datasets.

Datasets usually appear in relatively the same order since each dataset depends on previous datasets. Prior to answering complex questions, *baseline data* are needed: confirmation of the administrative boundaries (level 1: country, level 2: first subdivision in regions/municipalities, and level 3: second subdivision in district/zones) and the population within each. *"Sometimes basic questions like determining the boundaries of the disaster may take a lot of time and effort. But there is nothing that can be done before those questions are answered. Before trying to figure out how many people is in need I should know how many people they are"* (P7). The next step is to obtain a primary estimate of the magnitude, namely the impact and affected population, to categorize the more affected districts and to decide whether to deploy on-field teams to state the most vulnerable groups, their most pressing needs and potential displacement.

In the next phase, various clusters are operating, each one working on particular information which is aggregated to provide a 3W; what/where the needs are, what/where the situation is (e.g., access constrains, bridges, logistic hubs, etc.) and who/where the responders are (e.g., organisations, relief goods). The information is made available through Humanitarian Response Info and ReliefWeb. There are usually quite simple maps without complex analysis because it is not needed at this point (P7).

The response to a known type of disaster within a country is practically pre-planned, with details that need to be adapted. Cross-boundary disasters bring additional challenges, since disasters do not know about boundaries but humanitarian actors do.

As shown in Figure 5, IMOs identify administrative boundaries and a population baseline aligned with these administrative boundaries as the most important datasets. HDX datasets downloaded in the aftermath of the Hurricane Matthew (over 6,300 times from 1 October to 17 November) also confirm this information (most downloaded datasets: 1st administrative boundaries, 2nd 3W and 3rd population estimate 2015) (Band Jain 2016). These were also the first geospatial datasets requested through Skype.

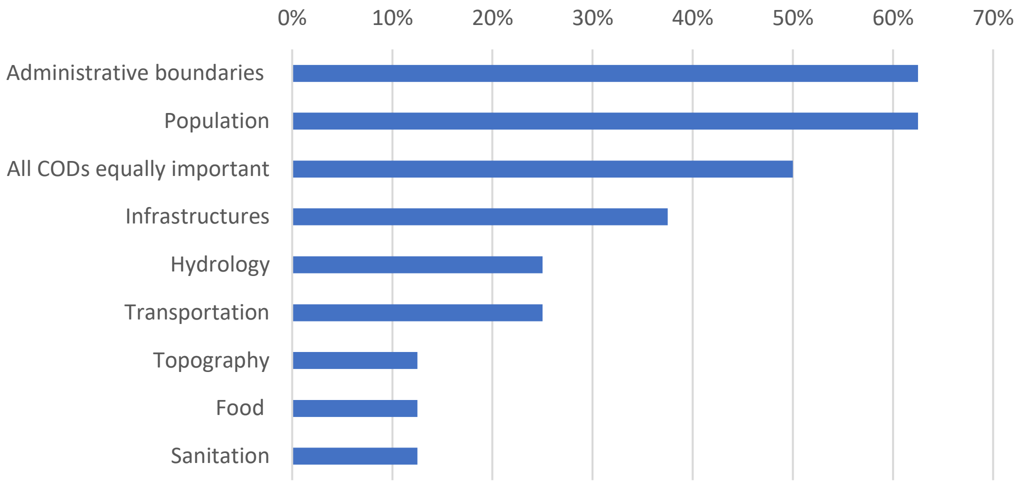

Figure 5 Percentage of participants identifying the main datasets calculated considering the number of IMOs identifying each dataset compared to the total number of IMOs interviewed.

Nevertheless, for the majority of the IMOs in the study, all CODs should be considered equally relevant. The specific CODs and FODs that were mentioned are listed in Figure 5. This information defines the type of support that is needed and what support may be brought over. These datasets are made available by UN agencies, MapAction and local governments (i.e., health ministry, environmental ministry, statistics office). Alternatively, several IMOs confirmed that information might also be obtained from other sources such as OpenStreetMap.

The main issue related to geospatial preparedness is that pre-crisis data need to be linked to the administrative boundaries and should be in a tabular format to be user-friendly and machine-readable (i.e. spread sheets). That means having rows with administrative areas and columns with data such as population figures, male/female ratio, food insecurity, nutrition, poverty, type of habitat, diseases, health facility locations, and livelihood zones. Otherwise, it is necessary to overlay these data into the corresponding administrative areas, which might generate inaccurate datasets. In general, the issues derived from the practical use of the existing CODs and FODs is a topic that should be object of further research.

3.4.2. Perspectives on GIS for disaster response in humanitarian missions

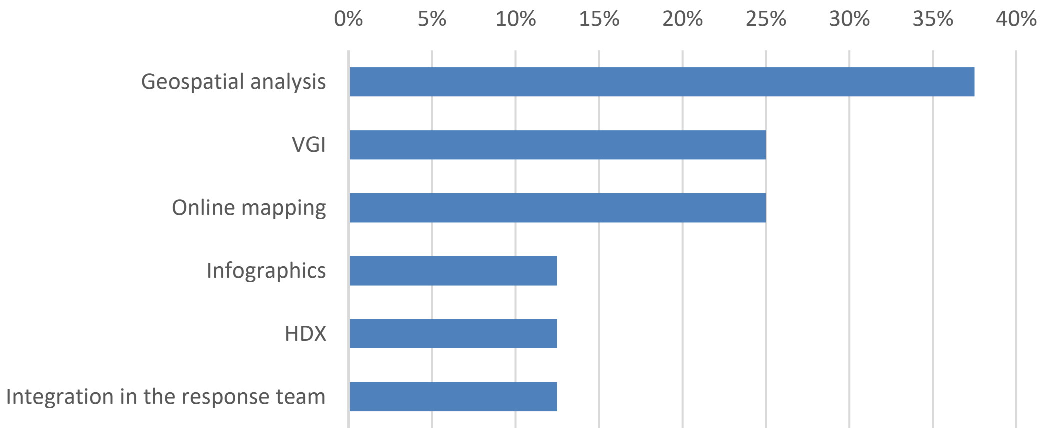

Figure 6 Percentage of interviewees with common opinions about the evolution in the use of GIS calculated considering the number of IMOs mentioning each topic compared to the total number of IMOs interviewed.

Participants stated the importance of GIS: *"The use of geospatial information has been the great difference in disaster management in the last decades"* (P6). Now, GIS allow decision makers to be accountable with data-based decisions. Figure 6 shows how the significant evolution of GIS during the last 5 to 10 years is linked to the development of online mapping, remote sensing and VGI: "*10 years ago, there were not even roads. For example, during an earthquake in Cashmere, we had to send agents biking the roads mapping with GPS. In 2010 Haiti earthquake, similar situation with the roadmaps, but in this case, OpenStreetMap generated all the maps within 3 days with satellite imagery"* (P4). This development of online mapping capabilities has allowed pdf maps to be replaced by dynamic mapping visualization and crisis mapping tools. In addition, new forms of data sharing such as HDX make datasets available to everyone: *"5 years ago, those datasets would have been in the pc of some consultant …."* (P4).

The GIS have evolved from a tool that was limited to situational awareness to a fundamental tool supporting the decision-making process. Geospatial analysis particularly has gained in complexity and importance. However, geospatial analysis requires preparedness and data. Even if it is impossible to be prepared for everything, geospatial preparedness was considered important and useful by all the participants in the study. *"It is very important to have the baseline information, admin boundaries and related population ready and clean beforehand. […] if datasets are ready and publicly shared, those datasets are something not to worry about"* (P7).

Nevertheless, improving geospatial preparedness is challenging due to economic cost and capacity issues (i.e., lack of staff or technology), or even lack of government in a country. In addition, for some regions, it is also a matter of how space is perceived. *"They do not value maps. They do not need to have an address"* (P1). In such conditions, GIS are not always appreciated, and preparedness might not be valued (P6).

There should be geospatial data to cover the standard information management needs. In addition, there should be a collaborative system to respond to unforeseen needs. The collaborative mechanism described in the introduction is designed to address those unforeseen needs (Mark van den Homberg 2017). In the case of hurricane Matthew, 45 people representing 22 organizations joined the digital collaborative space and actively participated during the first week of the response. It is arguable whether the system is used to meet those unforeseen or to compensate for the lack of geospatial preparedness.

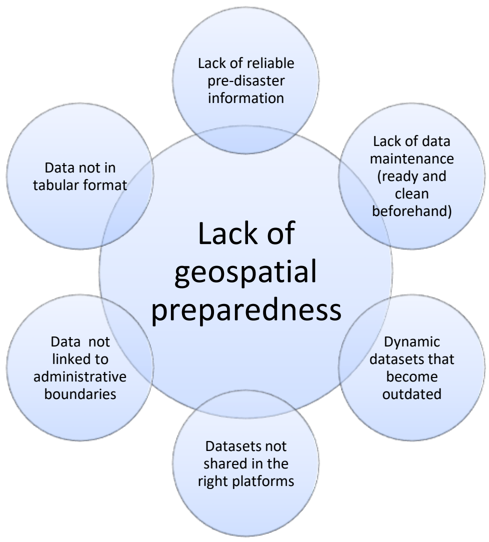

Figure 7 Challenges related to the lack of geospatial preparedness

This study partially confirmed that availability of reliable geospatial data is a bottleneck in the response. It also showed that some nuances should be considered. An issue might be locating the data because it is not always shared in a platform that is known to all the stakeholders. *"Not so sure if the problem is availability. The question is; can I find it?"* (P7). Once the information is found, other question to consider is whether the information is accessible, or the data owner is willing to share them. This inequity is country specific, as this participant (P1) showed with some examples: Zimbabwe shares all COD datasets except for hydrology, due to political issues; Kenya has made their data public. However, political boundaries change so often that they easily become outdated. Nevertheless, the issue is not only data availability, but the *timely* availability of that data. *"Sometimes there is too much information; […] the problem is not lack of information but lack of the right information at the right time"* (P2).

3.4.3. Proposed alternative sources of information

Due to the challenges showed in Figure 7, alternative sources of information might be required. The study questionnaire proposed 3 alternative sources to improve geospatial preparedness. IMOs' opinions about these sources are presented in Figure 8. The platforms and procedures to integrate the information gathered from these sources have not been considered at this stage and it will be object of future research.

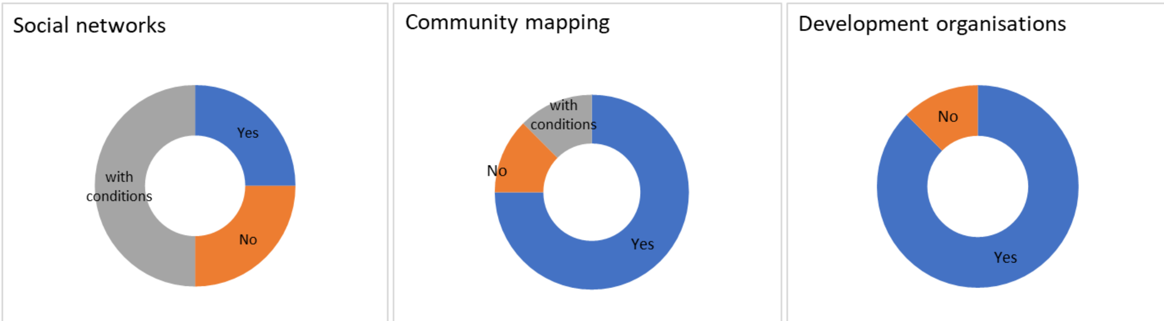

Figure 8. IMOs opinion about the feasibility of using alternative data sources; percentage calculated considering the number of IMOs with common opinion compared to the total number of IMOs interviewed.

3.4.3.1. Development organizations

Organisations working in development in disaster-prone areas could gather data. Development organisations know the local actors, while humanitarian actors go from one disaster to another. In the reverse direction, needs and aid during humanitarian actions could bounce back into development projects (San Martin 2014). This does not mean that such interactions are not already happening, but they should occur on a regular basis (P7). Development organisations see the value of geospatial data in the evaluation and monitoring of their projects, but they have an internal conflict in allocating resources: "*do we spend efforts and resources on this (GIS) or on our primary mission?*" (P6). In addition, to become a reliable source of information, they should have a solid data management strategy (P8). Another limitation could be their unwillingness to share the gathered data or lack of access to the right platforms to do so. Relationship building and communication would be necessary to explore these synergies. Finally, many technical challenges should be addressed. For example, baseline datasets that are created in development activities should be in line with the administrative boundaries that are used during humanitarian actions.

3.4.3.2. Community Mapping

Most of the IMOs consider community mapping a potential source of information to improve geospatial preparedness. Communities producing their own datasets could save much time for the IMO. *"Community mapping is a powerful tool that will become even more important in the future with the widespread use of smartphones"* (P5). V&TCs have numbers to validate the information in real time. Another advantage of community mapping is ownership. *"Humanitarian actors arrive, map the area and leave. The information is going to go out of date. When the community collects the information, they also maintain and update. That means this is probably the best resource we have"* (P7). OpenStreetMap might be considered the main representative of crowdsourced geospatial information in the form of community or collaborative mapping. While Humanitarian OpenStreetMap Team (HOT) applies the principles of open source and open data sharing to humanitarian aid (Poiani et al. 2016b; See et al. 2016). There are, however, some limitations such as reliability since the results depend on the commitment of the community. *"OpenStreetMap could be trusted in some places but not that much in others. It is open to mistakes and errors"* (P8). The way in which data are collected may affect how useful the data are to different people. Another issue is linked to the confidentiality of some information. It is impossible to control the distribution of this information since it is, by definition, open to everybody. This might create security issues; *"providing the location of MSF hospitals risks being bombed*" (P7). Finally, for UN Agencies, it is a problem when this information might be in conflict with "official" government information.

Nevertheless, it will be the decision of the IMO whether to use the information. *"You are going to triangulate to see if the information is reasonable, how well documented they are…. If they smell ok you are going to use them because it is a crisis. In summary, I would trust them as much as any other, but I do not trust the others too much"* (P4).

3.4.3.3. Social networks

Quite a different opinion was expressed about information sourced from social networks. All participants agreed with the general opinion that social networks might become important information sources; Social media georeferencing could become an important tool for situational awareness. "*Just being able to geolocate tweets, geolocate pictures….It has a lot of potential"* (P6). Nevertheless, in general, this is considered a "work in progress" (Mccormick 2015; Plotnick and Hiltz 2018). Therefore, they cannot be the principal source of information but an interesting tool to supplement the analysis. "*There is more smoke than fire so far"* (P4). In Libya, simple severity-scale mapping imagery and social media data were applied by UN Volunteers as a way of developing an early impact analysis (Standby Task Force and OCHA, 2011). However, it is a very complex data environment. *"It is very easy to draw bad conclusions from that data"* (P4). Internet availability is among the limitations: a missing mobile network tower may result in a blank spot when considering the use of a word in Twitter. Tweets tend to be free text, so they are difficult to analyse. "*The use of the word "water" can be linked to a flooding but also to people on the beach"* (P5). Regardless of projects to assess the reliability of this information, it is still necessary to learn how to mitigate the noise. The latency of the information is also very important. "*The help could have already arrived by the time the information is on a map" (*P8). It is necessary to develop technology to automatize the process (e.g., machine learning). "*Using people, volunteers, takes too long to be useful"* (P8). Nevertheless, this is a matter of capacity: *"Humanitarian actors do not have the budgets to develop these technologies"* (P7).

Finally, crisis mapping could be considered as the intersection of social media and community mapping. It is performed by local actors using platforms such as Ushahidi, where data are gathered, analysed and displayed in real time (Pánek et al. 2016). This poses a challenge to the international community. *"It is interesting in the digital humanitarian world to see that it is no longer international actors making crisis map and affected population […]. Two good examples of this shift are the Nepal earthquake and the Ecuador earthquake with really strong grass-roots crisis mapping teams"* (P7).

Table 4. Summary of finding related to the proposed alternative sources of information

Alternative sources	Benefits	Challenges
Development Organisations	Pre-disaster local knowledge Synergies	Allocation of resources Data management strategy Access to sharing platforms Openness to data sharing Technical challenges
Community Mapping	Pre-disaster local knowledge Ownership ensures maintenance	Reliability Security issues Conflict with "official" data
Social Networks	Amount of data available Real time update	Complex data environment Need to mitigate the noise Latency vs Amount of data Lack of capacity to develop technology

3.5. Conclusions

The use of GIS in humanitarian missions has dramatically changed in the last years as a result of the development and widespread use of online mapping, remote sensing and VGI. This evolution is bringing new challenges to the digital humanitarian community. Officially IMOs should use information from “official sources” (i.e. governmental institutions) to provide CODs and FODs. In reality, IMOs use the best available dataset. OpenStreetMap, for example, is a valuable source of information that is regularly used. IMOs are tapping alternative sources of geospatial data and institutions are adapting their working procedures to this new reality. Nevertheless, these changes do not fully address the lack of geospatial preparedness, particularly lack of pre-disaster data in many disaster-prone countries. A question that remains open is whether data do not exist, are not reliable or are just not shared.

Social networks as source of information have an enormous potential, but they are not reliable. The technology is not ready and humanitarian actors do not have the capability to develop it. Moreover, the use of social networks to evaluate the severity of a disaster differs from the IMOs “standard” practice. This might represent a challenge for institutions that are in the process of establishing procedures and working standards.

Organisations working in development projects could gather data to improve geospatial preparedness. There are obvious synergies. For development organisations to become a reliable source of information, they should have a solid data management strategy and be involved with the humanitarian community. If these organisations worked to improve OpenStreetMap these limitations could be overcame.

4. Geospatial preparedness: empirical study of the joint effort to provide geospatial support to disaster response[7]

Abstract

In a disaster aftermath in places lacking geospatial preparedness, the United Nations Office for the Coordination of Humanitarian Affairs creates a framework for cooperation with the Coordinated Data Scramble initiative where Information Management Officers (IMOs) from different organisations work together in supporting the coordination of humanitarian aid. The perspective of these IMOs has been considered to identify the factors influencing the use of Geographic Information Systems in this context. The results show the requirement for a geodata management strategy including geodata gathering, maintenance, and decision-making processes based on those geodata. Geodata should be reliable and up to date. It requires consistent and useful metadata and the possibility of contacting the geodata source. Security and political issues limit information sharing. In this context, OpenStreetMap is often used as a source of information. Therefore, improving OpenStreetMap improves geospatial preparedness. Nevertheless, the use of this open platform highlights issues related to information privacy.

4.1. Introduction and background on the coordination of Information Management in disaster response

On 3 October 2016, category 4 Hurricane Matthew was 440 km south-west from Port-au-Prince (Haiti). Two days later, it swept towards the Bahamas, pummelling Haiti. On 4 October 2016, 44 Information Management Officers (IMOs) from United Nations (UN) institutions and partner organisations received an activation email due to the expected effects of the hurricane. The call was part of a pre-agreed procedure with those Agencies and partners which form part of the Information Management Working Group that have expressed interest to participate in the *joint situation and needs analysis* (OCHA CASS 2016). This initiative was a first step to creating an information management group to share data and information to achieve a joint multi-sectoral analysis to launch a *Flash Appeal* to fund the disaster response. An officer from the United Nations Office for the Coordination of

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Humanitarian Affairs (OCHA) was appointed as the focal point. A Skype room was established to facilitate the coordination of the support to IMOs deployed on the field as part of a UN Disaster Assessment and Coordination team. Within minutes, a Trello board with public access was created by the *Coordinated Data Scramble*. Other tools (i.e. dropbox, google drive) would shortly follow. The call cascaded through IMOs from different organisations to expand the support. Within a week, 45 personnel from 22 organisations were actively participating in the skype room from an overall 70 workforce from 30 organisations (during the West Africa 2014-2015 Ebola outbreak 232 people, from 92 organisations were actively participating) (Moore 2016). The call was open to any institution with the demonstrated capacity to process and analyse data and information. They included several OCHA sections, national and international agencies, UN clusters, networks or consortiums of agencies, research institutions and academia, NGOs, volunteer networks, and the private sector. The work of this group was to be considered within the framework of the *Multi-Cluster/Sector Initial Rapid Assessment* (MIRA) and the *Humanitarian Needs Overview* established by the Inter-Agency Standing Committee. The target was to produce an operational picture from primary (i.e. field data) and secondary (i.e. pre-crisis and in-crisis data) sources, including a baseline situation analysis drawn on the most recent pre-crisis information. The outcomes were to be presented in a *Preliminary Scenario Definition* (within 72 hours) and a *MIRA Report* (after two weeks). The MIRA Analytical Framework establishes the information priorities (i.e. scope and scale of the crisis, conditions of the affected population, capacities and response and humanitarian access) (Inter-Agency Standing Committee 2015). During this period, when major decisions are taken, there is a high demand for and a low supply of information (Lovon and Austin 2016). The first files made available through the Coordinated Data Scramble were geospatial information (i.e. Haiti Administrative Boundaries uploaded to Humanitarian Data Exchange (HDX)). Using Geographic Information Systems (GIS) to analyse the population in those administrative divisions located in the track of the hurricane would provide a first estimation of the magnitude of the disaster.

Making this pre-disaster geodata available was a precondition to use GIS to facilitate the disaster response decision-making process. *Geospatial preparedness* is a complex concept commonly implemented in developed countries; there are political support and regulations to create institutions with tools and trained people to gather, share and use geodata (DHS 2014). The different approach to geospatial preparedness across the world creates inequality; while information is readily available in countries with a high level of geospatial preparedness, in many disaster-prone areas, the geographical element of information is not considered. Therefore, geospatial pre-disaster information does not exist. This lack of geospatial preparedness hinders emergency response coordination (San Martin and Painho 2016). In those places, international organisations provide coordination, information management and emergency funding. The *rapid appraisal* of the disaster magnitude compared to local capacities leads to the deployment of international humanitarian aid coordinated by OCHA (San Martin 2014). On 4 October 2016, the multifaceted team described above was assembled to provide the necessary information overcoming the limitations caused by the lack of geospatial preparedness in Haiti.

There are few academic works in the use of GIS in humanitarian missions. In addition, these studies do not address the actual framework in which more partners are able to create and handle geospatial information. Therefore, the scope of this empirical study is to understand the management of geographic information by the international humanitarian community in places where reliable information is not readily available. Previous studies were missing the perspective of the people deciding which information was used and how it would be used. Eventually, the information used to address the lack of geospatial preparedness depends not only on procedures and logic but on subjective decisions. Therefore, the objective is to analyse the opinion of IMOs providing an inside practical view on the process leading to the identification and validation of information that is made available to decision-makers in humanitarian missions. The purpose of the study is to answer the following questions; how do IMOs taking part in international cooperation for disaster response address the lack of reliable pre-disaster geographic information? Moreover, could the identification of the methods used, and the issues and constraints found in this process bring potential short-term solutions to address the lack of geospatial preparedness? Ultimately, the research aims to establish areas of further research to identify potential long-term sustainable solutions.

The present study does not aim to evaluate the effectiveness of the actual system in place but rather to provide an inside view and to identify the issues originated due to the lack of reliable pre-disaster information. Moreover, it is acknowledged that geospatial preparedness is a more complex concept including institutions and regulations, tools and the people who use them. Furthermore, providing those would be related to capacity building which is outside the scope of this research.

4.2. Methodology

The research is grounded on a multi-method strategy (Denscombe 2014) including literature review, semi-structured individual interviews with information managers and the study of the tools used to coordinate the support (i.e. Skype room, Google Docs and Trello boards and datasets uploaded to HDX). It followed a supplementary literature review on the topics identified during the analysis of the interviews.

The interview guide was drafted based on the review of previous related works and the characteristics of the target population of the study (i.e. IMOs with experience during international disaster response operations). A purposive sampling technique followed by snowball sampling were used to select key informants covering the different profiles for on-field and remote IMOs from the main stakeholders as shown in Table 5; UN institutions at local, regional and headquarters level (OCHA and High Commissioner for Refugees) and NGOs from volunteers to management level (Digital Humanitarians, MapAction and GISCorps). All participants fulfilled the condition of having participated as IMOs in international disaster response operations in the last five years. Eight semi-structured interviews, with an approximate duration of 60 minutes each, were completed via Skype in 2016 and 2017. This sample was considered adequate given the size of the target population (i.e. 9% of the IMOs involved in response to Hurricane Mathew were interviewed). Together with the key positions of the IMOs interviewed (i.e. NGO Volunteers, NGO Founder and Director, Coordinated Data Scramble organiser, UN Consultant, UN GIS Coordinator, UN Data Systems Analyst, and UN Head of Unit) and, the overall methodology of the research not relying merely on the interviews.

All participants were expressing their personal opinions and not necessarily the official views of their institutions. Therefore, the identity of the interviewees including details of their specific roles, are not revealed to preserve confidentiality. Furthermore, to ensure the ethical use of data from research participants, the general ideas expressed during the interviews are cited by using the letter “P” followed by an assigned number. In addition, italics and quotation marks were used to denote an exact quote of the participant’s words.

Table 5. Characterisation of the participants in the study identified by a P followed by a number indicting the chronological order in which the interview was conducted to ensure the ethical use of data from research participants.

P1	**P2**	**P3**	**P4**	**P5**	**P6**	**P7**	**P8**
UN	NGO	UN	UN	UN	NGO	UN	NGO
Head office	Volunteer & Manager	Local office	Head office	Local office	Volunteer	Head office	Volunteer & Manager
Field & remote support	Field & remote support	Field & remote support	Field & remote support	Field & remote support	Remote support	Field & remote support	Remote support

Each participant was presented with the same questions. Interviews were recorded, transcribed and coded manually following an inductive approach. Interview outcomes were never discussed with other participants to avoid influencing individual opinions. The interview guide was the result of a literature review described in a preceding paper. The initial phase of the research considered seven *a priori* codes for topics directly introduced in the interviews. The results of their analysis were also presented in the aforementioned paper reference (San Martin and Painho 2019a). In addition, grounded coding of the interviews defined a list of recurrent topics referred by the IMOs. The analysis of these topics is presented in the current article. Each topic is exemplified by a selection of quotes from the interviews. In order to facilitate the analysis, the topics were grouped into two themes.

The initial results of the study were validated considering the eleven topics identified within the tools used for the coordination of support to on-field IMOs. These tools were monitored during the actual response (i.e. Hurricane Matthew in Haiti in October 2016) and *"a-posteriori"* (i.e. Cyclone Winston in Fiji in February 2016 and the Ecuador earthquake in April 2016). Upon invitation, the Skype room for the response to Hurricane Mathew was monitored daily from 14 October 2016 to 4 November 2016 (the chat history was studied from its creation on 4 October 2016). The Trello board, shown in Figure 9, documents shared through Google Docs, and datasets that were uploaded to HDX were followed in parallel. It should be noted that four of the members of the Hurricane Matthew emergency response team had been interviewed as part of the study. The response to Cyclone Winston and the Ecuador earthquake were studied through the Trello boards and datasets that were uploaded to HDX. The identified topics of common reference were also the basis for a supplementary literature review.

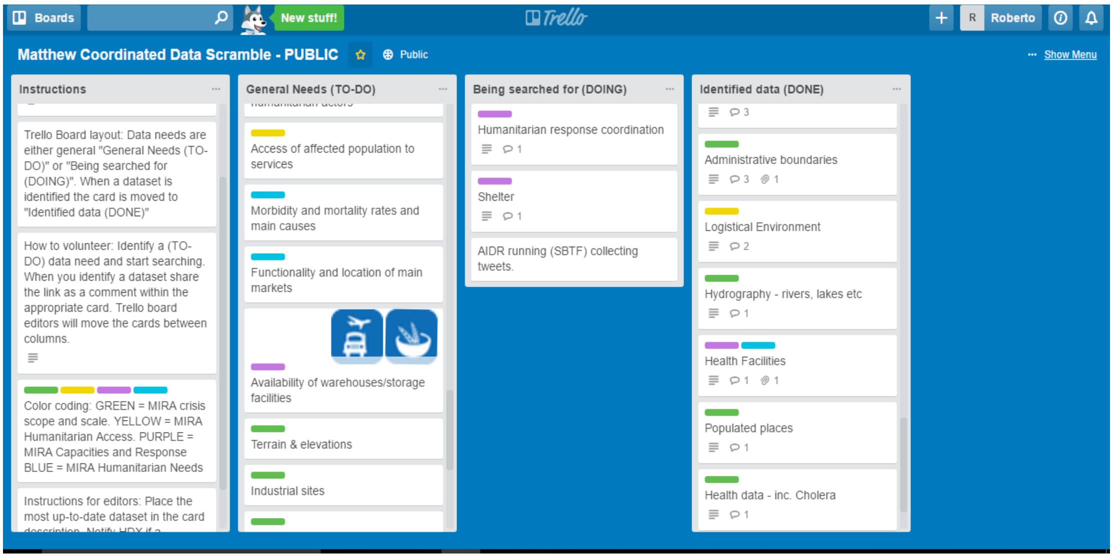

Figure 9. Coordinated Data Scramble Trello board used during the response to Hurricane Matthew in Haiti showing the general instructions on the use of the board, the information needs (to-do), the work in progress (doing) and the data identified (done).

4.3. Framework and related work

There are few academic works related to the practical application of GIS to humanitarian aid. Tomaszewski et al. provide a general overview of GIS for disaster response (Tomaszewski et al. 2015). The main actors and concepts used in the present study are described within this state-of-the-art report. The work of Miyazaki, Nagai and Shibasaki reviews geospatial technologies for Disaster Risk Management and their applications (Miyazaki, Nagai, and Shibasaki 2015). Boccardo and Tonolo provide an overview of the use of remote sensing, mainly satellite, for disaster response including techniques, international initiatives and limitations (Boccardo and Tonolo 2015). However, only the research of Soden and Palen (Soden and Palen 2016) considers the opinion of information managers about the use of GIS for the coordination of humanitarian aid, with a particular focus on OpenStreetMap. In addition, the most relevant works specifically related to preparedness are: the Data Preparedness Framework developed by van den Homberg et al., within the Netherlands Red Cross 510 project (Mark van den Homberg, Visser, and van der Veen 2017) and Raymond and Al Achkar's work for the Harvard Humanitarian Initiative (Raymond and Achkar 2017). In both works, there is a strong geospatial component.

Remote sensing (i.e. satellite, aerial, Unmanned Aerial Vehicles) has become an essential data source. Several international initiatives provide access to this type of information; the INSPIRE initiative and Copernicus Programme or Group on Earth Observation/Global Earth Observation System of Systems, Sentinel Asia, International Charter, UNITAR/UNOSAT, USGS Emergency Response, SERVIR, GEO GSNL, and Global Disaster Alert and Coordination System (Miyazaki, Nagai, and Shibasaki 2015). The ubiquity of remote sensing together with advances in volunteered geographic information (VGI) and WebGIS are influencing production and data sharing. As a result, institutions are evolving from a source of information to a coordination point between relief agencies and volunteers (Kawasaki, Berman, and Guan 2013b; Meier 2015). Patrick Meier's book provides an inside view of the first steps of "Digital Humanitarians" work and the integration of that VGI in the institutional system (Meier 2015). The new role of VGI in disaster response has been portrayed in studies looking for a bottom-up approach to data sharing in opposition to the traditional top-down method. In this context, VGI and open standards are commonly linked to data sharing (Poorazizi, Hunter, and Steiniger 2015).

The use of geospatial big data presents numerous challenges; nevertheless, it also opens several research opportunities (Robinson et al. 2017) particularly when it is applied to disaster management (Qadir et al. 2016). Crisis mapping, the processing of big data by volunteers in response to an emergency, represents a new paradigm for the humanitarian community (Givoni 2016). When considering the application of different forms of crowdsourced information such as volunteered geographic information (VGI) (See et al. 2016), studies state the potential of this source of information in disaster response but also challenges such as data quality, bias in contributions, data management, and security issues (B. Haworth and Bruce 2015). OpenStreetMap, particularly Humanitarian OpenStreetMap Team (HOT), applies the principles of open source and open data sharing to humanitarian aid (Givoni 2016; Poiani et al. 2016a; See et al. 2016; Soden and Palen 2016; Dittus, Quattrone, and Capra 2017). As Neis and Zielstra's 2014 review shows, research related to OpenStreetMap has been focused on data quality and contributor patterns (Neis and Zielstra 2014). Numerous papers have studied the level of accuracy through different methods (Eckle and de Albuquerque 2015; Basiri et al. 2016; Sehra, Singh, and Rai 2017) with reliability being one of the main concerns regarding this platform.

In general, the work of crowdsourced mapping is positively assessed. OpenStreetMap has been considered to have the potential to be a reliable geographic open data platform

(Westrope, Banick, and Levine 2014). During the 2014 West Africa Ebola epidemic, the UN recognised that "good information" was necessary for the coordination of humanitarian aid. Among many challenges, the lack of geospatial preparedness was at the centre of that problem. To solve that issue, Medecins sans Frontiers (MsF) and Red Cross International decided to crowdsource the task of mapping newly infected areas relying on HOT and Missing Maps (Koch 2015). HOT work was also significant in response to the 2015 Nepal earthquake and other major disasters (Poiani et al. 2016b; Givoni 2016; Dittus, Quattrone, and Capra 2017). The Missing Maps project was initiated by HOT together with MsF, the British Red Cross and the American Red Cross in 2014. Missing Maps aims to improve geospatial preparedness using volunteers and OpenStreetMap (Herfort, Eckle, and de Albuquerque 2016). The objective is to work in geospatial preparedness mapping vulnerable places in the developing world, so information is ready for the humanitarian community if a disaster occurs. MsF considers Missing Maps a *clear added value* in the field (Gray, Stringer, and Jobanputra 2017). Missing Maps has been analysed in several research works (Albuquerque, Herfort, and Eckle 2016). The disconnection between local communities and mappers brings concerns about the necessary maintenance and updating of the datasets. The transition from crisis mapping to sustainable and locally-owned community-mapping is only possible with the engagement of the community (Soden and Palen 2014). Capacity building is needed to deliver long term cartographic solutions (Turk 2016). Consequently, Missing Maps also works on capacity building with NGOs and local communities (Missing Maps 2017).

Fewer studies consider the implications of openly distributing data that might include sensitive information. Security issues are a general concern for information published through participatory platforms especially when used at conflict zones where disclosing information could put people at risk (Mark van den Homberg and Neef 2015; Tilanus 2016). Christian Bittner's research about OpenStreetMap in Israel and Palestine shows different aspects of this issue; security concerns about the location of military areas, political implications of conflicting borders, different designation of locations, language issues, and national inequities (Bittner 2017).

Within the UN, the Secretary-General acknowledged the importance and evolution of geospatial information management proposing to rename the Cartographic Section as the Geospatial Information Section. In parallel, a self-described "identity crisis" is recognised by the fact that this section was relocated several times (UN doc 2015) until being placed in the

Information & Communications Technology Division within the Department of Field Support. Political challenges are identified as a limiting factor in the use of remote sensing and geospatial information by the UN institutions especially in sensitive operations as those within the UN peacekeeping framework (Convergne and Snyder 2015). The disconnection between information managers and decisions makers also limits the use of GIS by UN institutions. Decision makers are not aware of what IMOs can do for them using GIS. Moreover, the information flow does not always take the right information to the appropriate decision maker (Convergne and Snyder 2015). The Strategic Framework on Geospatial Information and Services for Disasters 2016-2030 drafted by the UN-GGIM Working Group on Geospatial Information and Services for Disasters identifies data management as one of the priorities to be addressed. One of the targets related to this priority is to obtain completed, updated and validated datasets. In addition to data development, it also pursues the setting of data standards and protocols, and data use guidelines. This document also acknowledges the need to engage the *Open Data Community* (WG-Disasters UN-GGIM 2016b). The UN-GGIM foresees the importance of crowdsourced geospatial information, open source and open standards in the different editions of their reports on *future trends* in geospatial information management (Norris 2015; Carpenter and Snell 2013). A UN Strategic Framework is also necessary to provide geospatial information for disaster management (WG-Disasters UN-GGIM 2016a).

Finally, the Coordinated Data Scramble project is OCHA's invaluable partner to provide a coordinated data sharing framework in which everybody uses the same data for each particular topic. "Scrambles" initiated during the 2011 crisis in the Horn of Africa. Social Networks such as Skype, Slack or Telegram are used to communicate and coordinate in combination with other collaborative tools like Google Docs and Trello. Scrambled datasets are usually uploaded to the HDX (Verity 2017; Campbell 2017; Mark van den Homberg 2017). Roxane Moore presented a summary at the GeOnG Forum with detailed analyses of how digital collaborative spaces were used, the number of messages, signal-to-noise ratios, and the type of exchanged data sets that has been the base for the study of these tools in the present study (Moore 2016).

4.4. Findings and discussion

The analysis of the interviews defined a list of recurrent topics referred by the IMOs. Figure 10 lists the number of occurrences in which each topic was coded. In order to facilitate the analysis, the topics were grouped into two themes: data management strategy, and geographic information and the use of GIS.

4.4.1. Topics related to data management strategy

For a better understanding of the analysis methodology, examples of the different codes considered within this theme are gathered in Table 6. The percentage of interviews with occurrences of each topic is indicated in Figure 11.

Table 6. Examples of variables related to data management strategy.

Variables	Examples
Data sharing	P 7. *"The data is out there; you just need to find it. Everything you can do to encourage sharing in open source, like HDX, would be ideal. In that way, everybody would know that the data exists. If the information is not directly shared, the government could list the information available so everybody can contact them to request it".*
Data reliability	P2. *"Reliability is an issue. It will become more important with the increase in information available. It is also important for the responders whether the information is a "best guess" or actual contrasted information".* P 4. *"Even official information is not really reliable…. Sometimes you wonder whether the administrative boundaries you have are the latest version…. The ones you get from the statistics office may be different from those from the department of internal affairs…".*
Data maintenance	P 4. *"Maintenance of the datasets is essential. There is a need to have a system in place, a cycle, to update those datasets. The standards are there".*
Cleaning datasets	P 5. *"Cleaning and maintaining the datasets is as important as data gathering. It would be important to check with the local government for new data on a regular basis, 6 months to 1-year frequency".* P 4. *"The fact that there is not a single point of truth for administrative boundaries at the beginning of an operation is a major problem, for example people using data with different spelling of the admin names, different versions with a different number of admin units. […] This is a problem that does not take much attention. People expect the IMOs to do fancy analysis. It is not easy to understand the time-consuming task that is "fixing" datasets, cleaning data, copy-pasting a string of numbers in excel".*
Metadata	P 2. *"Metadata is more from an operational standpoint. It means a compromise between the usual "non-disaster time" metadata in a dataset. Working for preparedness you can include more data methodology on how the dataset was created or upgraded".*

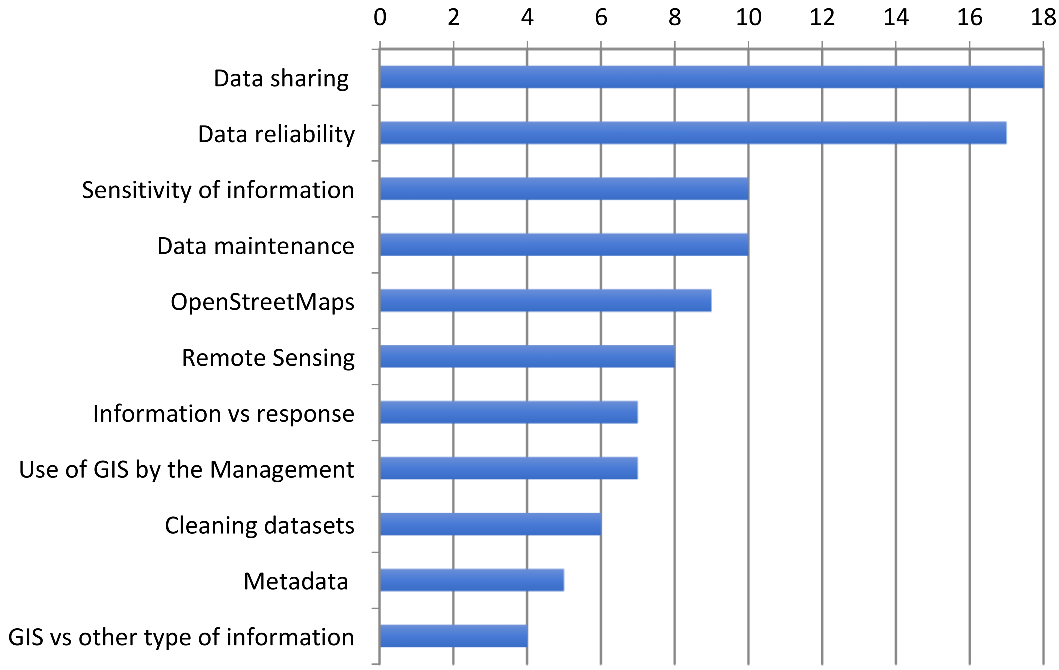

Figure 10. List of variables coded during the interviews and number of occurrences

Data sharing is fundamental in the aftermath of a disaster when IMOs from different organisations are searching for the same information in parallel. *"Information loses value if it is used only by one organisation*" (P5). Subsequently, the "same" information can be found from different sources, for the coordination to be effective everybody should be using the same datasets. For example, Administrative boundaries available at Global Administrative Areas or at HDX might not match the datasets in use in the country. "*Whatever is released earlier becomes the default"* (P7). OCHAs main task is compiling datasets with the Coordinated Data Scramble avoiding the duplication of information and facilitating data sharing among all stakeholders.

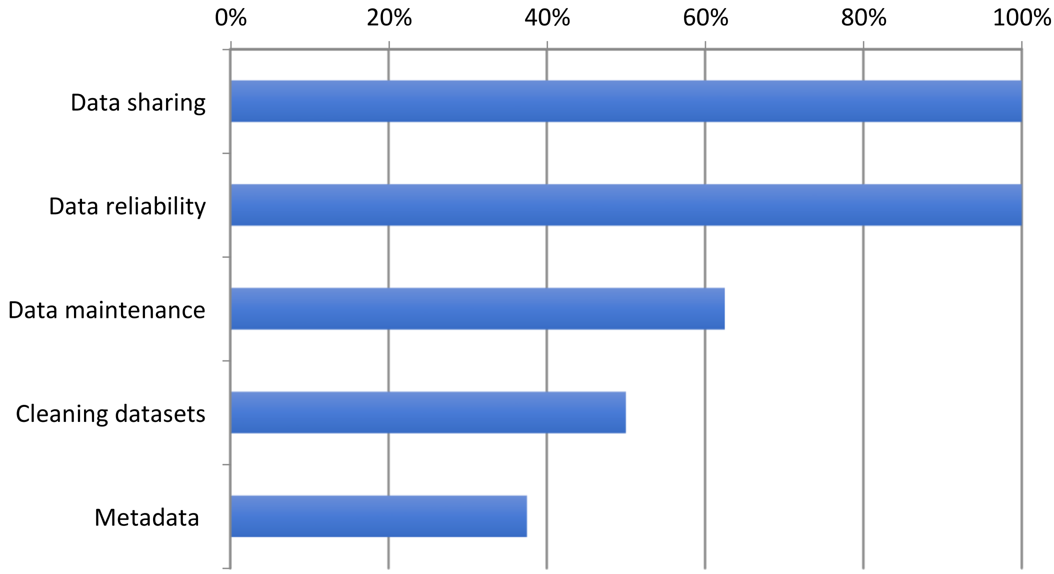

Figure 11. Percentage of participants identifying each variable related to data management strategy.

Even if the concept of open data is gaining strength, in some cases, governments try to charge for the datasets (P3), or they do not allow OCHA to share them. For example, "*The Nepal government only allows sharing under certain conditions. Usually, the condition is a disaster happening"* (P1). Only after the 2015 Nepal earthquake, was OCHA allowed to move CODs to HDX (P1). Data sharing is also limited as a result of the emergency situation in itself. "*There is just no time to share information because there are other priorities*" (P5). Another limitation to data sharing, that will be studied later is the sensitivity of the information.

Once information is shared, the question is to which extent that information is reliable. "*Timeliness versus accuracy is a great dilemma"* (P6). In an emergency environment information is urgently needed but it might not be entirely reliable. It is important to consider: date, where it comes from and who has created it. Problems with a dataset should be explained in the metadata, but this is not always the case. *"[…] duplications or information missing due to political reasons…. That cannot be explained in the metadata, even if it should be"* (P1). That is where relationships and data source contacts become important (Mehta, Bruns, and Newton 2016; Givoni 2016).

OCHA policy in terms of metadata has evolved over time. *"Dublin metadata standards were an issue around 2010 and 2011. […] This is worthy but… with the modern GIS systems that can transform on the fly, almost everything is WGS84…. It is not that important anymore"*

(P4). Nowadays, data sharing is prioritised if the datasets have enough metadata to be useful. For example, Haiti Flood Risk Communes[8] (OCHA February 2015) did not have information about the indicators driving this map and whether it could be used as a proxy for greater damage to precipitation. This issue restricted the use of this dataset during the response to Hurricane Matthew. Another matter is the content of the metadata itself. Ensuring consistency of definitions is necessary. For example, during an epidemic such as Ebola, the terms "suspected case" and "confirmed case" may be used differently by different organisations. Alternatively, they might use different scales with a different number of variables (i.e. 3 types or 2 types…). That means that information among districts is not consistent (P7). "*It is important to understand the reasons behind those definitions because they are related to the way the organisations work"* (P7). Language might also be an issue when the local language is other than English, which is commonly used by international humanitarian aid organisations. In Haiti, national datasets use French (departments, arrondissements, communes and communal sections) while HDX uses English (Administrative boundaries 1, 2 and 3). In this regard, the work of Translators without Borders was critical during the Hurricane Matthew data scramble.

For IMOs to trust a dataset, the topology should be correct. There should not be problems with the projection or contradictions between datasets (P5). For that reason, the cleaning of datasets should be done as part of a regular scheme. For example, during the response to Hurricane Mathew, an incorrect *administrative boundaries dataset* became a bottleneck. A dataset where the commons of one district were scattered all over Haiti was the cause of losing precious time until the problem was identified and fixed. *"It was not considered important to work on them until something happens"* (P5). Moreover, the information should be up to date. The UN Committee of Experts on Global Geospatial Information Management (UN-GGIM) stated the inequity among countries and pointed to outdated information as one of the main issues (Konecny, Breitkopf, and Radtke 2016). Datasets might become quickly outdated. Population statistics depend on censuses that are not carried out so often (P1). Administrative boundaries might not be updated because of political implications or just because they change quite often. For example, "*Kenya has made their data public in a data-portal; However, political boundaries change so often that they are easily outdated*" (P1). Therefore, data maintenance becomes a critical task. The operational decisions taken should determine the scale of the map within a level of detail that allows

[8] http://reliefweb.int/map/haiti/haiti-flood-risk-communes-february-2015 last accessed on 29 December 2018

maintaining the information. Because the level of detail has implications in the cost, time to produce and maintain, and uses for the dataset. *"They should have enough information to be useful but not too much. Too much detail makes it impossible to maintain"* (P5).

In summary, a strategy with a number of layers, data governance and framework architecture is required to ensure that the data have been cured or collected (P8). Standardising the meaning of data quality and data accuracy is necessary. *"It is not only the metadata itself but the content of the metadata. What does it mean?"* (P8). A methodology is required including how information is collected, validated and updated. The last update and consistency of update should be clearly indicated, "*[…] whether it was an annual report or one of time survey*" (P7). *"Trustworthy data is the base for any application. But data is not sexy, and applications are. And this is not always understood by the decision makers"* (P8). In this regard, some IMOs request a known, agreed *single point of truth*, a predictable schema where data can be consumed as a service (P4, P8).

4.4.2. Topics related to the Geographic information and use of GIS

Table 7 lists examples of the different codes grouped under this heading. The percentage of interviews with occurrences of each topic is presented in Figure 12.

The last three topics listed in Figure 12 are clearly interrelated because it is a management decision on how to use different types of information to adapt the response to the needs and local capacities. *"Responders get bombarded with too much information. They do not know what information to use with the priorities they have. Information managers should indicate why they are providing that information and how that dataset could be useful for the decision-making process. That means providing information rather than data*" (P2). The integration of IMOs in the response teams should improve this interaction. There are no specific procedures on how the management should use geospatial information but decisions based on previous experience (P2 & P5). Information analysis becomes a personal choice of the decision maker in charge. While for some it is a powerful tool, others just use "excel sheets" to produce infographics. Therefore, georeferencing information might be losing importance restricting the possibilities of geo-analysis (P1 & P5). In this context, whether the decisions are taken based on sound information or the information used to show and justify previously made decisions is a matter for discussion.

Table 7. Examples of variables related to Geographic information and the use of GIS.

Indicator	Example
OpenStreetMap	P 7. *"OpenStreetMap used to be the base map for any humanitarian map. The biggest limitation is reliability. People are reluctant to trust as they are with Wikipedia. There may be user errors in the map, for example, information misplaced, roads disconnected…. But this is not a big deal because it can be cleaned so it can be used as a base-map".*
Sensitivity of information (political and security implications)	*P 5. "In a dataset about Ebola cases in the world they were using OpenStreetMap as a cartographic base. The problem was that in that base Taiwan appeared and this produced a diplomatic complaint from China that does not recognise it".* *P 5. "Another restriction to sharing and distribution is security. For example, in Burundi we tried to map the location of hospitals through volunteers from CrisisMappers. However, there was information that hospitals were the place to kidnap and repress critics to the regime after demonstrations. Giving the information on hospital locations could support the repressing government".*
Remote Sensing	P 8. *"Imagery is the key to damage assessment. It is becoming easier since a government initiative facilitates commercial companies providing post-disaster imagery".*
Use by the Management	P 5. *"In some cases, management may ask for very specific maps orientated to a particular meeting, for example founding, coordination…".*
Information vs response	P1. *"The response has changed. In the last 2 years, there have been more "cash transfers". Agencies are giving money to the people instead of food or shelter. For this, the location of where bases are is necessary, for example, telecommunications, where cell towers are, where internet is available…"*
GIS vs other types of information	P 5. *"Some agencies are using data scientists who work directly on the analysis of the data. In these cases, georeferencing is completely out of the picture".* P 5. *"Senior management does not give importance to the geographical localisation; For example, they want to know how many hospitals are in a province but they do not care where they are".*

In this environment, OCHA's coordination deals with highly political issues, and it needs to work behind the scenes which also affects information management. OCHA tries to find where all the actors are located to provide a common operational picture. Coordination is more reactive than proactive. It describes what is already happening and, only after, redirects to optimise resources avoiding accumulation of NGOs in one area or areas without support (P7). The response is coordinated through meetings based on the cluster approach. Subsequently, each cluster has its internal coordination with the different NGOs. This aspect is challenging for NGOs that work in many different areas (i.e. Save the Children works in sanitation, hygiene, health…). “*There is a disconnection between the way coordination works and the way NGOs implement”* (P7). In addition, each cluster collects data in the best manner for them so aggregating that information is also challenging (P7).

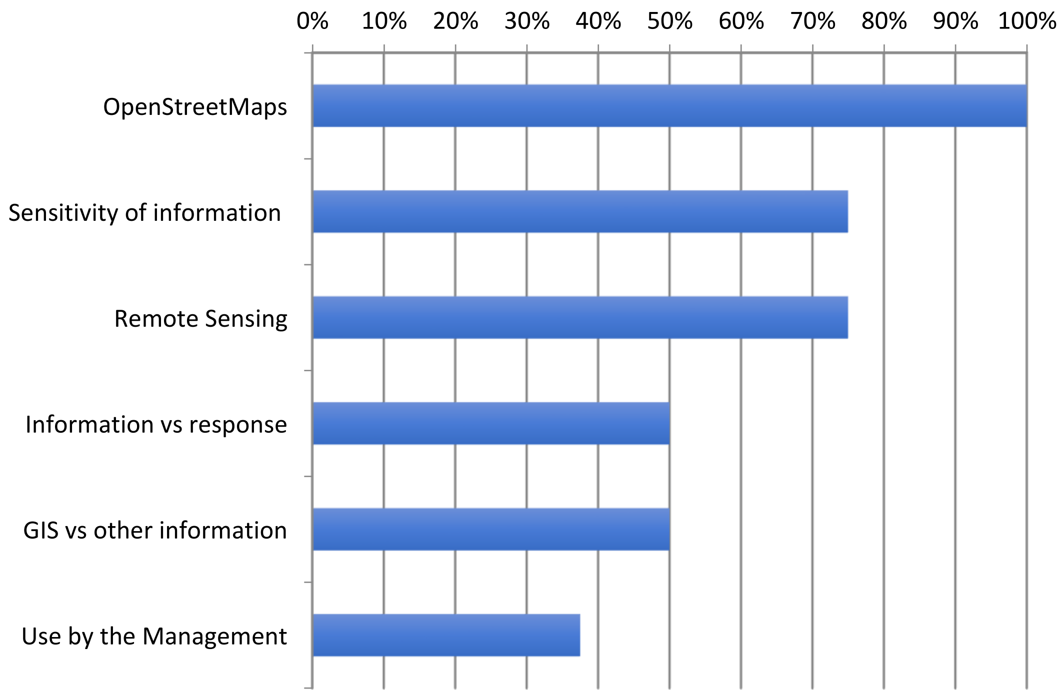

Figure 12. Percentage of participants identifying each topic related to geographic information and the use of GIS.

The objective of UN IMOs is to provide the best datasets available. Even if some IMOs only used governmental data, OpenStreetMap is a vast repository that is often used and trusted (P7). The main advantage of OpenStreetMap is accessibility, whereas the main limitation remains reliability. Although there are ways to validate OpenStreetMap information to a certain degree, and as a minimum, it can be used to complement and triangulate existing data and to provide a contact person (P1). Moreover, in cases such as the 2015 Nepal earthquake, it was already a common source of fundamental geospatial data (Givoni 2016). Projects such as Missing Maps aim to increase this potential through data gathering and also the conversion of data into OpenStreetMap formats (P6). Another consideration is the license under which a dataset is released. For example, during the response to the Hurricane Matthew, datasets had to be released into HDX under public domain or Creative Commons Attribution 4.0 International (CC BY 4.0) because of the interoperability with the

OpenStreetMap distribution licence, ODbL 1.0 (e.g. Terra Bela data is released under this license). Finally, data privacy is another concern affecting the use of OpenStreetMap. Cases like the bombing of MsF hospitals in Syria demonstrate the risks of making information open to everybody (P7).

Sensitive information should be protected against unwarranted disclosure which limits data sharing. "*People want to share but, in a stressful environment, there are concerns about which information can be shared*" (P2). There are two main reasons for information to become sensitive, viz. security and political. Three categories can be considered: data that is so sensitive that cannot be shared with any other organisation (i.e. it may have people names), data that is relatively sensitive but it can be shared with other humanitarian organisations (these organisations should understand the limitations in the use of these data), and there is public data (P2). IMOs are more likely to share datasets with people with whom a pre-disaster relationship had been built. During the Syria conflict, a transnational conflict with a myriad of political issues and cross-boundary operations, NGOs with transboundary activities could not disclose their identity to avoid prosecution. The solution was to anonymise data. "*Data was made available based on on-field relationships to trust the non-disclosure of information"* (P1). In this regard, the International Committee of the Red Cross and Red Crescent developed a handbook on data protection in humanitarian action (ICRC 2017). This reference should be considered together with a policy to determine the data that is important to be published in any condition. "*Even in very poor security environments, what information do we need to have regardless of the risk? For example, health facilities, it does not matter the risk, but the people need to know where they are"* (P7).

There are several causes for a dataset to generate political sensitivity. Merging boundaries, partially because the CODs are very country-specific, are one of them (P1). For example, in the case of India-Pakistan, the UN office in Pakistan takes the data from the Pakistani government with a border that clearly creates conflicts with a politically sensitive UN agency. Frequently, there are public maps on the conflict area and "not so public" (usually hard copies) operational ones (P1).

Remote sensing imagery has become such a fundamental tool for disaster response that it is taken for granted. Satellite**,** together with aerial and unmanned aerial vehicle (UAV) imagery, and direct observation in the field are essential for damage assessment. In addition, from satellite imagery, it could be possible to estimate population considering buildings and a basic anthropological knowledge of the local culture (P6). Usually, satellite imagery is provided by UNOSAT and Copernicus (information is available at the Global Disaster Alert and Coordination System (GDACS) Satellite Mapping Coordination System). There is also imagery from private companies (i.e. Digital Globe, Google and Terra Bella). US agencies NSA/NOAA (i.e., during Hurricane Matthew, they deployed a Global Hawk) and the National Geospatial-Intelligence Agency (NGA) can also provide imagery. OpenStreetMap also deploys UAV missions so their contributors can perform building damage evaluation from these images (i.e. deployment of Potentiel 3.0 during the response to Hurricane Matthew).

4.5. Conclusions

The present research taps into IMO opinions to present an empirical study of the joint effort to provide geospatial support to disaster response. The limitations identified are mainly related to the selection of the participants. It is acknowledged that the initial participants might tend to refer to colleagues with similar opinions. Nevertheless, this limitation was minimised with the choice of the initial sample representing the different stakeholders and by crosschecking the outcomes with the analysis of the coordination tools and products delivered during the responses to emergencies.

The development and widespread use of online mapping, remote sensing and, VGI are influencing the production and data sharing which is becoming more dynamic, transparent, and decentralised. In this environment, IMOs face new challenges. The question is no longer the lack of information but access to the right information at the right time. In this emergency context, information is urgently needed, but it might not be entirely reliable. Good metadata and especially the possibility of contacting the data source to improve that reliability.

IMOs participating in international support to disaster response have a pragmatic approach to geospatial information management. In order to trust a dataset, the topology should be correct, and information should be up to date. Datasets should be cleaned to avoid problems with the projection or contradictions which could delay the delivery of information. Therefore, data maintenance becomes a critical task. Organisations need a solid data management strategy including data gathering, maintenance and decision-making process based on those data. A known, agreed *single point of truth* might be necessary, a predictable schema where data can be consumed as a service. A platform where pre-agreed datasets are harvested, validated, cleaned and maintained following a methodology, so they are complete, updated, and ready to be used. A platform where applications can be plugged in knowing that someone is making sure that the data is correct. It could be a web-service to be consumed by mobile data collection platforms used in the field. Information management is a transversal issue. Nevertheless, each UN Agency relies on its own department. Further investigation is required to verify whether a unique Information Management Agency/Department working for all UN institutions could host this single point of truth and improve the way information is handled.

Until such a platform is developed, OpenStreetMap is often used because of its accessibility regardless of limitations, such as reliability and data privacy. Therefore, improving OpenStreetMap improves geospatial preparedness. Further research is required to find ways to promote community engagement and capacity building to assure that the data gathered is maintained up to date. The possibility of involving NGOs, as representatives of the local community, to improve geospatial preparedness should be explored in order to create a framework that could break the dependency on external support. Additionally, research is also needed about the consequences of sharing sensitive information through open platforms.

5. Addressing geospatial preparedness inequity: a sustainable bottom-up approach for Non-Governmental Organizations[9]

Abstract

In less developed areas, the use of Geographic Information Systems (GIS) to coordinate disaster response is hindered by a lack of geospatial preparedness. Humanitarian missions often rely on OpenStreetMap as a source of information to overcome this limitation. In these places, Non-Governmental Organizations (NGOs) might already be using GIS to implement development projects before the disaster. This study considers the management of geospatial information by those NGOs and whether they could improve geospatial preparedness from within the communities. This bottom-up approach would allow the inclusion of information relevant to the community in the disaster response decision-making process. The research method was an online survey with a worldwide sample of more than 200 development NGOs. The results show that many NGOs use digital geographic information, mostly open-data. They could indeed improve geospatial preparedness while using open-data and community mapping for the implementation of their projects. There is, however, a limitation; most of the development NGOs using open geographic data are not familiar with the open platforms used by the humanitarian community (i.e., OpenStreetMap). Therefore, the study indicates that the sustainability of this synergic approach requires further harmonization between development and humanitarian organizations working for the wellbeing of the same communities.

5.1. Introduction

Communities are exposed to hazards with different consequences depending on their levels of vulnerability, preparedness, and response. In the aftermath of a disaster, situation, needs, and response capabilities are assessed. Depending on the local capacities and complexity of the disaster, international and multidisciplinary response teams might support the local response. Geographic Information Systems (GIS) are among the tools used to coordinate and facilitate the decision-making process. Geography is a complex reality full of synergies between space, ecosystem, society, culture, and economy. During an emergency response,

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GIS provides this spatial dimension mainly as a cartographic tool for information sharing, resource allocation, planning, and logistics, and to map population and displacements. Modeling capabilities, optimization methods, problem-solving, and decision support tools (e.g., route and resource allocation) are also of special interest for in-field operations (Shorbi and Wan Hussin 2015; Tomaszewski et al. 2015).

The use of GIS to implement these functionalities requires *Geospatial Preparedness*. This concept is described by the United States Department of Homeland Security (DHS) as: "*… the level of overall capability and capacity necessary to enable all levels of the Department to use geospatial data, geographic information systems software and hardware, and geospatial applications to perform essential functions such as prevention, detection, planning, mitigation, response, and recovery in order to minimize loss of life and property…*" (DHS 2004) (p. 3). There is a geospatial preparedness inequity issue across the world (Sumadiwiria 2015). In some countries, institutions and private sector count upon skilled staff, tools, and reliable geospatial data, making a holistic approach to disaster management possible. In other countries, however, geospatial information is nearly not considered, and GIS are hardly used. As a consequence, geospatial preparedness is deficient or does not exist (San Martin and Painho 2016). The United Nations Committee of Experts on Global Geospatial Information Management (UN-GGIM) report about the status of topographic mapping in the world stated this inequity and pointed to out-of-date information as one of the main issues (Konecny, Breitkopf, and Radtke 2016). Due to the lack of geospatial pre-disaster information in less-developed countries, during disasters, Information Management Officers (IMOs) should produce that information ad hoc losing precious time and hindering the response coordination (San Martin and Painho 2016).

In the aftermath of a sudden-onset disaster happening in a place without adequate resources to cope, the UN Office for the Coordination of Humanitarian Affairs (OCHA) provides coordination, information management, and funding. The first phase is to compare local capacities with the magnitude of the disaster. UN Disaster Assessment and Coordination (UNDAC) teams, including IMOs from partner organizations (i.e., MapAction, ACAPs) might be deployed. The Coordinated Data Scramble project coordinates IMOs from different organizations to remotely support the IMOs in the field. Most IMOs, deployed or supporting remotely, have similar information requirements. This project provides a framework to gather and share, so everybody uses the same data for each particular topic (Verity 2017; Campbell 2017; Mark van den Homberg 2017). In this context, UN institutions are no longer the unique source of information but a coordination point between the affected community, and relief agencies and volunteers. Production and data sharing have become more dynamic, transparent, and decentralized (Kawasaki, Berman, and Guan 2013b).

It is important to consider the actual use of open-data by these IMOs involved in humanitarian operations. The objective of these IMOs is to provide the best datasets available, ideally sourced from governmental data. In the past, that would have been the only source of information considered. However, the response to the 2010 Haiti earthquake showed a significant change, placing collaborative mapping at the center of the response (de Albuquerque et al. 2016). Nowadays, OpenStreetMap is often used as an easily available and reliable geographic open-data platform (Westrope, Banick, and Levine 2014). OpenStreetMap might be considered the main reference of crowdsourced geospatial information in the form of community or collaborative mapping. In parallel, the Humanitarian OpenStreetMap Team (HOT) applies open-source and open-data sharing to humanitarian aid (See et al. 2016, 2017). OpenStreetMap can be used at least to complement and triangulate existing data and to provide a contact person (San Martin and Painho 2019b). During the 2014 West Africa Ebola epidemic, Medecins sans Frontiers (MsF) and Red Cross International decided to crowdsource the task of mapping newly infected areas relying on HOT and Missing Maps (Koch 2015). HOT work was also significant in response to the 2015 Nepal earthquake and other major disasters (Poiani et al. 2016a; Givoni 2016; Dittus, Quattrone, and Capra 2017). Indeed, information management during the 2015 Nepal earthquake shows the development of a new paradigm in data sharing and the use of volunteered geographic information VGI, especially through OpenStreetMap (Soden and Palen 2016). Indeed, crowdsourcing post-disaster information through volunteers (Kankanamge et al. 2019) and the use of deep learning for the same task (Chen et al. 2019) have focused academic research in this area. Nevertheless, in a previous study (San Martin and Painho 2019b) it was established that, since IMOs in humanitarian missions consider OpenStreetMap a reliable tool (Soden and Palen 2016; Givoni 2016), improving pre-disaster information in OpenStreetMap improves geospatial preparedness.

However, it is not only mapping but also capacity building that is needed to deliver the long-term cartographic solutions that promote the social sustainability of the community. The projects listed above represent mainly humanitarian organisations mapping communities non-related to them. They are examples of communities depending on external support.

Therefore, the disconnection between local communities and volunteer mappers brings concerns about the longer-term sustainability of these projects that do not consider the necessary maintenance and updating of the datasets (Turk 2016). This transition from crisis mapping to sustainable and locally-owned community-mapping is only possible with the engagement of the community (Soden and Palen 2014; Sumadiwiria 2015).

Moreover, an implementation that breaks the unidirectional top-down flow of information is necessary for Information and Communication Technologies (ICT) capacity building projects to be able to empower the community. ICT should allow communication to also be bottom-up from the community to the establishment, and horizontal within the community (Gigler and Bialur 2014). This approach could allow not only breaking the dependency of the community from external support but also creating communities more equitable and connected.

In less developed countries, however, contributions to OpenStreetMap are mainly disaster response related. These event-driven contributions are not in line with the long-term work necessary to use OpenStreetMap as Information and Communication Technologies for Development (ICT4D) (Mahabir et al. 2017). A different approach would be required. Community mapping aiming to develop OpenStreetMap for a particular location has already been successfully implemented in projects such as Map Kibera (Hagen 2017). Also, the GroundTruth Initiative uses volunteers and handheld GPS to upload information to OpenStreetMap for community mapping. In a different line of work, also built on OpenStreetMap, Development Seed[10], in partnership with the World Bank, makes Openroads and Rural Accessibility Map available, a suite of tools for least developed countries which allows road mapping and planning and impact modeling. These projects show OpenStreetMap's potential for democratizing mapping. They also establish the possibility of finding a balance in the debate between process-oriented community mapping vs. goal-oriented professional mapping for targeted results within communities (Hagen 2017). In addition, development NGOs might use OpenStreetMap data without any payment or limitations since it is free for any purpose through the Open Database License (ODbL1.0) distribution license (Miyazaki, Nagai, and Shibasaki 2015).

IMOs involved in humanitarian operations consider community mapping and NGOs working in development projects reliable sources of data to improve geospatial preparedness (San

[10] https://developmentseed.org/projects/openroads/ accessed on 17th July 2019

Martin and Painho 2019a). GIS could be a key tool for these organizations, which should be considered within the framework of ICT4D (Sala and Dendena 2015). NGOs working within the community could use OpenStreetMap to cover their information management needs while improving geospatial preparedness. In the reverse direction, needs and aid during disaster response actions could bounce back into development projects.

Therefore, considering that OpenStreetMap is used during disaster response in places lacking geospatial preparedness, that development NGOs could improve geospatial preparedness providing long-term sustainability and that IMOs would trust that information, it is necessary to study the feasibility of these NGOs improving OpenStreetMap. Moreover, in order to consider the possibility of development NGOs using OpenStreetMap to improve geospatial preparedness, it is necessary to understand how these organizations use geospatial information and their relationship with open-data. There are, however, no indications of exhaustive research in this area. Therefore, the present research aims to study the use of geographic information by NGOs working in development projects in areas lacking geospatial preparedness. The object of the study will be referred to using the terms development NGOs, and NGOs working in development projects alternatively. "Development NGOs" is a rather extensive designation. Conceptually, the study is focused on Non-Governmental Development Organizations (NGDOs) which places the topic on NGOs working within the framework of International Cooperation. As indicated by Makuwira, the generic concept of these NGOs as "*organizations that work for the aid and development of others, without direct profit for themselves*" includes a great diversity of organizations and it has many nuances (Makuwira 2014). Indeed, given the thin and blurry line separating NGOs in general from NGDOs, it is difficult to estimate the number of organizations that fit in the total target population (Lewis and Kanji 2009), but it could exceed the hundreds of thousands (Fowler 2011; Makuwira 2014).

Moreover, in practical terms, the study contemplates a broader range including NGOs and grassroots associations working in development projects in less developed countries, and locations potentially with a low level of geospatial preparedness. Moreover, the humanitarian and development communities might be difficult to separate. NGOs usually working in development may become part of the humanitarian community supporting the response to a disaster. In addition, some NGOs that usually work in disaster management have projects focused on disaster risk reduction and capacity building that could be considered development projects. Within OpenStreetMap, HOT has as an objective to provide a transition from Crowdsourced Mapping to Community Mapping (Soden and Palen 2014). Other platforms, such as Crowdmap created by Ushahidi (Brandusescu, Sieber, and Jochems 2014), Missing Maps, or Tomnod, use OpenStreetMap to work in specific projects in this fuzzy line between humanitarian action and long-term development. However, at this stage of the research, we focused only on NGOs working in development projects. During the selection of the target population, NGOs working mainly in disaster management were not considered. Please refer to the methodology section for further information about the target population. The approach of the research places a particular focus on the use of geographic open-data. Consequently, this paper aims to answer the following questions: How do development NGOs working in less developed countries use geographic information? Can these organizations improve geospatial preparedness through open platforms such as OpenStreetMap?

After this introduction, the article presents the methodology used for this research and specifies the outcomes related to the subject in question in a series of figures to facilitate the visualization of the results. The paper closes with a discussion on those results and the overall conclusion. The main outcome is that OpenStreetMap is not widely known among the development community; this factor being the main limitation to improve geospatial preparedness.

5.2. Materials and Methods

This research is based on a multi-method strategy using qualitative and quantitative methods to "triangulate" the findings (Denscombe 2014). In this particular case, the methodology includes a literature review, a semi-structured individual interview with an OpenStreetMap manager, and a questionnaire distributed online to development NGOs.

Since practitioner engagement is necessary for ICT4D research (Walsham 2017), a questionnaire applied to development NGOs was considered the optimal method to investigate the topic. Several geospatial specialists and researchers tested the survey before initiating the study. The online questionnaire was drafted based on the results of previous research (San Martin and Painho 2019a, 2019b), the outcomes of the literature review described in the introduction, and a semi-structured interview with an OpenStreetMap representative. The questionnaire included two parts, an initial part to characterize the participant organization with seven mandatory questions and a second part with questions orientated to define the approach to the Sustainable Development Goals and the use of maps by the participant NGOs, as shown in Figure 13. It should be noted that the results of second part related to Sustainable Development Goals were not used for this article.

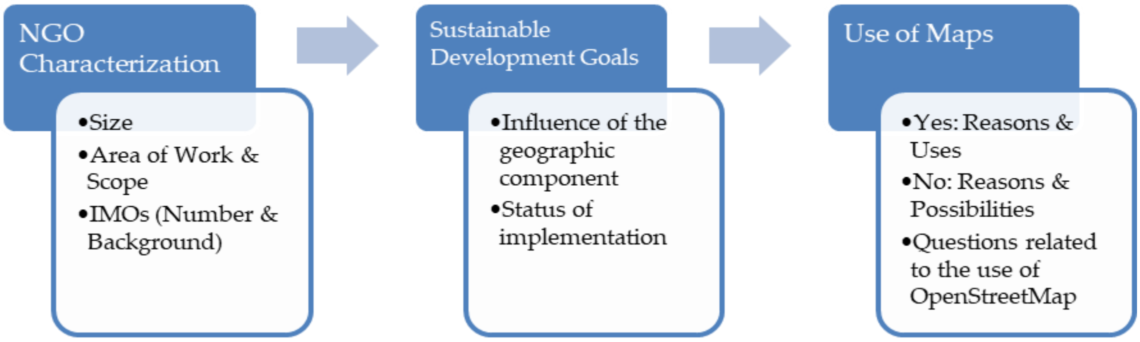


Figure 13. Questionnaire structure overview

For those participants replying positively to the use of maps, the subsequent phase of the questionnaire explored the type of maps considering the format used as described in Figure 14. A full description of the questionnaire may be found in Appendix A.

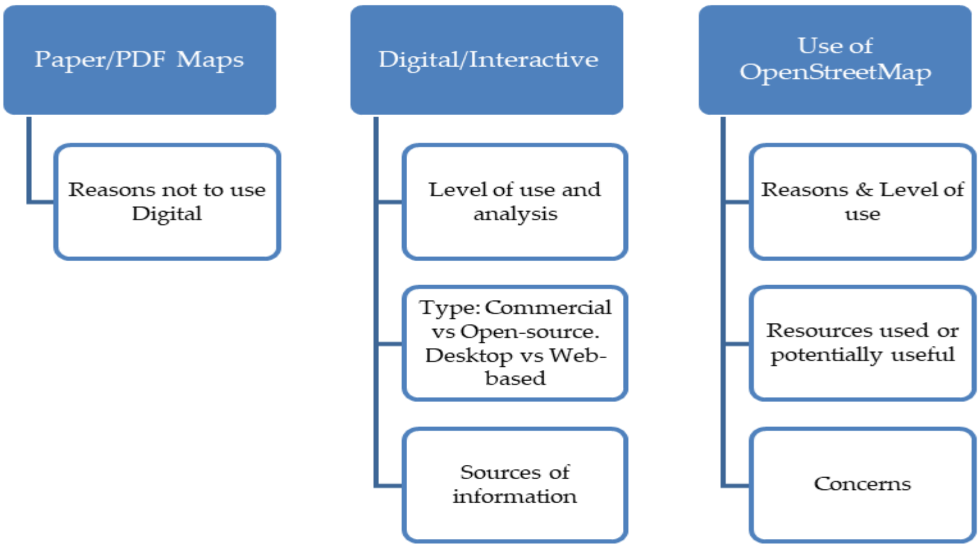


Figure 14. Questionnaire structure for NGOs using Maps

The research includes both international and local NGOs considering their geographical scope of intervention. Main international development organizations have IMOs responsible for the management of these tools. On the contrary, small local organizations might not be able to afford the necessary resources. Therefore, both realities should be considered. They could serve the community as external stakeholders or themselves be part of the receiving community (Fowler 2011; Makuwira 2014). The research was conducted globally to avoid country or culture-related biases. Purposive sampling techniques (Denscombe 2014) were used to identify NGOs from several databases (i.e., OnGood by the Public Interest Registry formed by the Internet Society, Civil Society Organizations System developed by the UN Department of Economic and Social Affairs, Organizations listed in The Idealist, Forus network of National NGO Platforms and Regional Coalitions, Latin American Network Information Center, Participants Of The Netzkraft Movement, Civil Society in the Commonwealth of Nations, and the Non-Governmental Organization Network of the Global Environment Facility). In the second stage other networks and partners of the initial sample were used to identify further NGOs within the target population. NGOs that might have disaster management as their main activity were disregarded. The survey was online for three months from September 2018. The resulting sample of 2684 NGOs was contacted by email or contact forms on the organization's websites, with a description of the study and a link to the questionnaire. In order to increase the sample size , the invitation to participate in the study requested to cascade the call to include further NGOs within the target population. From 383 responses to the questionnaire (over 14% of the number of development NGOs contacted), partial replies were disregarded and only completed replies were considered for analysis. The analysis of the Internet Protocol (IP) address of the device used to complete the questionnaire led to dismissing further answers to avoid duplications. The final sample was therefore 204 answers. This sample was considered representative of the target population in view of the characterization of the participants and their geographical location as shown in Figure 15. Data was anonymized and treated in an aggregated way. Therefore, all responses remain confidential.

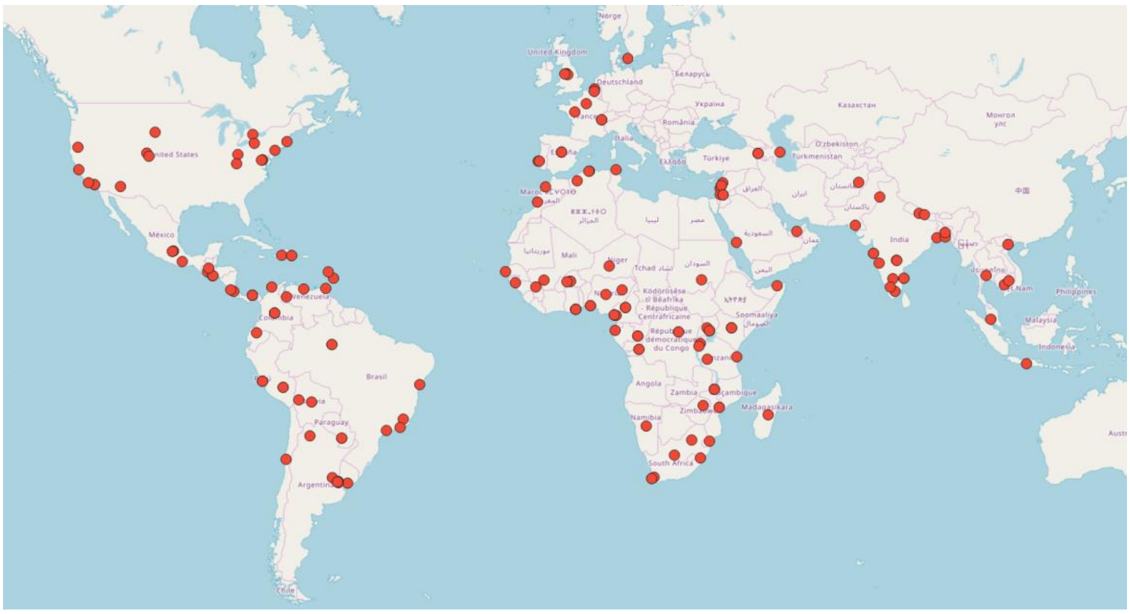


Figure 15. Geographic location of responses based on the IP address of the participant in the study which might not be related to the geographical location of the implementation of the projects.

5.3. Results

5.3.1. Characterization of the sample

The participants included all ranges of development NGOs based on size (considering the number of paid staff and annual implementation budget), working strategy, areas of work, and geographical scope of project implementation as shown in Figure 16.

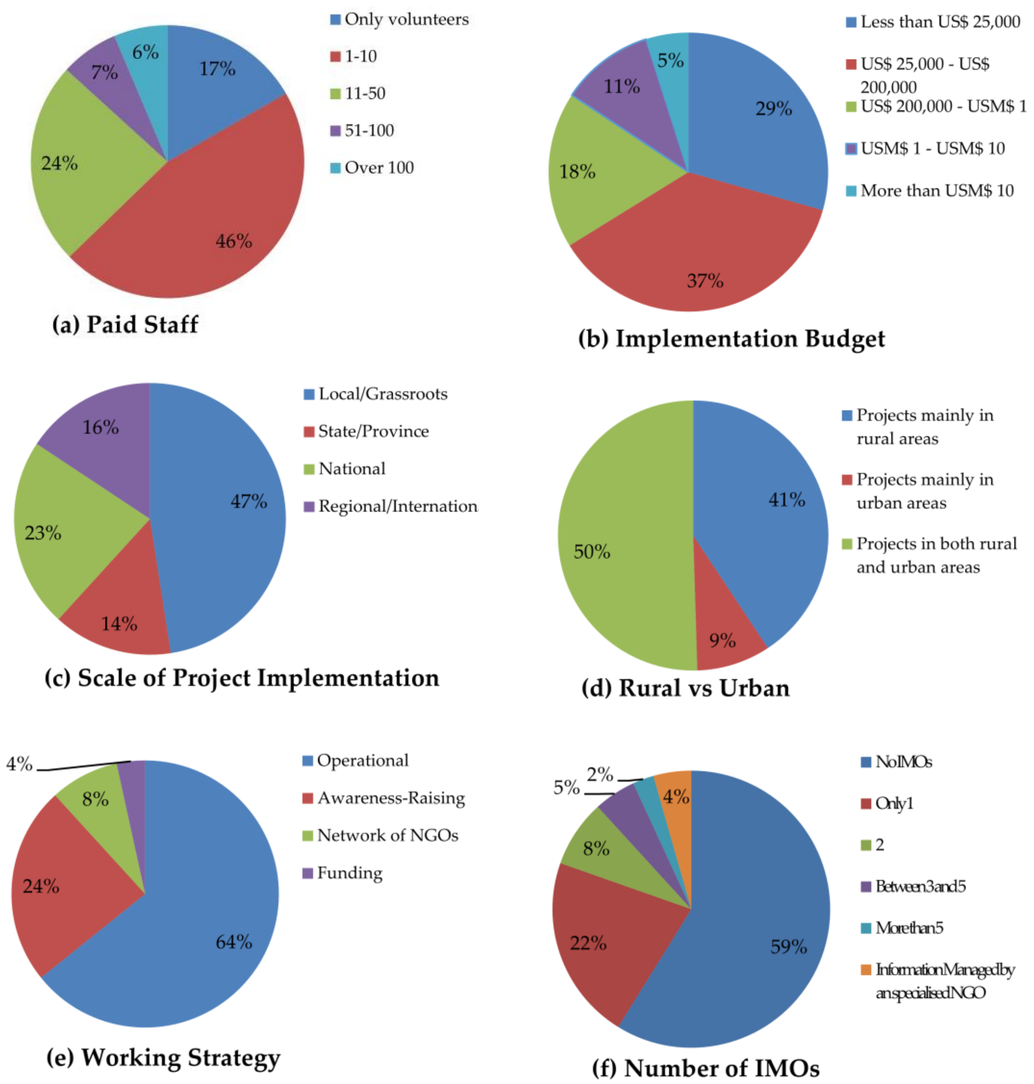


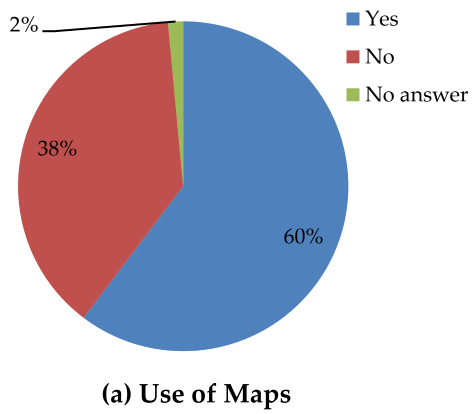
Figure 16. Characterization of the participants in the study based on (**a**) Number of Paid Staff, (**b**) Annual Implementation Budget, (**c**) Scale of Implementation of the Projects, (**d**) Implementation of Projects in Rural or Urban areas, (**e**) Working Strategy and (**f**) Number of IMOs

The sample characterizes the different sub-sets of the targeted population proportionally represented. It is interesting to note the large representation of small development NGOs, both considering number of paid staff (34 relying only on volunteers and 94 with less than 10 personnel which would total 63% of the sample) and budget (60 under US$25,000 and a further 75 under US$200,000 which would total 66%), working in local grassroots projects (97 participants 47%). The rural vs. urban division is also well represented with half of the sample (103 NGOs) working in both. Finally, the development NGOs that did not count on a dedicated IMO represent a large portion of the sample (59% accounting for 120 participants).

5.3.2. Use of geographic information by development NGOs

There is a substantial percentage of development NGOs (38% of the sample that amounts to 78 participants) that do not use geographic information in the form of maps for their work as Figure 17a shows. The main reasons not to use geographic information are the lack of equipment followed by the lack of staff and know-how. Further reasons are described in Figure 18a.

For those NGOs using geographic information, digital maps allowing for interaction with the geographic information are the preferred format as reflected in Figure 17b (74% which means that from the 123 participants that do use maps 89 mainly use this format).



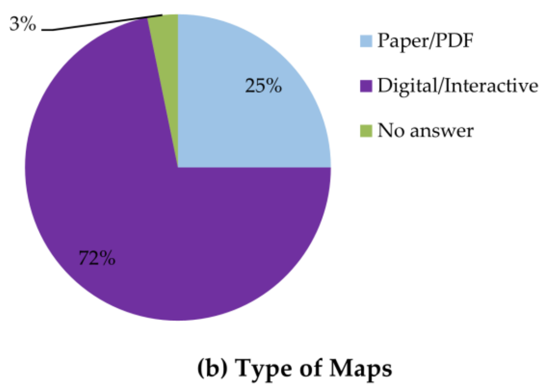


Figure 17. (**a**) Percentage of participants using geographic information in the form of maps. (**b**) Use of geographic information in pdf/paper format vs. digital/interactive

When considering the 26% (31 participants) that use mainly paper/PDF format, again, the lack of equipment was presented as the main reason not to use digital format. Further reasons are presented in Figure 18b. All the participants presenting the lack of equipment as the reason not to use maps confirmed that they have access to the internet and a cheap smartphone.

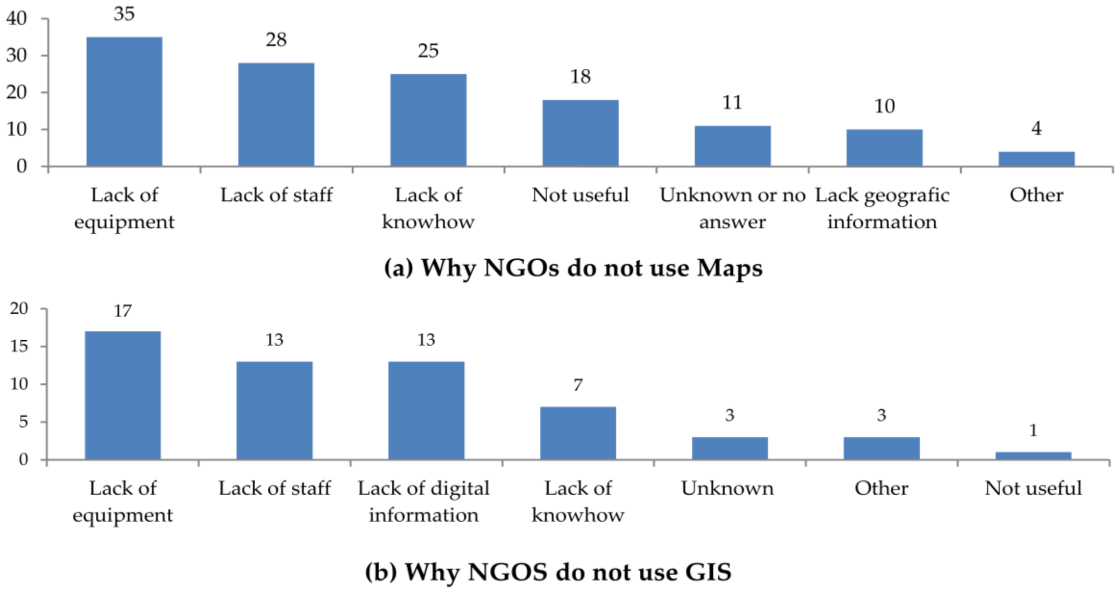


Figure 18. Reasons presented ordered by number of participants for (**a**) not to use maps and (**b**) not to use geographic information in a digital/interactive format

As for the 123 participants using geographic information in the form of maps, the main use is *project planning and monitoring* as shown in Figure 19. It is also interesting to note the high number of NGOs involved in community mapping (62 development NGOs are involved in this task which means 56% of maps users). Among the "other" uses, there are some NGOs (6 participants) using maps for some type of research. Maps are considered necessary and/or useful by the participants using them. When asked about the reasons to use maps, 87 participants answered that maps are necessary while 82 considered them useful. There is also a certain number of development NGOs (21 participants) that use maps because donors request them. Nevertheless, none of the participant NGOs claimed donor request as the only reason to use maps.

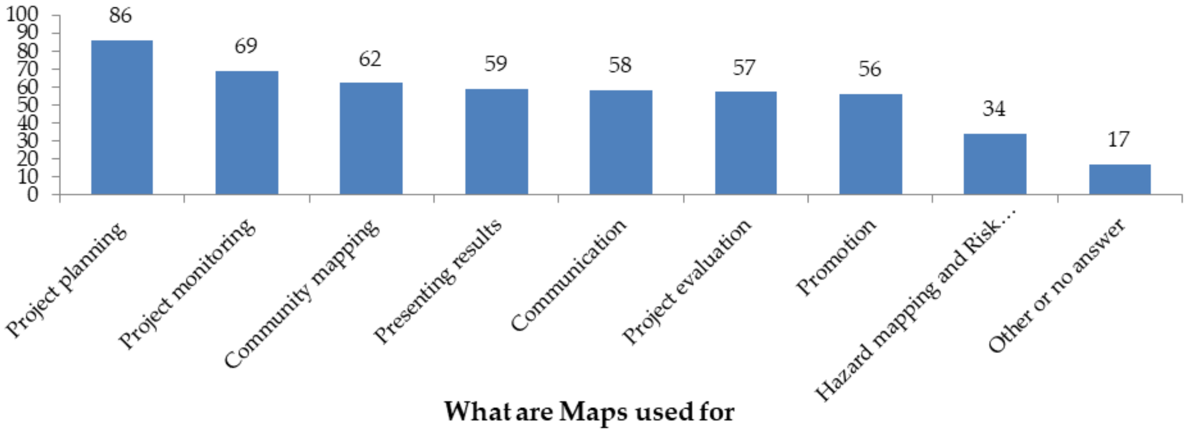


Figure 19. Description of the use of maps considering the number of participants using maps for each task

5.3.3. Use of open-source by development NGOs

Open-source was expected to be an interesting option for development NGOs. The study confirmed this point. Figure 20a displays the types of software used by the development NGOs. Thirty-five participants stated desktop open-source, with a similar number using web-based open-source, as the GIS software used for the management of geographic information. Analyzing these answers in the context of the 89 participants using geographic information in digital format, Figure 20b shows the percentage of users of open-source vs. commercial software. From the results, it might be established that open-source software is the preferred option (41 development NGOs rely exclusively on open-source software and 16 more use it together with commercial options).

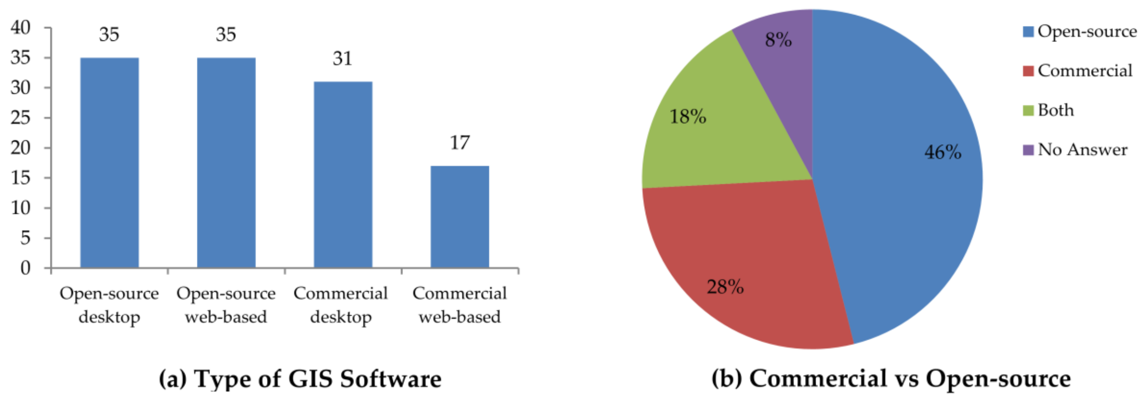


Figure 20. Description of the different software options used by the participants (**a**) by number of participants for each option (**b**) by percentage of those using digital maps

The sources of geographic information considering the 89 participants using digital maps are displayed in Figure 21a. It is interesting to find that gathering the information directly is the main source. Open-data, governmental data, and data obtained from partner organizations are almost equally used. When only considering the sub-set of 57 participants that use open-source software (in some cases together with commercial software), the use of open-data gains importance as shown in Figure 21b.

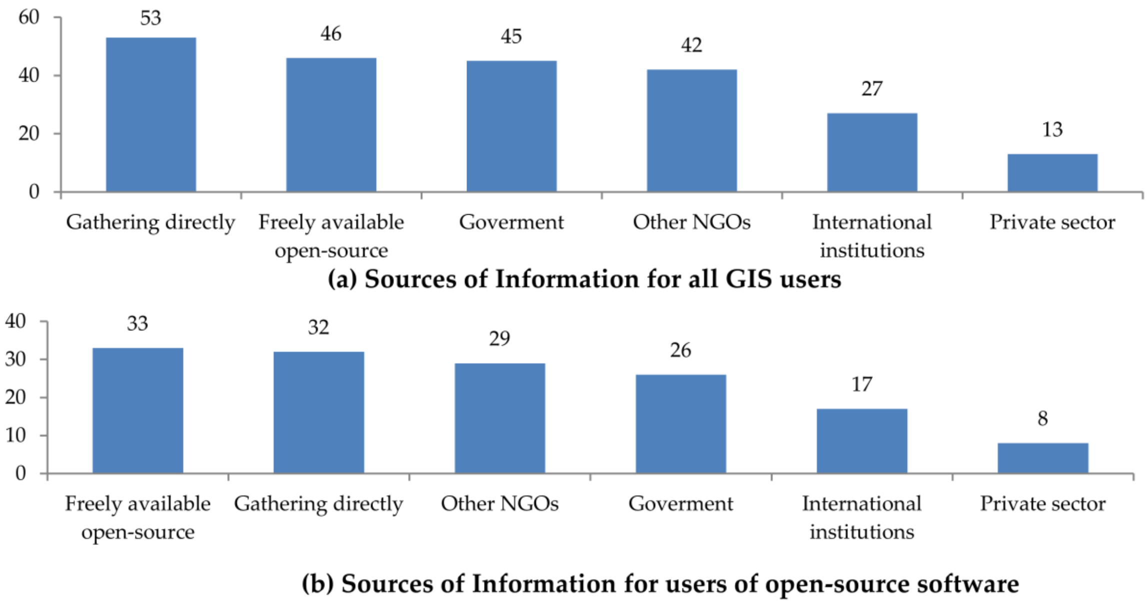


Figure 21. Sources of information considering the number of participants (**a**) all digital maps users and (**b**) the users of open-source software

5.3.4. Use of OpenStreetMap by development NGOs

From the 123 NGOs using geographic information in the form of maps, only 26 participants (21%) use OpenStreetMap as displayed in Figure 22a. If the sub-set of 57 users of open-source software is considered independently, the percentage of OpenStreetMap users rises to 26% (15 participants). From the 26 users of OpenStreetMap, 69% (18 participants) recognize that the main task is just as a basemap (see Figure 22b).

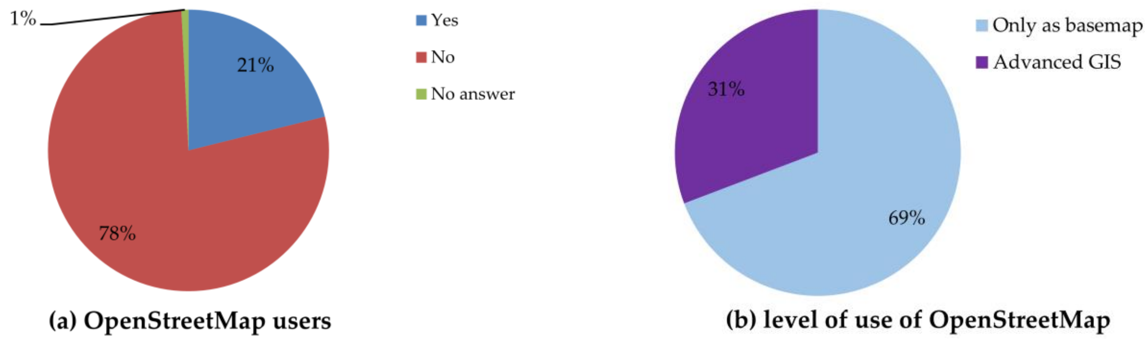


Figure 22. (**a**) Percentage of participants using OpenStreetMap among the users of maps (**b**) percentage of the level of use for those users

Some of the NGOs using OpenStreetMap (26 participants) have concerns about the use of an open platform. Figure 23 presents how security and accuracy are the main concerns when using these types of platforms. In addition, no concerns were expressed by 15% of the development NGOs (4 participants).

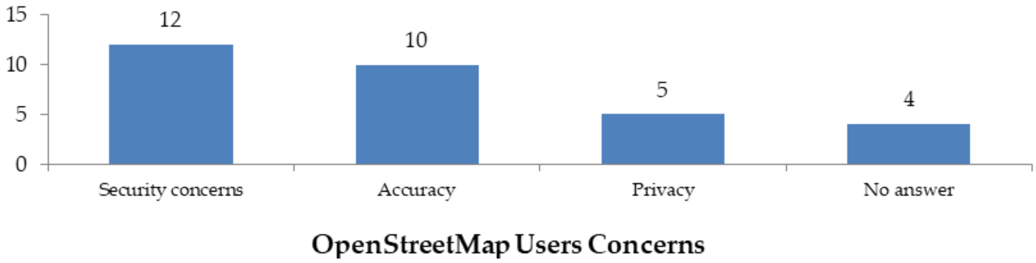


Figure 23. Concerns among the users of OpenStreetMap representing the number of participants

Regarding the 97 users of maps that do not use OpenStreetMap, the main reason offered was that they did not know OpenStreetMap before completing the questionnaire. The reasons behind the lack of adhesion to OpenStreetMap are displayed in Figure 24. Only three NGOs pointed to security concerns as the only reason not to use OpenStreetMap while just one did so over privacy. Two participants considered a lack of accuracy as the only reason not to use it. In two other cases the participants do not use OpenStreetMap because they use Google Maps.

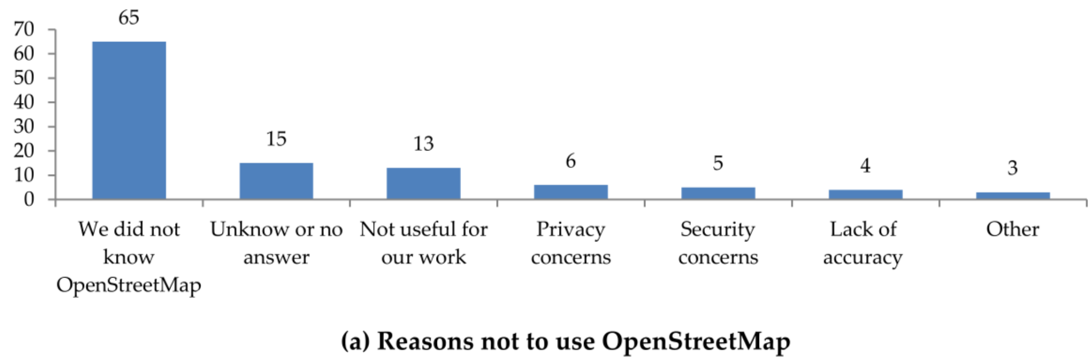


Figure 24 Reasons not to use OpenStreetMap represented by the number of occurrences

In terms of the 174 participants that do not use OpenStreetMap (considering those using maps and those that do not use them), 72% (125 participants) found an OpenStreetMap application that could be useful for their organizations. Figure 25 displays the opinion of these participants regarding the different OpenStreetMap services that could be of use for their organizations

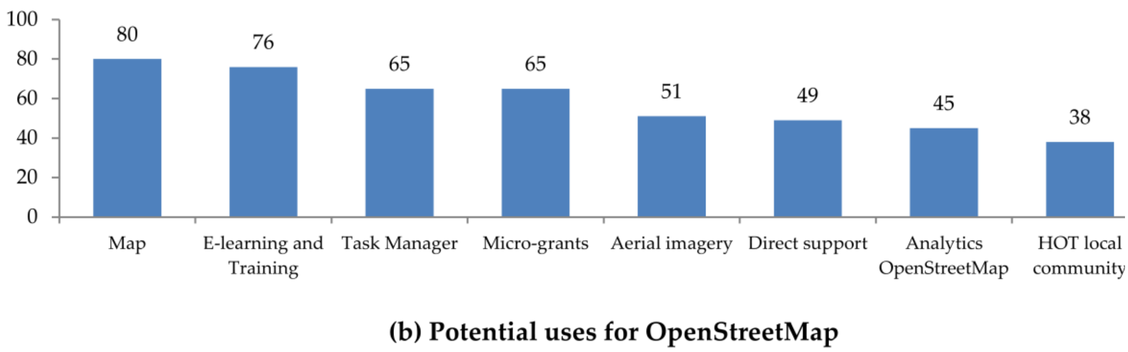


Figure 25 Potential uses recognized as interesting for the participants including those not using Maps (78) and not using OSM (96)

5.4. Discussion

The benefits of using geographic information are clear for those participants who actually use it. NGOs using maps do so during all phases of their development projects, from planning to implementation and evaluation. Maps are also used to communicate, to promote projects or organizations, and to present results. There are other uses for this information, and among them, community mapping should be highlighted. Further research is necessary to establish the objectives, tools used, and methodology followed by development NGOs conducting community mapping and how it could be embedded in capacity building initiatives. The maps used by development NGOs are mostly in a digital format that allows for interaction with the information. The use of paper maps or in PDF format is indeed quite limited. Development NGOs might have dedicated IMOs (37% of the participants) or development practitioners taking over information management among other tasks (59% of the participants). Both consider geographic information for their work, and GIS are a common tool. Open-source GIS, either desktop or web-based, is the most common software among these users of digital information, even if in some cases open-source options are used together with commercial ones. In addition, it should be noted that the use of open- source GIS software usually runs together with the use of open-data as the main source of information.

Regardless of the benefits of using geographic information, some development NGOs do not use maps in any format. The lack of equipment is pointed out as the main reason not to use digital maps or not to use maps altogether. However, the same participants confirmed that they have access to the internet and a cheap smartphone. They consider many of the possible applications of GIS and open platforms (i.e., OpenStreetMap) interesting for their work. Nevertheless, the use of geographic information is limited by the idea that specialized equipment is needed when the reality is that it is not. The OpenStreetMap representative confirmed that a cheap smartphone and internet access is all that is needed to take advantage of their tools and services. This issue could be explained by Sen's *capabilities* approach, in which "what people have" is replaced by "what people can do" (Sen 1985). Development is understood as a process where people help each other to gain *entitlements*, to obtain *access capacity* (Haq 1995). In this case, development NGOs not using maps need to learn that the equipment they "have" is sufficient so they "can" gain the capacity to use geographic information in the form of digital maps. Likewise, the use of OpenStreetMap presents similar circumstances. NGOs consider that OpenStreetMap tools and services could be useful for their work. However, most of the participants in the study do not use them. The reason behind the lack of adhesion to OpenStreetMap is mainly because the participants did not know about the open-platform before contributing to the study. Therefore, development NGOs would need to learn about the existence of OpenStreetMap and the capabilities of the platform so they could gain the *entitlement* to access these tools and services. Further research is required to consider the use of other crowdsourced platforms by the development community.

Another issue presented as a reason not to use GIS is the lack of digital information. This issue could be solved if more organizations gathered information and shared it on an open platform such as OpenStreetMap. Indeed, the main source of information for most of the development NGOs using GIS is to gather their own. In addition, many also use data from other NGOs and freely available open-data. The widespread implementation of open-data policies among development NGOs could initiate a virtuous cycle in which the availability of data would drive more NGOs to use GIS and to create more open-data. The ownership of the project by the community would ensure the maintenance of the information and that it would be kept up to date. This approach would empower the community allowing for a horizontal transfer of information within the community, and bottom-up from the community to the establishment. The inequity in the access to information would be reduced allowing for a more sustainable community. The main issue is that, while IMOs involved in humanitarian missions do use OpenStreetMap, a great number of those managing information for NGOs working in development projects do not even know about the existence of this open platform. The results of the study do not show a link between this fact and the use of dedicated IMOs or their background. In order to establish the causes of this lack of knowledge and how to solve it would require further research. Moreover, OpenStreetMap is considered by many in the academic world as paramount of open platform for community mapping. Studies should consider this ambiguity between development practitioners and researchers.

The actual approach to close the gap in geospatial preparedness using OpenStreetMap might be focused in the use of remote sensing imagery analyzed by volunteers working remotely or computers using machine learning. This approach might be able to map the areas. However, it does not offer a socially sustainable alternative since it would lose the reality of those communities.

The present study is limited by the use of a digital platform to conduct the survey. Obviously, the fact that the survey was conducted online supposes that all participant NGOs should have internet access, in principle. This aspect, however, does not affect the validity of the survey results. Nevertheless, the existence of a more intense digital divide created by the lack of access to the internet should be the object of further research.

5.5. Conclusions

A sizable number of development NGOs do not consider geospatial information. Some NGOs deem that they lack the necessary equipment to handle digital geographic information. Capacity building initiatives are needed to provide the know-how that would allow them to create and use geospatial data. These NGOs could learn that the use of open geographic data does not require special resources while the benefits could be spread through the whole community. Nevertheless, the results of the study show that, for those development NGOs already using geographic information, a majority use it in a digital format that allows for interaction with the information. In this case, the main limitation to become a source of information to improve geospatial preparedness for humanitarian institutions is the lack of harmonization between the tools used by these communities. Humanitarian missions rely on OpenStreetMap as a source of information. The use of this open platform by development NGOs could improve the availability of open-data and geospatial preparedness for disaster response by humanitarian missions. In addition, this capacity building approach would empower the community allowing for a new paradigm in the transfer of information. This process would facilitate the transfer of information within the community and the connection of the community to the outside world. The information significant to the community would become part of the information considered by the decision makers supporting that very same community in the aftermath of a disaster. In parallel, the ownership of the project by the community would ensure long-term sustainability since the community would maintain and keep the information up-to-date. Indeed, development NGOs use geographic information and GIS open-source software for community mapping and the implementation of development projects. The main issue is that OpenStreetMap is not widely known among the development community. The reasons behind this lack of knowledge should be the object of further research. The interaction between humanitarian and development communities could be more frequent becoming more open and transparent. Development NGOs that already use open-data should consider OpenStreetMap as an option for the management of digital geographic information. This approach would allow the harmonization of tools used by development NGOs and humanitarian missions working for the well-being of the same communities. In addition, these development NGOs, as representatives of the local community, would improve geospatial preparedness creating a framework that could break the dependency on external support.

6. Overall conclusions and final remarks

6.1. Conclusions

GIS are commonly used at different levels of complexity to support the decision-making in the coordination of disaster response. Certain degree of geospatial preparedness is required for these implementations regardless of the level of complexity. Nevertheless, there is a lack of geospatial preparedness, particularly pre-disaster information, in many disaster-prone areas. In these places, humanitarian missions support local authorities managing information to compare the local disaster response capacities with the magnitude of the disaster. There are standard pre-disaster datasets (i.e., CODs and FODs) used by IMOs to perform this task. In some cases, the access to these datasets is restricted or they might be available but not always are maintained up to date.

Indeed, the use of GIS in humanitarian missions has changed in the last years as a result of the development and widespread use of online mapping, remote sensing and VGI. In a near future, the use of deep learning might change it even more. UN institutions are no longer the only suppliers of geospatial data but a distribution channel. Now a day, there is even a data overload in situations that in the pass were dominated by the lack of information. In this dynamic and decentralised information environment, the question is access to the right information at the right time. Nevertheless, the "mass-production" of data in the aftermath of a disaster does not compensate for the lack of pre-disaster data. OCHA, through the Coordinated Data Scramble, creates an environment where international institutions, NGOs, the private sector, and V&TCs work together to provide the ad-hoc answer to the gaps in the information available. The objective is that everyone has access to the information needed and that all IMOs are using the same information avoiding duplication.

In addition, the increase of geospatial data production stresses the importance of data quality and reliability. In this emergency context, information is urgently needed, but it might not be entirely reliable. Officially, IMOs should use information from "official sources" (i.e. governmental institutions) to provide CODs and FODs. Nevertheless, IMOs participating in international support to disaster response have a pragmatic approach using the best available dataset. They might trust any dataset with the correct topology and information up to date. Therefore, datasets should be cleaned to avoid problems with the projection or contradictions which could cause delays. Consequently, data maintenance becomes a critical task.

In this context, IMOs are tapping alternative sources of geospatial data and institutions are adapting their working procedures to this new reality. NGOs working in development projects in these areas are consider a trustful source of information by the IMOs of the humanitarian community. Community mapping is another trusted source of information. OpenStreetMap, for example, is a valuable source of information that is regularly used. OpenStreetMap is used because of its accessibility regardless of limitations, such as reliability and data privacy. Therefore, improving OpenStreetMap improves geospatial preparedness.

The reality, however, is that geospatial information is not considered by a sizable number of development organizations. In many cases, because these NGOs consider that they lack the resources and equipment to handle geospatial information. This is a paradox because only a cheap mobile phone and internet connection are needed to manage information in OpenStreetMap, tools which are available to all participants in the study. Other question to consider is that OpenStreetMap is not widely known among the development community

6.2. Implications

Development organisations could gather data to improve geospatial preparedness. One issue is that, to be useful, organisations need a solid data management strategy including data gathering, maintenance and decision-making process based on those data. Consequently, development organisations could improve OpenStreetMap to make that information available to the humanitarian community without the need of a massive data management structure. The use of this open platform by development NGOs could improve the availability of open-data and it could improve geospatial preparedness for disaster response by humanitarian missions. These NGOs, as representatives of the local community, would improve geospatial preparedness creating a framework that could break the dependency on external support. In addition, this capacity building approach would empower the community allowing for a new paradigm in the transfer of information. This process would connect the community to the outside world. The information significant to the community would become part of the information considered by the decision makers supporting that very same community in the aftermath of a disaster. Moreover, the ownership of the project by the community would ensure long-term sustainability since the community would maintain and keep the information up to date.

Since many development NGOs do not use geospatial information, capacity building initiatives are needed to provide the know-how that would allow them to create and to use geospatial data. These organizations could learn that the use of open geographic data does not have special requirements while the benefits could be spread through the whole community.

Nevertheless, the results of the study also show that, for those development organizations already using geographic information, a majority use it in a digital format that allows for interaction with the information. Indeed, NGOs use geographic information and GIS open-source software for community mapping and to implement development projects. The main issue is that OpenStreetMap is not widely known among the development community. In this case, the main limitation to become a source of information to improve geospatial preparedness for humanitarian institutions is the lack of harmonization between the tools used by these communities. Humanitarian missions habitually use OpenStreetMap. Development NGOs find OpenStreetMap a useful tool fit to their task but unknown to them. The interaction between the humanitarian and development communities should be more frequent becoming more open and transparent. Development organizations that already use open-data should consider OpenStreetMap as an option for the management of digital geographic information. This approach would allow the harmonization of tools used by development NGOs and humanitarian missions working for the well-being of the same communities.

The actual approach to improve geospatial preparedness using OpenStreetMap is focused in the use of remote sensing imagery analysed by volunteers working remotely or computers using deep learning. This approach might be able to map the areas fast and efficiently. However, it misses an important part of the geographic information that should be considered by disaster responders. A socially sustainable alternative should also include the reality of those communities that are part of that geography. Development NGOs as representatives of those communities could provide that information. To be clear, both approaches have benefits and are not exclusive but full of synergy.

6.3. Limitations

The limitations identified in this research are mainly related to the cascade methodology used to increase the number of IMOs participating in the interviews. It is acknowledged that the initial participants might tend to refer to colleagues with similar opinions. Nevertheless, this limitation was minimised with the choice of the initial sample representing the different stakeholders and by crosschecking the outcomes with the analysis of the coordination tools and products delivered during the responses to emergencies. A similar limitation might be considered for the selection of development organisations participating in the survey. In this case, the limitation was minimised by the choice of the initial sample from different sources covering a wide geographic range and all the diversity of NGOs in terms of size (budget and number of staff) and area of intervention.

The fact the analysis is cross-sectional (unique in time) might represent a limitation. Since, time effects and the very dynamic nature of NGOs are not considered. Therefore, to avoid this limitation, similar studies should be replicated in different timeframes to assess the evolution of the parameter studied. In this regard, the methodology is clearly defined so the study can be replicated.

Finally, the methodology used for the survey (i.e., online) is a limiting factor since all responders had, by default, access to internet. This access limits the possibility of quantifying the influence of the digital divide (i.e., those without, or limited, access to ICT) in the hypothesis presented. In order to avoid this limitation paper surveys could be conducted among those NGOs lacking internet access.

6.4. Suggestions for further research

Further research is required to find methodologies of community mapping that allows for the promotion of community engagement and capacity building to assure that the data gathered is maintained up to date.

OpenStreetMap is a tool commonly used by the humanitarian community and familiar to the academic research with many studies based on its performance. However, it seems to be unknown to the NGOs working in development projects. The reasons behind this lack of knowledge by this community should be object of further research.

The use of OpenStreetMap does not require complex technology against the common believe among development organisations. Indeed, all the participants confirmed the access to a cheap smartphone and internet. There are, however, other resources that should be consider such as time and personnel. Further research is required to quantify the needs by NGOs that might use OpenStreetMap to plan, implement, monitor and evaluate their development projects.

The feedback received from some participants in the online survey indicated poor internet connection limiting the possibilities of quickly responding. Indeed, further research is needed to quantify to which extend internet access is common to all NGOs implementing development projects. Moreover, even if most web-based geographic tools have offline capabilities, the research should consider how poor or non-existing internet connection could affect the use of these tools while working on the field.

In general, development organisations do not consider sharing sensitive information through open platforms a limitation to the use of OpenStreetMap. However, further research is required to evaluate the consequences of making this information accessible to the public.

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Appendices

Appendix 1

This appendix presents in detail the questionnaire in which the research is partially based.
() indicates unique response; [] indicates possibility of multiple answers

A NGOs Characterization

A.1 How many paid staff work in your organization?
() 0 (my organization relies solely on volunteers)
() 1–10
() 11–50
() 51–100
() over 100

A.2 What was the latest annual budget of your organisation including project implementation and running costs?
() less than USD 25,000
() USD 25,000–USD 200,000
() USD 200,000–USD 1M
() USD 1M–USD 10M
() more than USD 10M

A.3 Which of the following would better describe your organisation working strategy? Please, choose only the one that better describe it.
() Operational: change achieved directly through projects
() Awareness-Raising, Campaigning and Advocacy: change promoted indirectly through influence on the political system/public opinion
() Association, Network, Forum for NGOs
() Funding: proving funds to other NGOs

A.4 In which of the following sectors does your organisation work? Please check all answers that apply.
[] Agriculture, Livestock and Rural Development
[] Banking, Finance, Credit and Micro-credit, Trade and Markets
[] Children and Youth
[] Climate Change
[] Community Building, Disabilities, Ethnic Minorities, Social Protection and Social Development
[] Conflict Prevention and Resolution, Post-Conflict, Fragility, Violence and Peacebuilding
[] Development and Economic Growth, and Sustainable Development
[] Disaster Management, Risk Reduction and Preparedness
[] Education and Culture
[] Emergency Relief, Humanitarian, and Post-Humanitarian Action
[] Environment, Wildlife, Forestry, Fisheries and Natural Resources
[] Food and Nutrition
[] Gender equality and Women's Rights
[] Governance
[] Health, Drug abuse, and Reproductive Health

[] Information and Communications Technology (ICT)
[] Information, Journalism and Media
[] Infrastructure, Transport, Energy, Industry and Mining
[] Law, Justice and Human Rights
[] Poverty
[] Public Management, Government Support, External Debt, Macroeconomics and Fiscal Management
[] Refugees and Internally Displaced Peoples (IDOs)
[] Religious
[] Research, Science and Technology
[] Tourism
[] Urban Development
[] Water, Sanitation and Hygiene (WASH)
[] Other

A.5 What is the scale of implementation of your projects?
() Local/Community/Grassroots
() State/Province
() National
() Regional/International

A.6 How would you define the places where your organisation works?
() Projects are mainly implemented in rural areas
() Projects are mainly implemented in urban areas
() Projects are implemented in both rural and urban areas

A.7 Is there any Information Management Officer in your organisation?
() Yes
() No
() We do not have an Information Management Officer but use a specialised NGO to manage geographic information

A.7.1 How many? (Access only after positive response to A.7).
() only 1
() 2
() between 3 and 5
() more than 5

A.7.2 What are their backgrounds? (Access only after positive response to A.7).
[] Geography/Environmental Science
[] Computer science
[] Other (please specify) ______

B Sustainable Development Goals

B.1 Is your organisation working towards achieving the 2030 Sustainable Development Goals?
() Yes
() No

B.1.1 Many of the 232 indicators in which the 17 Sustainable Development Goals are divided have a Geographical component. How is your organisation integrating that component into your projects? (Access only after positive response to B.1)

() We are already implementing it
() We are planning but we have not yet implemented it
() We are doing nothing about it
() I do not know

C Use of Maps

C.1 Does your organisation use maps?

() Yes
() No

C.1.1 What do you use maps for? Please check all answers that apply. (Access only after positive response to C.1).

[] Project planning
[] Project monitoring
[] Project evaluation
[] Hazard mapping and risk reduction
[] Communication
[] Promotion of projects/NGO
[] Presenting results
[] Community mapping
[] Other (please specify) ______

C.1.2 Why do you use maps? Please check all answers that apply. (Access only after positive response to C.1).

[] They are a necessary tool
[] They are useful
[] Donors request us to use them
[] I do not know
[] Other (please specify) ______

C.1.3 What type of maps do you use? What type of support? (Access only after positive response to C.1).

() We use mainly digital/interactive maps
() We use mainly paper/pdf maps

C.1.3.1 What type of maps/software do you use? Please check all answers that apply. (Access only after responding option 1 to C.1.3).

[] Commercial desktop GIS
[] Open-source desktop GIS
[] Commercial web-based GIS
[] Open-source web-based GIS

C.1.3.2 How do you use these maps? Please check all answers that apply. (Access only after responding option 1 to C.1.3).

[] We use maps to display and visualise information
[] We use maps to analyse information
[] We use maps to relate data

[] We use maps to compare data
[] We use maps to share data
[] Other (please specify) ______

C.1.3.2.1 What type of analysis do you perform? Please check all answers that apply. (Access only after responding option 2 to C.1.3.2).

[] Spatial analysis (i.e., overlying, interpolation, windows, density estimation, buffer, etc.)
[] Optimization
[] Descriptive summaries (i.e., spatial statistics)
[] Image analysis
[] Simulation
[] Modelling
[] Other (please specify) ______

C.1.3.3 How do you obtain the information for your maps? Please check all answers that apply. (Access only after responding option 1 to C.1.3).

[] From the Government
[] From international institutions
[] From other NGOs
[] Freely available open-source
[] From private sector
[] Gathering the information directly
[] I do not know
[] Other (please specify) ______

C.1.3.3.1 What are the "tools" that you use to gather the information? Please check all answers that apply. (Access only after responding option 6 to C.1.3.3).

[] Questionnaires
[] Paper
[] Smartphone
[] GPS
[] Drones
[] Other aerial
[] Satellites
[] Other (please specify) ______

C.1.3.4 Why does your organisation not use digital/interactive maps (i.e., GIS)? (Access only after responding option 2 to C.1.3).

[] We would not know how to use them
[] We do not have enough staff
[] We do not have the necessary equipment
[] There is no digital information in the area where we work
[] They are not useful for our work
[] I do not know
[] Other (please specify) ______

C.1.3.5 Does your organisation use OpenStreetMap? (Access only after responding option 2 to C.1.3).

() Yes
() No

C.1.3.5.1 How do you use OpenStreetMap? (Access only after positive response to C.1.3.5).

() We use it to implement our projects
() We collaborate to improve OpenStreetMap so it can be used for any project in the area
() Both of the above

C.1.3.5.2 What is the level of use? (Access only after positive response to C.1.3.5).

() We use OpenStreetMap only as basemap
() We use OpenStreetMap for advanced GIS (i.e., analysis)

C.1.3.5.3 What resources from OpenStreetMap does your organisation use? Please check all answers that apply. (Access only after positive response to C.1.3.5).

[] We use the map https://www.openstreetmap.org
[] We access training resources and e-learning http:/learnosm.org/en/
[] We use the Task Manager to create a project and to define the area to be mapped
[] We get direct support contacting through info@hotosm.org
[] We have support from Humanitarian OpenStreetMap Team local community
[] We obtain micro-grants for equipment or other needs https:/www.hotosm.org/projects/microgrants_and_community_development
[] We obtain aerial imagery https://openaerialmap.org/
[] We do geospatial analysis using OpenStreetMap Analytics http://osm-analytics.org/#/

C.1.3.5.4 Do you have concerns about using information in an open-source platform? Please check all answers that apply. (Access only after positive response to C.1.3.5).

[] We have security concerns about sharing information in an open platform
[] We have concerns about the privacy of the information
[] We have concerns about the accuracy of the information found in OpenStreetMap
[] We have other concerns (please specify) ______

C.1.3.5.5 Why does your organisation not use OpenStreetMap? Please check all answers that apply. (Access only after negative response to C.1.3.5).

[] We did not know about OpenStreetMap until today
[] OpenStreetMap is not useful for our work
[] We have security concerns about sharing information in an open platform

[] We have concerns about the privacy of the information
[] We have concerns about the accuracy of the information found in OpenStreetMap
[] I do not know
[] We have other reasons (please specify) ______

C.1.3.5.6 Are you aware that OpenStreetMap offers you the following possibilities? Please select those that you consider could be useful for your organisation. (Access only after negative response to C.1.3.5).

[] Free access map at OpenStreetMap https://www.openstreetmap.org/
[] Access to training resources and e-learning http:/learnosm.org/en/
[] Use the Task Manager to create a project and to define the area to be mapped
[] Direct support for your project contacting through info@hotosm.org
[] Support from Humanitarian OpenStreetMap Team local community
[] Obtain micro-grants for equipment or other needs https:/www.hotosm.org/projects/microgrants_and_community_development
[] Obtain aerial imagery https://openaerialmap.org/
[] Geospatial analysis using OpenStreetMap Analytics http://osm-analytics.org/#/

C.1.4 Why does your organisation not use any type of maps? (Access only after negative response to C.1).

[] We would not know how to use them
[] We do not have enough staff
[] We do not have the necessary equipment
[] There is no information in the area where we work
[] They are not useful for our work
[] I do not know
[] Other (please specify) ______

C.1.4.1 Do you have access to internet, a computer and a cheap smartphone? (Access only after responding option 6 to C.1.4).

() Yes
() No

C.1.5 Are you aware that OpenStreetMap could support your organisation through the following possibilities? Please select those that you consider could be useful for your organisation. (Access only after negative response to C.1).

[] Free access map at OpenStreetMap https://www.openstreetmap.org/
[] Access to training resources and e-learning http:/learnosm.org/en/
[] Use the Task Manager to create a project and to define the area to be mapped
[] Direct support for your project contacting trough info@hotosm.org
[] Support from Humanitarian OpenStreetMap Team local community

[] Obtain micro-grants for equipment or other needs https:/www.hotosm.org/projects/microgrants_and_community_development

[] Obtain aerial imagery https://openaerialmap.org/

[] Geospatial analysis using OpenStreetMap Analytics http://osm-analytics.org/#/

Book Spine

Nov 2019

Enhancing geospatial preparedness for disaster management through the work of development organisations Roberto San Martin

PhD