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Identifying Users' Requirements for Emergency Mapping Team Operations in the Dominican Republic

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Abstract: In recent years, a growing number of stakeholders have been taking part in the generation and delivery of geospatial information and services to reduce the impact of severe natural disasters on the communities. This is mainly due to a huge demand for accurate, current and relevant knowledge about the impacted areas for a wide range of applications in risk-informed decision makings. The aim of this paper is to identify users' requirements for emergency mapping team (EMT) operations in the Dominican Republic (DR). An online survey was applied to collect data from key users involved in the Inter-Institutional Geospatial Information Team in DR. Our findings suggest a set of users' requirements for EMT operations: (1) standardization; (2) establishing and maintaining a spatial data infrastructure; (3) partnership; (4) effective communication among stakeholders; and (5) capacity building. A better understanding of the users' requirements and the associated information workflows will lead to a superior level of readiness for EMT operations in DR. This knowledge will support future studies/practices at the local and national levels in the Caribbean region, which share similar challenges in terms of natural hazards and development issues.

Keywords: emergency mapping; users' requirements; natural disaster management; geospatial information management

1. Introduction

1.1. General Introduction (Including Research Questions and Objective)

Natural disasters have been seriously threatening the well-being of the global society in different aspects. Current findings from the United Nations Global Assessment Report on Disaster Risk Reduction (DRR) points out that the economic loss from disasters such as earthquakes, hurricanes and flooding range from US$250 billion to US$300 billion each year [1]. In the case of the Dominican Republic (DR), a small island developing state (SIDS) in the Caribbean region, the average annual losses due to multi-hazards effects reaches US$ 1 billion each year, which is ±24 percent of its annual social protection expenditure [2].

During natural disasters, geospatial information is crucial for informed decision making [3–5]. This type of information could provide a comprehensive picture of where, what, and when events and resources are located for disaster risk management activities in the territory. In a general context, government agencies are responsible for the generation and sharing of geospatial information and technologies for disaster managers and being responsive to reduce the risk of disasters on the communities [6–8]. Nonetheless, large-scale disasters might overcome the capability of the government agencies to meet the huge demand of the spatial information and services in a short period of time. In response to disastrous events, the emergency mapping teams (EMT) initiatives have emerged as a collaborative effort to support decision makers on the realization and sharing of a common operational picture regarding the status of the damages and disaster response activities [9,10].

There are fundamental challenges regarding what needs to be prepared beforehand in order to take full advantage of the EMT contributions. In this regards, the paper addresses the following research questions to guide our work: who are the key users involved in EMT operations, and what are the users' requirements for EMT operations in the DR? This study assumes that extreme phenomena will lead to a huge demand of geospatial information and services, as more different stakeholders join the disaster risk reduction and response efforts. Therefore, the EMT has to facilitate new and updated data and map services to meet a variety of stakeholders' needs. As the EMT is better prepared, decision makers will be better supported to address disaster risk reduction and response efforts.

The objective of this research is to identify a set of users' requirements, in term of geospatial and non-geospatial information and services for EMT operations in the Dominican Republic. A clear identification and description of these users' requirements are necessary in view of being better prepared for future occurrences of natural phenomena, especially in the numerous small island developing states (SIDS) with similar settings in the Caribbean region.

This research is built upon previous works, which have paid great attention to the identification and analysis of users' requirements as a key step toward a sound and effective sharing of spatial information among stakeholders in DRR activities. For instance, Diehl et al. [11] reported on the identification of general user requirements of geoinformation services in emergency response with respect to 25 disaster management activities in the Netherlands. Neuvel et al. [12] applied a network-centric approach to identify relevant geoinformation and geotechnology for risk and emergency management. Moreover, Diehl and van der Heide [13] evaluated critical factors to establish a geoinformation facility to support the public order and safety sector.

In this paper, we report on the results of an online survey questionnaire that focused on the identification of users' requirements at each main task of the EMT for disaster response operations in the Dominican Republic. The survey was targeted to members of the Inter-Institutional Geospatial Information Team (EIGEO, in Spanish). The EIGEO is the government unit responsible for executing the emergency mapping team (EMT) tasks and operations in the DR. The respondents were given the chance to provide their own perspective about what should be prepared beforehand to enhance the EIGEO operations. To the best of our knowledge, there are no previous works in the literature regarding the application of users' requirements analysis processes for EMT operations in the Caribbean region. The contribution of this research will serve as a basis for enhancing the sharing of geospatial information for disaster risk management in the DR as well as future developments of EMT operations in other Caribbean SIDS countries.

The paper is structured in the following way. First, a theoretical overview, including basic concepts of users' requirements analysis, spatial data infrastructure, and emergency mapping team, is presented in the remaining part of Section 1. Section 2 briefly describes the Dominican Republic context, geographical setting, natural hazard issues, disaster risk reduction framework and EMT operations in the DR. Section 3 explains the research methodology approach undertaken in this research. Section 4 presents and discusses the results of the identification of users' requirements for EMT operation in the DR. Finally, Section 5 closes the paper with the main conclusions.

1.2. Theoretical Overview

This sub-section briefly introduces the key terms users' requirements identification, spatial data infrastructure, and emergency mapping team.

1.2.1. Users' Requirements Identification

Understanding user requirements is an integral part of information systems design and is critical to the success of interactive systems [14]. User requirements are high-level, abstract requirements based on end users' and other stakeholders' viewpoints [15].

In the context of emergency mapping operations, the analysis of users' requirements is intended to understand better how organizations are arranged during disastrous happenings, and how and which information is exchanged among teams and their respective operational centers [16]. In this research, users' requirements mean the resources (i.e., geospatial and non-geospatial information and services) necessary for the emergency mapping teams to achieve their goals.

1.2.2. Spatial Data Infrastructure

Spatial data infrastructure (SDI) is about the facilitation and coordination of the exchange and sharing of geospatial data between stakeholders in the geospatial data community [17]. SDIs already exist in many countries and in different contexts, and have proven to have a great capacity to deal with geographic information, knowledge, and services in distributed environments (see, e.g., the implementation of the EU Directive INSPIRE—Infrastructure for Spatial Data in Europe) [18–21]. An SDI brings an opportunity to deliver geo-referenced geospatial data and services that can be transversally exploited in all the phases of the disaster management lifecycle [22].

1.2.3. Emergency Mapping Team

Traditionally, different government agencies create and manage the geospatial information and technologies to deliver accurate, current, and relevant knowledge to disaster managers and responders to reduce the impact of disasters on the communities [23]. Nevertheless, severe natural disasters may exceed the responsiveness of some government agencies to the huge demand of the geospatial information and services in a short period of time [6–8]; this information allows decision makers to save lives and resources in such difficult circumstances (e.g., the Great East Japan Earthquake in 2011, the Haiti earthquake in 2010, and the Sumatra earthquake in 2004). Since recent years, in response to extreme natural disasters, public and private enterprises, NGOs, independent volunteers, and international organizations have been taking part in the collection and distribution of geographic information and services to support the disaster management activities. These collaborative efforts have been recently named as emergency mapping team (EMT) [9,24].

The EMT development has been mainly driven by the severity and extent of recent natural disasters that have been affecting many countries around the world. However, the technical capabilities and experiences of these teams to integrate and use available geospatial information and technologies have not been fully exploited for natural disaster risk management [10,19,20]. The EMTs' main functions are the following: (1) collect, sort, evaluate, analyze, and process information from different sources; (2) create and share map products and services to different relevant groups such as emergency command centers, field response organizations, local governments, and the general public; and (3) continue updating all relevant geospatial resources [9,25].

In general, the first EMT initiatives in the United States mainly focused on maps creation and distribution, as well as the provision of access to existing geospatial databases prior to the events [26,27]. Moreover, the EMT also focused on sharing geospatial data generated during the response period [23–25]. However, a recent trend of the development of the EMT has emerged focusing on the delivery of information services (e.g., Google crises response team) [22,23]. These services are not just for the distribution and visualization of the geospatial data required for disaster response activities, but also for providing location-based services to the general citizens and disaster managers [9,25,28]. Moreover, recent EMT initiatives have the capability to move from one country to another with a very wide international scope [10].

In many small island developing states (SIDS), emergency mapping teams have been playing a major role in the disaster risk reduction efforts in recent years. For instance, Jamaica has established a National Emergency Response Geographic Information System Team (NERGIST) in 2010. The NERGIST has two main responsibilities: (1) in the field, damage assessment and geospatial data collection; and (2) in the operation center, management of data integration, analysis and map production [29]. In the Dominican Republic, the Inter-Institutional Team on Geo-Spatial Information for Disaster Risk Management and Emergency Response (EIGEO) was established in 2013. The EIGEO is an EMT focused on enhancing the use of geospatial information in disaster risk management, preparedness and emergency response [30].

2. Dominican Republic in Context

This section briefly presents the geographical setting of the Dominican Republic, its natural hazards, the institutional and legal context of disaster risk reduction, and EMT.

2.1. Geographical Setting

The Dominican Republic (DR) land area covers a surface of 48,320 km^2. According to the 2010 census, the country has a population of around 9,500,000 inhabitants [31]. The limits of the DR are the Atlantic Ocean to the north, the Caribbean Sea to the south, Puerto Rico to the east, and the Republic of Haiti to the west. Figure 1 presents the location of the Dominican Republic in the Caribbean.

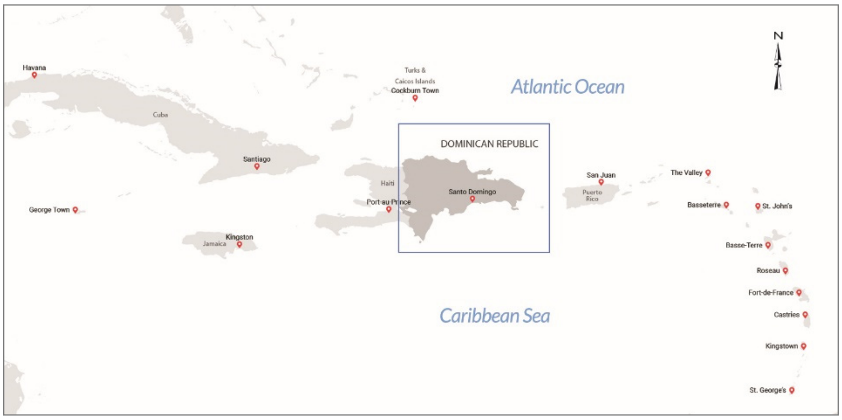

Figure 1. Map of the Dominican Republic in the Caribbean region. Source: National Geological Survey.

The Dominican Republic's form of government is democracy. In the DR, the representative democracy is divided into three powers: executive, legislative and judiciary. The administrative division of the DR is organized into one national district, 31 provinces, 154 municipalities and 232 municipal districts [32]. Over the last two decades, the DR has been standing out as one of the fastest-growing economies in the Americas. The DR had an average economic growth rate of 5.1% annually between 2008 and 2018, with a real GDP growth at 7 percent in 2018 [33].

2.2. Natural Hazards Issues

The Dominican Republic, due to its geographical position, is severely affected by numerous hydro-meteorological events, such as cyclones and hurricanes. These events derive into other natural phenomena, namely landslides, floods, debris flow, etc. [34,35]. For instance, from 2010 to 2016, a total of 44 disaster events have impacted the Dominican Republic, affecting 558,688 people and causing economic damages summing up to US$ 617,435,000 [36]. The major occurrences of disasters are driven by hydro-meteorological and geophysical phenomena.

Hydro-meteorological threats: the climate in the DR is predominantly humid tropical. The annual rainfall ranges from 500 to 3000 mm and the temperature ranges between 15 and 30 °C. The Dominican

Republic lies in the middle of the hurricane belt and it is subject to severe storms from June to October every year. The hurricane season causes occasional flooding and droughts. Some of the environmental problems are related to water shortages, soil erosion and deforestation [37]. Figure 2 shows a map of flooding areas in the Dominican Republic.

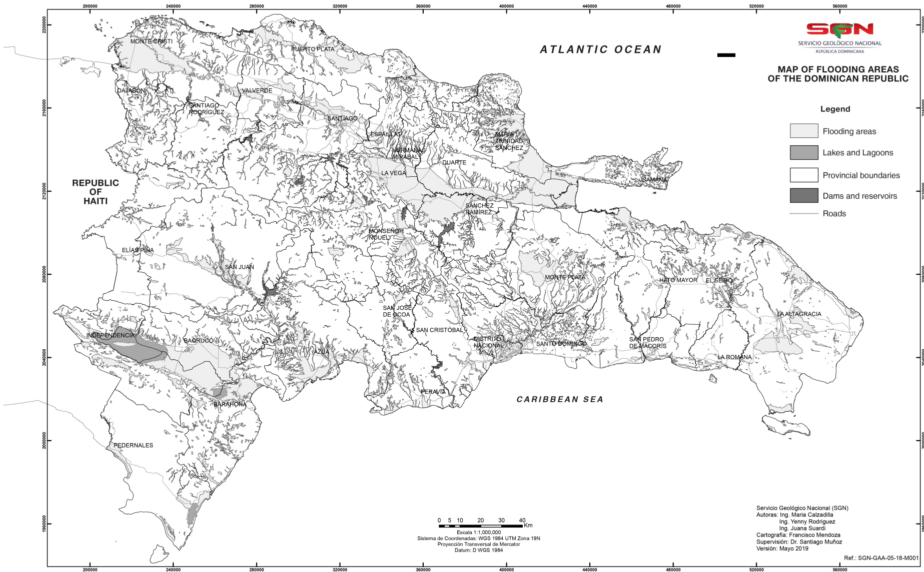

Figure 2. Map of flooding areas in the Dominican Republic (DR). Source: National Geological Survey, 2019.

Geophysical threats: the Hispaniola Island (Dominican Republic and Haiti) is located on the edge of the interaction between the tectonic plates of North America and the Caribbean. This causes the whole island to be exposed to a high seismic threat, especially in the northeastern part of the island. In this area, the northern faults, the Camú fault and Rio Grande fault, are located, which are important seismic sources that have caused several devastating events in recent history [38]. For instance, in 1946, a magnitude 8.1 earthquake generated a tsunami with waves of up to five meters, which spread damages from the east to the west of the island, causing around 500 deaths [34]. Figure 3 presents the geological faults map of the DR.

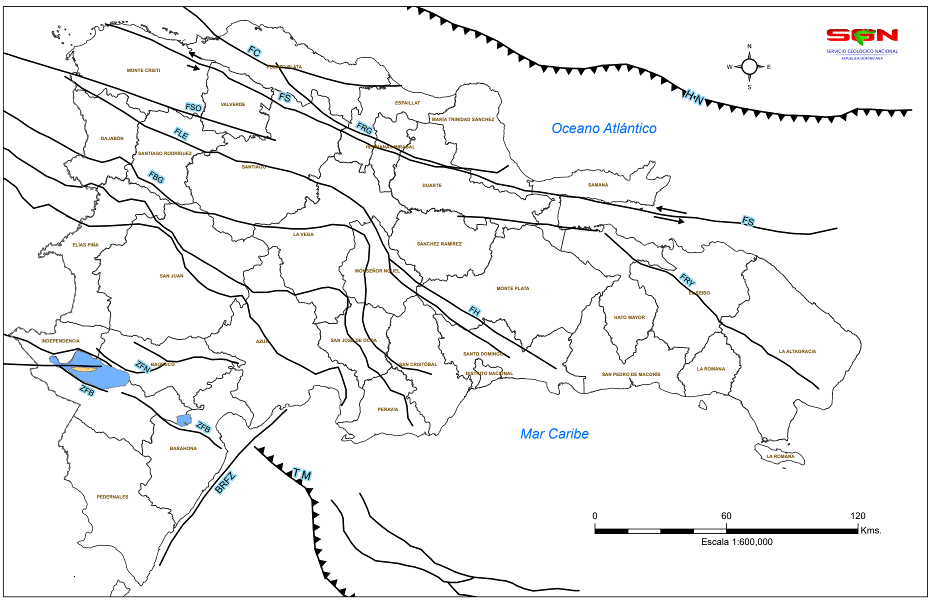

Figure 3. Geological faults map of the DR. Source: National Geological Survey, 2019.

2.3. Disaster Risk Reduction: Institutional and Legal Framework

In the Dominican Republic, there is a legal framework for disaster risk reduction. Law 147-02, on risk management, establishes the creation of four major instances for risk management at the national level: (1) National System of Prevention, Mitigation and Response (SN-PMR, in Spanish); (2) National Risk Management Plan and National Emergency Plan; (3) National Integrated Information System; and (4) National Fund for Prevention, Mitigation and Response [39]. The coordinator and responsible body for disaster preparedness and response is the Emergency Operations Center, which is part of the SN-PMR and consists of representatives from more than 22 official government agencies [40].

Law 1-12, the National Development Strategy (END 2030), envisions a society with a culture of sustainable production and consumption, which manages the risk and the protection of the environment and natural resources with equity and efficiency, and promotes a suitable adaptation to climate change [41]. Moreover, it pursues a sustainable management of the environment; effective risk management to minimize human, economic, environmental, and financial losses; and an adequate adaptation to climate change.

2.4. Emergency Mapping Team in the Dominican Republic

The Inter-Institutional Geospatial Information Team (EIGEO) was officially established in 2013. The EIGEO is a permanent government unit of the National Emergency Commission, in charge of executing the emergency mapping team (EMT) tasks and operations in the DR. Its mission is to support decision making in the phases of disaster mitigation, preparedness, response, and recovery. The EIGEO brings together 14 organizations, including ministries and technical governmental agencies: the Ministry of the Armed Forces; the Ministry of Economy, Planning and Development; the Ministry of the Environment and Natural Resources; the Ministry of Agriculture; the Ministry of Public Health and Social Assistance; the Ministry of Public Works and Communications; the National Office of Civil Defense; the Emergency Operations Center; the National Office of Meteorology; the Autonomous University of Santo Domingo (National Seismological Center and University Geographic Institute); the National Institute of Hydraulic Resources; the National Geological Survey; the Military Cartographic Institute; and the National Bureau of Statistics [30].

The EIGEO workforce is based on a memorandum of understanding among the stakeholders to ensure the effectiveness of the generation of geospatial information for the decision making in case of natural or anthropogenic disasters. The EIGEO structure consists of a chief coordinator, a coordination group, a technical team, an advisory team, an informatics team, a GIS team, and database and programming units. The EIGEO has three main objectives: (1) to create a centralized information platform, in which all geospatial data relevant to risk management and disaster response are stored; (2) to identify information needs and propose methodologies to correct them; and (3) to generate information necessary to support disaster decision making. The map products generated by the EIGEO team are used by government officers who coordinate the disaster response efforts in the National Emergency Operations Center. These maps are shared among stakeholders via the Integrated National Information System (SINI), which is a tailored clearinghouse system for disaster response purposes.

3. Materials and Methods

To identify EMT users' requirements in the DR, a cross-sectional survey was sent to all members of the Inter-institutional Geospatial Team (EIGEO). The survey was conducted from August to September 2018. The purpose of this survey was to identify minimum users' requirements for delivering geospatial and non-geospatial information and services to support disaster risk reduction and recovery efforts. The methodology used to identify these users' requirements consisted of the following four stages as proposed by Maguire and Bevan [14]: (1) information gathering; (2) users' need identification; (3) envisioning and evaluation; and (4) requirements specification. Figure 4 presents the followed methodology.

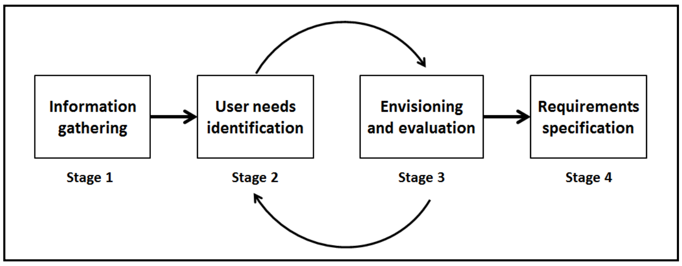

Figure 4. General process for users' requirements analysis. Source: Adapted from [14].

At first (Stage 1: information gathering), a semi-structured interview with the chief coordinator of the EIGEO was applied. Background information about the users, the stakeholders, and the processes that currently intervene in EIGEO operations was gathered. A list of 17 potential key user respondents was identified on the basis of information provided by the EIGEO chief coordinator.

The user needs identification (Stage 2) was conducted using a cross-sectional online survey. In this way, respondents were invited to provide valuable first-hand information from the users' perspective regarding minimum needs to enhance the workflow for the EIGEO operations. The design of the questionnaire was inspired by the geospatial data lifecycle proposed by the Federal Geographic Data Committee (FGDC) [42]. The adoption of this framework allows stakeholders to produce timely and high-quality geospatial data to support business processes and operations. The questionnaire consisted of 40 questions, including multiple-choice, close-ended, open-ended, and four-point Likert scale questions. These questions were constructed and categorized according to the general workflow for EMT operations [9,24]: (a) gathering information and stakeholders' needs (Q10–Q14); (b) generating data (Q15–Q25); (c) geospatial data processing (Q26–Q30); (d) mapping and layout (Q31–Q33); and (e) products sharing and continuous updates (Q34–Q38). The questionnaire also acquired information about the type of organizational setting, capacity building program and stakeholders participation required for EMT operations (Q1–Q9), as well as feedback information from the participants of the survey (Q39, Q40). Figure 5 shows a diagram of the general workflow of EMT operations.

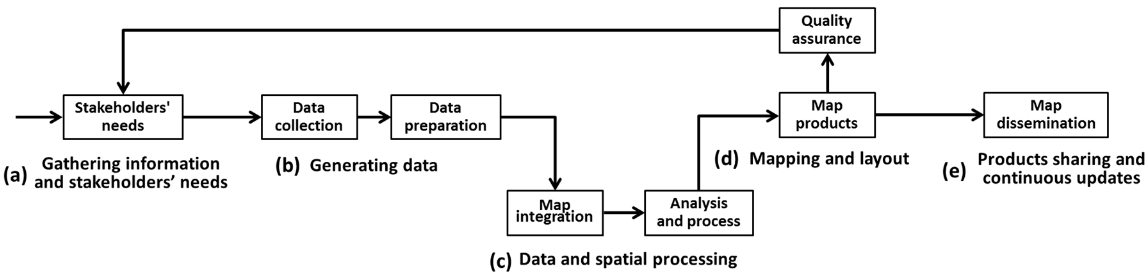

Figure 5. Workflow of emergency mapping team (EMT) operations.

These questions were pre-tested for readability and clarity through interviews with the EIGEO coordinator and experienced GIS professionals in the emergency mapping domain. For practical reasons, the questionnaire was developed using an online web form to enable digital collection of the data from spatially distributed respondents. The survey instrument was accessible at the following address: https://forms.gle/YfJxVQsRQN7SkfUy7. The link to the survey together with a cover letter was sent by e-mail to previously identified potential respondents. In addition, two reminder e-mails were sent.

The survey was responded by 16 out of 17 EIGEO members, hence a response rate of 94 percent was achieved. The survey sample was determined to be representative of the EIGEO personnel and large enough to make reasonable inferences about the users' requirements in EMT operations in the DR. The collected data were tabulated and analyzed using the SPSS software package.

The envisioning and evaluation of users' needs (Stage 3) was accomplished using the affinity diagram technique used by Eide et al. (2012) [43], to aggregate and organize information on EIGEO users' needs. The outcomes of this stage were a list of common themes serving as a basis for evaluating and specifying users' requirements for the different tasks that they perform. The analysis process ends with the users' requirements specification (Stage 4). At this stage, a task/function mapping technique [14] was applied to specify common users' requirements that lead to a successful EIGEO operation.

4. Results and Discussion

In this study, we aimed at identifying users' requirements for the EIGEO team operations in the Dominican Republic. In this section, the most important survey results are presented and discussed.

4.1. Survey Population

In this survey, all the respondents were from Dominican Republic (Q1). Most of the respondents (63%) worked with government agencies, followed by military forces (13%) (Q2)—see Figure 6. The respondents came from a variety of organizational units, mainly from geomatics (44%) and disaster risk management (19%) departments (Q3).

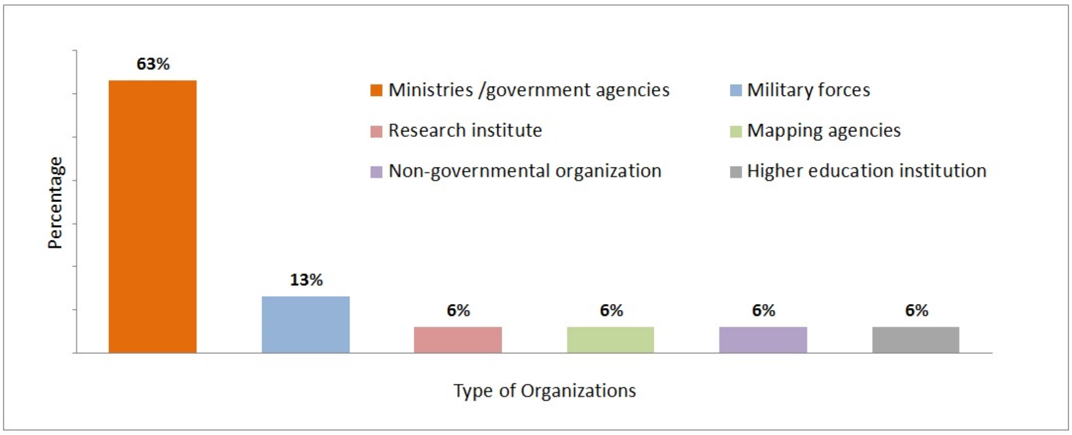

Figure 6. Distribution of responses by type of organization (Q2).

When asked about participants' background and working experience, the survey revealed that the respondents' highest degree of qualification ranges between a bachelor degree (50%), a master degree (31%) and technician (19%) (Q4). In terms of the respondents' professional background, participants were asked what is their domain of expertise (Q5), in which geographic information system (GIS) (25%) and geomatics (19%) represented a majority, closely followed by cartography and geography, each at about 13%. The respondents' experience in emergency mapping operations mainly ranged between 1–5 years (50%), closely followed by 10–15 years (31%) (Q7). In term of language skills (Q6), all EIGEO team members are native Spanish speakers; English is spoken by 35%of the respondents.

The respondents were mainly involved in the EIGEO operations representing national government agencies (94%) (Q8). Only 6% of the respondents represented NGOs and academia in the EIGEO operations. At the end of this questionnaire section, the respondents were also asked to describe the kind of tasks they execute while working in EIGEO operations (Q9). A substantial portion of the respondents identified mapping and layout (29%), data analysis (20%), and data collection (19%) as the main tasks realized by the EIGEO members (Figure 7).

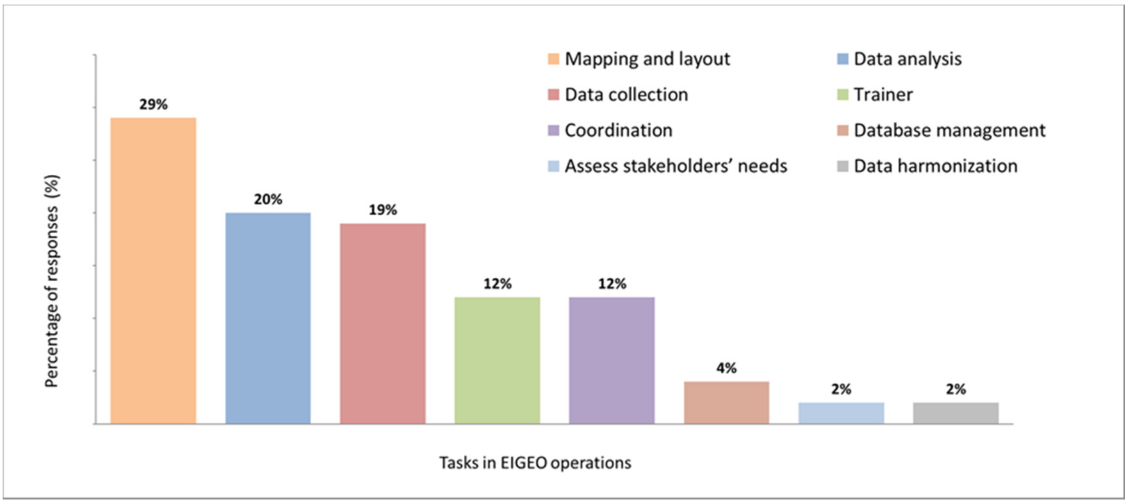

Figure 7. Distribution of responses by participant tasks (Q9). Note: Multiple answers allowed.

Overall, the survey results suggest that EIGEO is in an initial stage, where emergency mapping operations are centralized and led by government agencies with low participation of the private sector and NGOs stakeholders.

4.2. Gathering Information and Stakeholders' Needs

During an emergency mapping operation, the EIGEO is urged to communicate with and to give support to all stakeholders involved in the disaster risk management activities. It means having an appropriate strategy and technology to capture all stakeholders' demands of information and services. At first, participants were asked to rank on a four-point Likert scale (ranging from never to always) the communication media channels frequently used to gather information about users' demands (Q10). In this regards, e-mails (44%), WhatsApp (38%), and phone calls (31%) are strongly used by the respondents to gather users' demands. Surprisingly, a majority of the respondents indicated that social networks such as Twitter (56%) and Facebook (38%) technologies were never used for the emergency mapping operations. This result is of major interest to us, because social media is gaining momentum with its capability to connect people and be more involved in disaster management activities [5,40,41].

Regarding the necessity to include other stakeholders in the emergency mapping operations, the respondents were asked to suggest missing stakeholders that should be involved in EIGEO operations. The respondents replied that the most missing entities were research institutes (20%) and universities (19%) (Q11). The respondents also suggested that interactions with other Caribbean emergency mapping teams (10%) were needed. In addition, the respondents were asked in an open question to clarify the needs of stakeholders regarding necessary information gathering (Q12). In general, the respondents suggested that the right tools for data collection, standardization of data, communities support, and capacity building are basic needs of stakeholders regarding the necessary information gathering (see Table 1).

One survey question asked the respondents to mention what information is needed for capturing EIGEO stakeholders' requirements (Q13). In this regards, the respondents considered having a clear idea about the information purpose, quality, geographical disaggregation, stakeholder's profile, and information workflow as essential.

At the end of this questionnaire section, the respondents were asked in an open question to recommend improvements for anticipating EIGEO users' needs (Q14). The respondents reported that effective communication among the stakeholders, standardization, and automatization of information gathering processes and trainings on information handling and management are essential needs for anticipating EIGEO users' needs (see Table 2).

Table 1. Necessity of EIGEO stakeholders regarding information gathering (Q12).

Necessity of EIGEO Stakeholders	Detailed Mentioned Responses
Tools for data collection	- Availability of the right tools for data collection - Mobile applications with evaluation sheets and mobility facilities - Equipment - Collect baseline information for spatial analysis of risk management
Standardized data	- Spatial databases at provincial and community levels - Municipal maps and data - Updated information in open format - Defined coordinate system and attribute standardization
Communities support	- Effective and timely communication between stakeholders - Simplify the processes that hinder quick access to available data - Methodologies or templates to digitize the information from its origin - Teams that are on the ground that generate reports with coordinate points - More collaboration and/or commitment from key information/data owners
Capacity building	- Training of technical staff

Table 2. Recommendations for anticipating EIGEO users' needs (a) (Q14).

Recommended Actions for Gathering Information and Stakeholders' Needs	Detailed Mentioned Responses
Effective Communication	- Effective communication among the stakeholders - Manage direct communication using social networks - Establish specific communication channels - Consultation workshops to identify users' needs
Standardization	- Standardization of information gathering processes - Creation of a request form for maps output - Creation of a procedure form for the graphic outputs of the maps
Automatization of information gathering processes	- Identification of workflow and missing data sources - Building a stakeholders profile database - Modeling of possible occurrences of emergencies
Training	- Trained team in information handling and management - Trainings
Coordination	- Logistic support and incentives - Implement monitoring mechanisms for the mapping operations

Based on the findings presented above, we can state that a key EIGEO users' requirement for gathering information and stakeholders' needs is having an effective communication among stakeholders. This effective communication aims to empower the understanding about the kind of information and support other agencies need for their operations [44,45]. Eide et al. [46] reported similar findings, stating that enabling communication among stakeholders influences information sharing and collaboration within and across agencies. Social network and ICT development in the field are essential communication and monitoring tools for disaster management [5,43,44].

4.3. Generating Data

In the context of EMT operations, it is required to use and generate geospatial data to contextualize disaster events, producing comprehensive and easy-to-use map products and to provide value-added information on damages. The survey questions regarding data generation in the EIGEO workflow started by asking the participants to rank on a four-point Likert scale (ranging from never to always) the core geospatial datasets frequently used for the emergency mapping operations (Q15). In this way, administrative units (75%) were indicated as the most frequently used dataset by the respondents, followed by geographic names and transport network (each 63%).

The EIGEO uses and combines pieces of information from multiple sources. Herein, one survey question asked the respondents to cite the data sources used for their EIGEO operations. The majority of the respondents indicated that Google Earth (24%) and Open Street Map (21%) are the main sources of geospatial data (Q20). Other authors agree with this result, when stating that datasets produced by collaborative mapping initiatives have a great potential for emergency mapping activities, especially on areas with no official reference datasets available [47–50]. Nevertheless, just a few of the respondents (6%) also recognized spatial data infrastructure as a primary source of information. When the respondents were asked about which devices are used to acquire EIGEO data, most of the respondents replied that GPS, mobile phones, tablets, digital cameras, and total stations are mainly used for EIGEO operations (Q16). All the respondents (16) used text files and shape files as main data formats to store EIGEO data (Q17). The EIGEO spatial information is mainly managed using the ArcGIS geodatabase (39%) and the PostgreSQL (23%) database management systems (Q22).

The data and map products generated by EIGEO are presented at the different cartographic scales, in which the respondents considered the 1:10,000 scale (63%) as extremely relevant, followed by the 1:50,000 scale (69%) as relevant for EIGEO operations (Q18). With respect to the metadata information, the respondents report that the most commonly used metadata format for EIGEO operations is the Extensible Markup Language (XML) (32%). A few of the respondents (14%) mentioned that they do not save any metadata information for their data and products (Q19).

One survey question the respondents were asked was about the restrictions experienced while using EIGEO data (Q21). Not surprisingly, most of the respondents (81%) claimed that the EIGEO data cannot be shared with the public (see Figure 8). These restrictions can be explained by the fact that agencies working in disaster management scenarios tend to be more willing to receive information from others than providing information to other agencies [51].

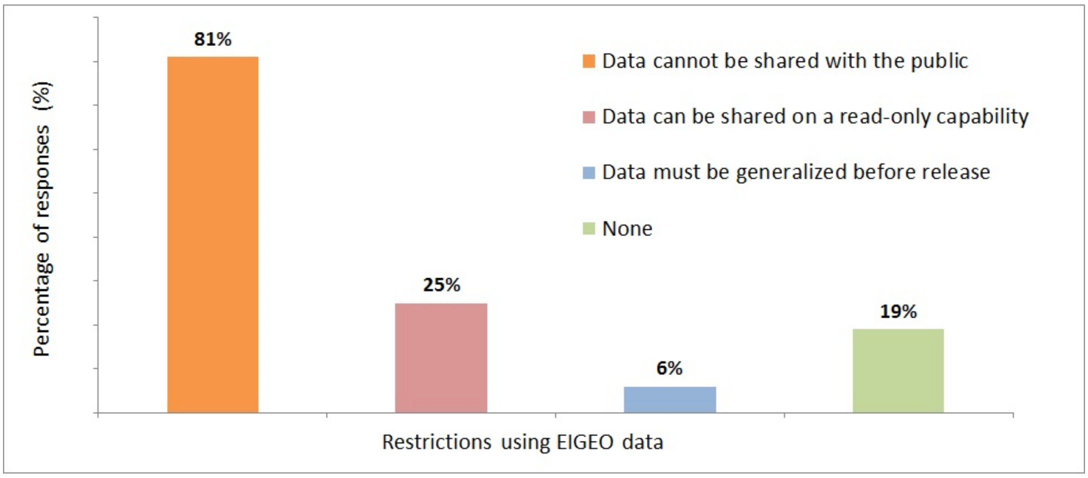

Figure 8. Restrictions for using EIGEO data (Q21). Note: Multiple answers allowed.

When the respondents were asked to suggest currently missing datasets for improving the EIGEO operations (Q23), most respondents reported a lack of gas station information (94%) as the most missing data. Datasets containing information about shelters or emergency operations facilities were also frequently mentioned as missing datasets (81%). The respondents were also asked what tools they recommend to improve data gathering for EIGEO operations (Q24). In this regards, most respondents (75%) suggested volunteered geographic information (VGI), spatial data infrastructure (SDI), and satellite imageries as basic tools (see Figure 9). VGI speeds up the interaction and flow of information between authorities, affected communities, and the broader public from in and outside the impacted areas [5,47]. Other research shows similar findings stating that the implementation of an SDI can facilitate the accessibility of geospatial information from multiple sources for rapid mapping operations [11,23,51–53].

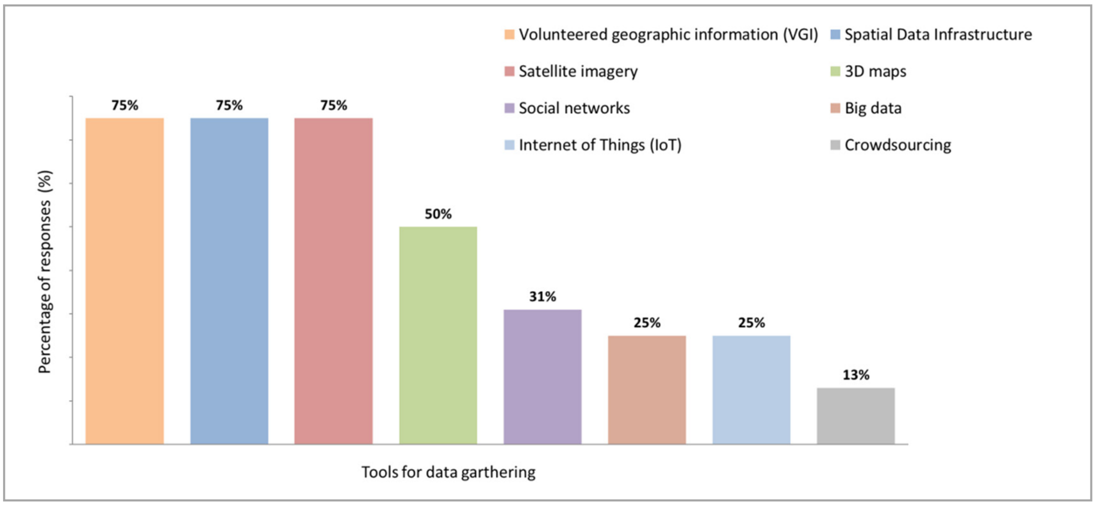

Figure 9. Recommended tools for improving EIGEO data gathering (Q24). Note: Multiple answers allowed.

In response to an open question on recommendations for enhancing data generation in EIGEO operations (Q25), the respondents presented different strategies for improving the data generation procedure (see Table 3). In this regard, most respondents recommended standardization (i.e., information workflow, tools, and template forms), spatial data infrastructure implementation (access network, technology, and policy), and continuous capacity building (i.e., trainings on GIS, information management, and disaster risk reduction) as key actions for improving data generation in emergency mapping operations.

Table 3. Recommendations for EIGEO data generation (b) (Q25).

Actions for Improving EIGEO Data Generation	Detailed Mentioned Responses
Standardization	- Standardization of data-capturing procedures - Unified national data-capturing template - Mobile phone system for capturing data in the field - Systematizing users' experiences analysis
Human resources and capacity building	- Skilled technical personnel exclusive for emergency mapping - Volunteers to collect data in the field for disaster risk reduction - Continuous trainings on data-capturing trends - GIS trainings - Trained team in information handling and management
Geospatial data	- Implementation of a national spatial data infrastructure (SDI) for disaster risk management - Better access to updated data - Enhance the access procedure to updated data - Exploit satellite data to monitor hazards - Continuous update of existing datasets - High precision on data-capturing
Coordination	- Logistical support and incentives - Implement monitoring mechanisms for the mapping operations

In general, our results clearly show that a key users' requirement for EIGEO data generation is the existence of standardization arrangements for data-capturing methods, quality, maintenance, and access network. Though almost all EIGEO geospatial data is in digital format, standardization and harmonization are an important issue to tackle [48,49]. Another important users' requirement in

EIGEO operation is related to continuous investment in capacity building. This can be explained due to the limited number of skilled professionals working in emergency mapping tasks. In this context, capacity building refers to improvements in the ability of EIGEO members to conduct data generation tasks in an effective and efficient manner [54]. Moreover, capacity building enables EIGEO members to integrate geospatial information to support emergency events [19,26,55].

4.4. Data and Geospatial Processing

During disaster events, the EIGEO has to process data from multiple sources to fulfill the response users' needs. Inspired by Kimura et al. [9], respondents were asked to cite which tasks are relevant in order to process geospatial data for EIGEO operations (Q26). Herein, the survey results revealed that updating old datasets (75%) and transformation of coordinate systems (69%) are extremely relevant tasks for EIGEO operations (see Table 4).

Table 4. Data processing tasks for EIGEO operations (Q26).

EIGEO Data Processing Tasks	No Response	Not Relevant	Moderately Relevant	Relevant	Extremely Relevant
Conversion of data formats	6%	-	-	31%	63%
Transformation of coordinate systems	6%	-	-	25%	69%
Adding necessary attribute fields	6%	-	-	50%	44%
Fixing topological errors		-	6%	50%	44%
Modifying database schemas	6%	6%	13%	44%	31%
Completing missing features	-	-	-	56%	44%
Updating old data	-	-	-	25%	75%
Digitizing paper-based maps	6%	19%	19%	38%	19%
Geo-referencing	6%	-	-	31%	63%

Software, hardware infrastructure, and storage technologies are important assets for performing geospatial data processing. One survey question asked the respondents to mention what software is frequently used to execute EIGEO operations. The analysis reveals that most of the respondents (56%) always use ArcGIS software, while other respondents (44%) declared that they frequently use the free/open-source QGIS software to execute geospatial data processing (Q27). Most of the data and geospatial processing is executed using in-house hardware infrastructure, standalone computers (67%), and local servers (17%). However, a few of the respondents (12%) claimed that an external server is also used for geospatial data processing (Q28). Regarding the media used to store information resources, local database/servers (40%) and external hard disks (29%) are frequently used by the respondents. Only 21% of the respondents claimed to store information resources in the cloud (Q29).

This section of the survey ends with a question asking the respondents to recommend improvements for enhancing data and geospatial processing in EIGEO operations (Q30). Practically all respondents referred to distributed processing as a primary requirement for improving EIGEO geospatial data processing (see Table 5). The respondents were in favor of continuously updated and redundant web services for an effective delivery of geospatial data and processing demands. Herein, the SDI in the cloud is a desired solution for data access, capture, geo-processing, and distribution for inter-agency cooperation in emergency responses [56,57].

4.5. Mapping and Layout

The emergency mapping teams collect and organize disasters-related information from different sources to meet the maps needed for disaster response [9]. In this regards, respondents were asked to rank on four-point Likert scales (ranging from never to always) the most frequently generated maps during EIGEO operations (Q31). Herein, over 56% of the respondents indicated that a shelter map and a road map are always generated for disaster management activities. Other map products, such as temporary health centers maps (44%), critical infrastructure maps (44%) and operations maps (38), are also frequently created by the respondents (see Table 6).

Table 5. Recommend actions for EIGEO geospatial and data processing (c) (Q30).

Actions for Improving Geospatial and Data Processing	Detailed Mentioned Responses
Distributed processing	- Rapid response to the necessary information updated - Availability of alternative web services applications to reduce redundancy of related tasks - Software and hardware update
Spatial data infrastructure	- Develop a national SDI with the base data for disaster risk reduction - Strengthen of an SDI supported with skill personnel and the latest technologies
Standardization	- Implement a protocol to standardize the data and geospatial processing - Standardized protocol for the data and geospatial processing
Capacity building	- Enhance the technical skills of the team in emergency management - Strengthen the technical and theoretical capabilities of the personnel - More training activities for the technical staff - Continuous training

Table 6. Maps generated during EIGEO operations (Q31).

EIGEO Maps	No Response	Never	Rarely	Sometimes	Always
Road map	12%	19%	19%	25%	25%
Shelters map	12%	12%	19%	25%	32%
Temporary health centers map	12%	19%	19%	44%	6%
Critical infrastructures map	12%	19%	19%	44%	6%
Operations map	12%	12%	25%	38%	13%
Blank map	12%	50%	38%	-	-
Buildings map	19%	19%	25%	31%	6%

One survey question asked the respondents to mention the main purposes of the maps generated for EIGEO operations. The respondents suggested that a majority (88%) of the EIGEO maps are primarily aimed at supporting emergency management stakeholders. 75% of the respondents also cited risk assessment and emergency planning and preparedness as a basic end-purpose of the EIGEO map products.

The respondents were asked an open question to suggest methods of improvements for EIGEO mapping and layout tasks (Q33). Most of the respondents argued that standardization is a key method for an effective map generation and layout during disastrous events. The standardization of emergency symbology, map templates, processes and information platforms were identified as an essential requirement for saving time and efforts while meeting the needs of EIGEO mapping and layout tasks. Ajmar et al. [23], similarly, stated that standard symbolization rules and map templates help map products to be interpreted and clearly branded. As emphasized by Kerle and Hoffman [10], the standardization of mapping symbols provides consistency and common understanding of information across all the stakeholders involved in disaster management activities (see Table 7). Herein, our results also suggested that enhancing the technical capabilities (hardware and skills) of the stakeholders involved in the emergency mapping at the local level is another EIGEO users’ requirement.

Table 7. Recommendations for EIGEO mapping and layout (d) (Q33).

Recommended Actions for Mapping and Layout	Detailed Responses
Standardization	Emergency symbology, map template, automotive processes and geospatial information platform
Technical capabilities	Strengthen the hardware infrastructure and technical trainings
Geospatial information	Continuous access to base data and real-time post-disaster information
Local level capabilities	Enhance the involvement and capabilities of the local authorities on the emergency mapping operations

4.6. Products Sharing and Continuous Updates

In this section, respondents were asked about the access media, formats and web services used for products sharing and continuous updates for EIGEO operations. Respondents were first asked about which media are currently offered for providing access to emergency maps and data products (Q34). In this regards, respondents referred to the geoportal and e-mail, with both at about 69%, as the most commonly used access media for providing access to EIGEO maps and products, followed by physical copy (63%). Web pages and spatial data infrastructure with each at about 31% were also used by the respondents.

In terms of specific media for sharing map products for emergency operations, respondents were asked to rank on four-point Likert scales (ranging from never to always) the sharing media frequency applied to distribute emergency map products (Q35). GIS maps were ranked high (56%) by most of the respondents as a common media for sharing map products, followed by digital images (32%) and paper maps (31%). Interestingly, up to 36% of the respondent have expressed that they have never applied web mapping services for sharing map products during EIGEO operations.

Regarding the web service applied during emergency mapping operations, the respondents were asked to rank on four-point Likert scales (ranging from not relevant to extremely relevant) relevant web services technologies for improving efficiency in sharing EIGEO map products (Q36). Most of the respondents ranked web mapping services (63%) and web feature services (50%) as extremely relevant technologies for improving EIGEO sharing of map products during emergency occurrences (see Table 8). A majority (56%) of the respondents also indicated that the web catalogue services and the web processing services are also relevant technologies for EIGEO operations.

Table 8. Web services for emergency operations (Q36).

Web Services for EMT Operations	No Response	Not Relevant	Moderately Relevant	Relevant	Extremely Relevant
Web Map Service (WMS)	6%	-	6%	25%	63%
Web Feature Service (WFS)	6%	-	6%	38%	50%
Web Coverage Service (WCS)	12%	-	12%	38%	38%
Web Catalogue Service (CSW)	13%	-	-	56%	31%
Web Coverage Processing Service (WCPS)	12%	-	19%	38%	31%
Web Processing Service (WPS)	13%	-	6%	56%	25%
Web Map Tile Service (WMTS)	19%	-	19%	43%	19%

In terms of the product sharing and continuous updates tasks, the respondents were asked to recommend improvements for the EIGEO mapping operations (Q37). Most of the respondents agreed that the development of a spatial data infrastructure focused on the disaster management is necessary (see Table 9). Moreover, in contrary to the current government-oriented structure of the EIGEO, the respondents perceived the local users' involvement as essential for improving the flow of more up-to-date, reliable, and relevant information from the field for the emergency mapping operations.

Table 9. Recommendations for EIGEO products sharing and continuous updates (e) (Q37).

Recommended Actions for Products Sharing and Continuous Updates	Detailed Responses
Spatial data infrastructure	Develop a national SDI for disaster risk management Open data approach Easy data access to users
Knowledge management	Enhance knowledge sharing in two ways, by increasing knowledge reuse within EIGEO members from each mapping operations and by brainstorming new ideas for developing required tools
Participatory mapping	Involving local users through two-way communication channels to provide more up-to-date, reliable and locally relevant information

Based on our research findings, there is no question that the SDI implementation is a key users' requirement to enable data sharing and continuous updates for EIGEO operations. The SDI provides an integrated framework for effective data collection, geo-processing, and data dissemination to support disaster management and recovery work [4,18,23,57].

Our results also confirm previous claims that partnership arrangements at the local and provincial levels are essential to facilitate data sharing in the SDI environment, as previously asserted by McDougall et al. [58] and Eelderink et al. [52]. Moreover, partnership arrangements with civil society relief organizations and local government allow effective communications and sharing of geospatial data based on a positive and trusted relationship [18,59].

This survey ended by asking the respondents an open question to cite missing elements that had to be tackled in this questionnaire (Q39). 87% of the respondents remarked on the completeness of the survey, covering most of the important aspects for the EMT operations. However, two (2) respondents (13%) considered that internal bureaucratic procedures for the emergency mapping operations and the role of the statistical tools and training to enhance the EMT operation were missing in this survey. A closed final question asked the participants if they wish to receive a copy of the final results of this research survey (Q40). 15 out of 16 respondents wanted to receive a copy of the final results of this survey.

5. Conclusions

The objective of this paper was to identify users' requirements for emergency mapping team operations in the Dominican Republic (DR). The focus was on the identification of geospatial and non-geospatial information and services that are necessary in view of being better prepared for future occurrences of natural phenomena. We identified these requirements by conducting an online survey questionnaire to key stakeholders involved in the EIGEO operations in the DR. Even though the sample size might be considered as a concern, this research is relevant not only to the DR, but also to the scientific community of at least 52 developing island states in the world.

The results of this survey revealed six key users' requirements to facilitate emergency mapping team operations in the Dominican Republic:

1. Standardization: standardization of data-capturing procedures, metadata, symbology, map products, services, and information workflow. This also includes technical guidance and specifications that help to save time while executing EMT operations;
2. Establishing and maintaining a spatial data infrastructure: the SDI allows the integration, geo-processing, and visualization of disaster-related data in a distributed environment;
3. Partnerships: partnership arrangements to connect with potential national and international stakeholders and to get more support from and interaction with local communities in the field;
4. Effective communication among stakeholders: effective and timely communication to reach a clear understanding of other stakeholders' needs and available resources to reduce redundancy of efforts;

5. Capacity building: continuous capacity building initiatives to enable more internal and external skilled stakeholders to collaborate and take full advance of geospatial data integration and sharing for disaster responses in an efficient manner.

This research provided a better understanding of the information workflow, tasks, and outcomes of the EMT operations in the DR. This work highlighted key users' requirements that can be prepared beforehand to increase the effectiveness for EMT operations. For future research, we have special interest to widen the scope of our survey to include first responder agencies and other main stakeholders involved in the disaster risk reduction and response efforts, e.g., NGOs, private enterprises, academia, etc. We will also strive to collect, analyze, and compare data from other small island developing states in the Caribbean region, which share similar challenges in terms of natural hazards.

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