United Nations Committee of Experts on Global Geospatial Information Management
Working Group on Policy and Legal Frameworks for Geospatial Information Management

Authoritative Data for Crises

Placeholder: Document ID from UN-GGIM

August 2025

Acknowledgements

This paper is authored by the Working Group on Policy and Legal Frameworks for Geospatial Information Management, a functional group established by the United Nations Committee of Experts on Global Geospatial Information Management (UN-GGIM) under the leadership of the Centre of Mapping and Earth Observation, Natural Resources Canada. The content is based on existing literature on the topic, as well as the contributions received in written form and the views expressed and trends identified at various discussions and consultations held in 2024 and 2025. As part of these consultations, drafts of this paper were presented to the various UN-GGIM functional groups, thematic networks as well as regional committees for additional consideration. This version has been developed having taken into consideration feedback received at these discussions and consultations including a global consultation process involving Member States and relevant stakeholders. The Working Group is co-chaired by Canada and Saudi Arabia.

Table of Contents

EXECUTIVE SUMMMARY

The urgency introduced in a crisis leads geospatial data users to prioritize timeliness and accessibility over other data characteristics (e.g., quality, privacy and security). Crisis responders often face difficult trade-offs stemming from this urgent need for timely and available data, particularly in jurisdictions lacking enabling laws and policies. This paper aims to support data users and producers in identifying and mitigating trade-offs in data characteristics and principles that can arise when responding to a crisis. It outlines policy and legal considerations linked to these trade-offs and identifies laws, policies and institutional arrangements that can be established to address them, including case studies to illustrate their implementation. Having robust data governance and cross-sectoral and bilateral/multilateral institutional arrangements in place confirms that data is suitable for crisis response, ensuring the presence of desired characteristics and/or required legal status. Building on previous works of the UN-GGIM Working Group on Policy and Legal Frameworks, the paper revisits a "control versus trust continuum", to illustrate that governance instruments overseeing the use and production of geospatial data for crisis applications exist along a spectrum between endpoints of "control" and "trust". More formalized, government-led instruments are found at the "control" end of the spectrum, while less formalized or voluntary initiatives overseen by the private and non-profit sectors are positioned closed to the "trust" endpoint. Enabling governance systems including robust policy and legal frameworks and institutional arrangements are necessary pre-conditions for trust in authoritative, fit for purpose data harnessed for crisis response. When governments establish transparent and effective laws, policies and institutional arrangements pre-crisis, they are better equipped to address the needs of data providers and users during the response phase and limit the trade-offs between characteristics of critical data resources. The paper concludes with a checklist for data users and providers to identify gaps in governance considerations for authoritative data for crisis applications, with a view to promoting transparency and mitigating trade-offs in essential data characteristics.

LIST OF ACRONYMS

ASEAN – Association of Southeast Asian Nations

CARE Principles – Collective Benefit, Authority to Control, Responsibility, Ethics

ECLAC – Economic Commission for Latin America and the Caribbean

EGS – Emergency Geomatics Services

FAIR Principles – Findability, Accessibility, Interoperability, and Reusability

GDACS – Global Disaster Alert and Coordination System

GIS – Geographic Information Systems

HDX – Humanitarian Data Exchange

IHO – International Hydrographic Organisation

IPRA – Intellectual Property Rights Agreement

ISO – International Organization for Standardization

MOU – Memorandum of Understanding

NSDI - national spatial data infrastructure

ODbL – Open Database License

OGC – Open Geospatial Consortium

UNDRR – United Nations Office for Disaster Risk Reduction

UNDRIP – United Nations Declaration on the Rights of Indigenous Peoples

UN-IGIF United Nations Integrated Geospatial Information Framework

UNOCHA – United Nations Office for the Coordination of Humanitarian Affairs

VGI – Volunteered Geographic Information

INTRODUCTION

Before, during and in the aftermath of a crisis, timely access to authoritative fit-for-purpose geospatial data[1] is critical for coordinating an effective response. Reliable access to geospatial data throughout these crisis phases is enabled by targeted legislation, regulation and policies situated within a robust national policy and legal framework. However, when responding to a crisis, trade-offs may arise as priorities are realigned to reflect the urgent need for timely and available data, particularly in jurisdictions lacking enabling laws and policies. In other words, characteristics that make data fit for purpose can shift as a crisis evolves from one phase to the next. With these realities in mind, this paper has three primary aims: (1) to support governments in navigating considerations for geospatial data characteristics and principles that may arise during the crisis response phase and address accompanying limitations; (2) to offer guidance and consider the perspective of responders navigating trade-offs while providing on-the-ground, real-time responses to crises ; and, (3) to shine a light on the data producer and user experiences, with an emphasis on identifying policy and legal instruments that facilitate access to reliable data sources while maintaining quality and standards given the constraints that a crisis scenario presents.

This discussion builds on a paper endorsed at the thirteenth session of the Committee of Experts, titled "Authoritative Data in an Evolving Geospatial Landscape: An Exploration of Policy and Legal Challenges", to address policy and legal considerations for crisis applications of authoritative data. It explores the pre-conditions for trust of authoritative, fit for purpose data used during crises, which involves the development of robust policy and legal frameworks including data governance in the pre-crisis phase[2]. The paper revisits the "control versus trust continuum" concept introduced in the former paper to highlight the various policy, legal and other governance instruments used to oversee authoritative data production and use for crisis applications. The continuum illustrates that oversight of authoritative geospatial data exists along a spectrum, with public sector, private sector, and civil society instruments positioned between endpoints of 'control' and 'trust' (*Figure 1*). In order to establish trust, government

[1] UN-IGIF Strategic Pathway 4: Data defines geospatial information, used interchangeably with "geospatial data", as follows: "Geospatial information reflects the physical world in which all human, economic and environmental activity takes place. It provides the digital version of our world - without which a digital economy is not possible. Geospatial information describes the physical location of geographic features and their relationship to other features and associated statistical information. Geospatial information is presented in many forms and mediums including maps, satellite imagery and aerial photography. It describes the connection between a place, its people and their activities. It illustrates what is happening - where, how and why, and can be used to examine what has happened in the past, and to create likely future scenarios. Geospatial information is collected and managed using a wide range of enabling technologies and tools, such as Geographic Information Systems (GIS), photogrammetric software, satellites, mobile devices, and other ground-based and airborne sensors, etc. GIS in particular, is typically used to manage geographic features in 2 and 3-dimensional space. It is also used to visualise the dynamics of the environment as a series of data of the same area captured over time (4-dimensional space)." Integrated Geospatial Information Framework (IGIF)." Strategic Pathway 4: Data", 2020, https://ggim.un.org/UN-IGIF/documents/SP4-Data-Refined.pdf

[2] This paper uses the terms "governance" in a manner that aligns with the following definition included in the UN-GGIM Policy and Legal Resource Kit: "the way geospatial information responsibilities are assigned, coordinated, managed and monitored within and across institutions." United Nations Committee of Experts on Global Geospatial Information Management (UN-GGIM) Working Group on Policy and Legal Frameworks. "UN-GGIM Policy and Legal Resource Kit", 2022, https://ggim.un.org/documents/UN-IGIF-Policy-and-%20Legal-Resource-Kit-Aug2022.pdf

authorities are encouraged to implement legal and policy tools and institutional arrangements to enable transparent access to fit for purpose data needed for effective crisis response.

The "control" end of the continuum represents oversight of geospatial data that is more tightly controlled or formally codified, including laws and regulations, treaties and conventions. The "trust" endpoint represents less formalized instruments with greater involvement or oversight by the private and non-profit sectors. The Concept Paper on Geospatial Data for Public Good (2024) presents an adapted version of the continuum, which identifies that governments have a broad range of initiatives to choose from, including not only state-driven instruments such as laws and regulations, but also negotiated bilateral or multilateral arrangements like memoranda of understanding (MOUs) and public-private partnerships. *Part IV* of this paper presents a more detailed version of the continuum to highlight the range of public sector, private sector, civil society and multilateral governance instruments that can be established in the pre-crisis phase to facilitate access to fit-for-purpose data, including examples of policy and legal instruments and institutional arrangements introduced in the forthcoming pages.

Figure 1. *An illustration of the "control versus trust continuum" concept.*

Scope

The paper will focus on **policy and legal instruments in addition to institutional arrangements (cross-sectoral and bilateral/multilateral)** that establish the preconditions for trust and prepare Member States to facilitate the provision of authoritative data for crises, while considering broader policy and legal considerations that may apply.

Crisis events are characterized by **immediacy of response**. Events include, for example, public health emergencies, climate change-related disasters, etc. Though the paper contents are linked to "climate and resilience" and "disasters" these are not a main focus of the paper, so as not to duplicate efforts of other UN-GGIM functional groups[3]. The scope of crises is also limited to **non-military, civilian responses** to crises, though the guidance presented here may be applicable in other contexts where first responders are on the ground facing similar challenges (e.g. military).

The paper will consider the needs of the data user, including crisis responders, whose role is instrumental in the crisis response phase. While some of the content and guidance will be relevant to

[3] Linkages between geospatial data and climate resilience are being explored by the UN-GGIM Task Team on Geospatial Information for Climate Resilience.

non-state (i.e., non-governmental) entities involved in crisis response, the paper will focus primarily on **policy, legal and institutional arrangements that fall under the purview of Member States**. It may be applicable to the work of any government organization or agency using or producing geospatial data for crisis response applications (e.g., National Mapping Authorities (NMAs), National Statistical Offices, etc.).

Given that UN-GGIM is Member State-led, the starting point of this paper is public sector decision-making, even as we consider the roles of a range of non-governmental actors (e.g., private sector, civil society, academic) involved in crisis response efforts as data providers and users. The guidance provided in this paper is intended to assist member states in mitigating trade-offs in data characteristics during a crisis by establishing enabling governance frameworks that facilitate data access to support a timely and effective response. It is important to note that **member states have distinctive governance systems and face different political and socioeconomic realities**, which may impact the combination of policy and legal tools and institutional arrangements that are used to promote access to fit-for-purpose data during a crisis. For example, in resource-constrained contexts (e.g., Small Island Developing States), responders may lack fit-for-purpose government data sources, relying on partnerships with non-state organizations established through institutional arrangements to provide low-cost alternatives. Where necessary, member states are encouraged to adapt the guidance presented in this paper to align with their national contexts and unique circumstances.

The Global Consultation Process

A month-long global consultation was held from April – May 2025. Overall reception of the paper was positive, with constructive feedback provided by Member States and non-state participants. Updates to the paper made to reflect this feedback included the addition of examples and use cases to clarify key policy and legal concepts, improvements to readability and addition of visual aids, and the incorporation of further policy and legal guidance for decision-makers. It should be noted that some of the recommendations made during global consultation were determined to fall outside of the scope of the paper and/or the Working Group mandate and field of expertise. For example, comments emphasizing data management practices rather than policy and legal perspectives were not incorporated into the final draft. In addition, given the WG's legal and policy expertise and mandate, guidance is not provided for the operational, on-the-ground work of first responders during a crisis. Inclusion of the user/ first responder perspective is intended to illustrate policy and legal gaps that Member States are positioned to address, and specifically to shed light on policy and legal considerations and tools that can be used to minimize trade-offs in data characteristics during a crisis, fostering trust between data users and providers to improve response outcomes.

Paper Structure and Framing

In *Part I* of the paper, we identify characteristics that are commonly used to designate data as authoritative[4] (i.e., fit for purpose) in crisis response applications, including accessibility, timeliness, and

[4] The paper Authoritative Data in an Evolving Geospatial Landscape: An Exploration of Policy and Legal Challenges (2023) refrains from defining "authoritative data" outright, instead providing guidance for decision makers and domain experts who may be seeking it. It proposes a "fit for purpose" criterion, which establishes that in order for any data asset, process or organization to be designated as authoritative, it must be fit for its intended, predefined purpose(s). United Nations Committee of Experts on Global Geospatial Information Management (UN-GGIM) Working Group on Policy and Legal Frameworks. "Authoritative Data in an Evolving Geospatial Landscape: An

quality. After the desired characteristics have been selected, decision makers are able to identify data principles which—given the designated purpose and needed characteristics—inform the data's use and management. In order to access the data needed to execute an effective response, users may face trade-offs or compromise on data characteristics to meet their immediate needs (e.g., timeliness vs. quality; privacy and security vs. accessibility). These types of compromises can erode trust between data producers and users, as well as among responders and stakeholders.

Part II of this paper outlines policy and legal considerations and tools, in addition to institutional arrangements, that form part of a robust governance framework, including discussion of the following areas: data privacy and security, intellectual property, legal interoperability and licensing, liability, data quality assurance, open data sources, equity in disaster response, collaborative partnerships, international standards, and validation frameworks for volunteered geographic information (VGI) sources. When these tools and arrangements are established in the pre-crisis phase, the trade-offs in data characteristics outlined in *Part I* can be minimized.

Part III of the paper outlines six case studies focussed on authoritative data governance instruments or approaches enabling geospatial data production, provision and use in crisis scenarios. The first case study focusses on the *International Charter: Space and Major Disasters*, a multi-lateral institutional arrangement that facilitates of Earth-observation satellite data access when activated by a registered national disaster management authority. The second case study summarizes legal and policy tools addressing flood mapping in Canada, which includes provision of foundational data to regional governments by the country's national mapping authority, publication of a flood mapping guidelines series, and an emergency geomatics service providing real-time mapping during a flood event. The third case study describes the Association of Southeast Asian Nations (ASEAN) Leaders' Declaration on Disaster Health Management, which commits to regional cooperation, information sharing, and capacity development for health emergencies and disaster response. The fourth case study discusses the Humanitarian Data Exchange (HDX), an open-source platform OCHA's Centre for Humanitarian Data that facilitate data sharing between organizations during crisis events. The fifth case study explores the Caribbean Disaster Emergency Management Agency (CDEMA)'s integrated and proactive approach to data sharing. The sixth case study examines the Missing Maps project, a collaboration between humanitarian organizations (e.g., Red Cross, Doctors Without Borders) and OpenStreetMaps that combines remote VGI data production with on-the-ground community mapping efforts in at-risk or crisis locations.

Part IV of the paper uses the control versus trust continuum to illustrate the range of governance instruments that can be established to enable access to fit-for-purpose data in responding to a crisis. It also emphasizes that throughout all crisis stages, trust is a fundamental principle that underpins data management and oversight. Government authorities can build trust by implementing legal and policy tools and engaging in institutional arrangements with key partners and stakeholders that enable transparent access to fit for purpose data needed for effective crisis response. Establishing data governance grounded in the principle of trust helps to mitigate or avoid the various trade-offs that data users (i.e., responders) face. Datasets maintained and/or overseen by government actors are most

Exploration of Policy and Legal Challenges", 2023, https://ggim.un.org/meetings/GGIM-committee/13th-Session/documents/E_C20_2023_16_Add%202Authoritative_Data_in_an_Evolving_Geospatial_Landscape_20Jul2023.pdf

effective when underpinned by laws and policies that foster a transparent environment for data use and collaboration. Having robust data governance and cross-sectoral and bilateral/multilateral institutional arrangements in place provides an assurance that the data is suitable for crisis response, ensuring the presence of desired characteristics and/or required legal status. The section concludes with general guidance for data providers and users on governance considerations for authoritative data in crisis applications.

1. EXPLORING TRADE-OFFS DURING THE RESPONSE PHASE

1.1 Defining a Crisis

A crisis is defined as "a serious threat to the basic structures or the fundamental values and norms of a social system, which—under time pressure and highly uncertain circumstances—necessitates making critical decisions".[5] Some experts have observed overlap between the features of crises and disasters, including "being unique, uncontrollable, triggering rapid public policy changes, presenting something extraordinary, being a high risk to business, and disrupting a system as a whole"[6]. Others have characterized disasters as a more severe or advanced subset of crises. Sawalha et al. (2013)[7] observe that a crisis can evolve into a disaster[8] if neglected or mismanaged. In some literature, the terms are used interchangeably, though this may vary across jurisdictions and domains. While this paper uses the term "crisis" in a broad context, note that our use of the term is intended to encompass disasters.

The paper *Advancing Geospatial Information Management for Disaster Risk Management in the Caribbean*[9] identifies three phases of disaster risk management: the pre-disaster phase (including mitigation, planning, preparedness), the response phase, and early recovery or post-crisis phase. In the pre-disaster phase, geospatial data assumes a critical role in early event detection, enabling proactive measures to mitigate crises before they escalate. The response phase encompasses actions taken immediately before, during, and after an event to minimize community harm and pave the road for the recovery phase. The post-crisis phase involves long-term planning and a commitment to return the environment, businesses and communities to an operational state.

1.2 Understanding the Role of Geospatial Data Providers and Users

This section explores challenges for users (with a focus on "responders") of authoritative geospatial data that arise during the crisis response phase, beginning with an outline of typical data sources and providers, followed by an outline of trade-offs that users face in obtaining data to enable real-time response. For the purposes of this paper, "data provider" refers to all data producers or creators, data

[5] Rosenthal, Uriel, Michael T Charles, and Paul 't Hart. Coping with Crises: The Management of Disasters, Riots, and Terrorism. Springfield, Ill., U.S.A.: C.C. Thomas, 1989.
[6] AL-Dahash, Hajer & Thayaparan, Menaha & Kulatunga, Udayangani. (2016). Understanding the Terminologies: Disaster, Crisis and Emergency. *Proceedings of the 32nd Annual ARCOM Conference*, 5-7 September 2016, Manchester, UK. Association of Researchers in Construction Management, Vol. 2, 1191 – 1200.
[7] Hanna Salman Sawalha, I., Eid Jraisat, L. and Al-Qudah, K.A.M. (2013), "Crisis and disaster management in Jordanian hotels: practices and cultural considerations", *Disaster Prevention and Management*, Vol. 22 No. 3, pp. 210-228.
[8] The UN Sendai Framework for Disaster Risk Reduction (2015 – 2030) defines a disaster as "a serious disruption of the functioning of a community or a society at any scale due to hazardous events interacting with conditions of exposure, vulnerability and capacity, leading to one or more of the following: human, material, economic and environmental losses and impacts." United Nations Office for Disaster Risk Reduction (UNDRR). "Sendai Framework for Disaster Risk Reduction 2015-2030 (Sendai Framework)", 2015, https://www.undrr.org/media/16176/download
[9] Dubrie, A., Emanuel, E., Opadeyi, J., and Grant, V. (2023). Advancing geospatial information management for disaster risk management in the Caribbean", *Studies and Perspectives series-ECLAC Subregional Headquarters for the Caribbean*, No. 119 (LC/TS.2023/62-LC/CAR/TS.2023/5), Santiago, Economic Commission for Latin America and the Caribbean (ECLAC).

brokers, and value-added re-sellers, while "data users" describes all consumers of data provided by the latter category. The user category includes crisis responders, sometimes referred to as first responders (i.e., Police, Fire, EMS including 911 Systems), in addition to public works, transportation, NGO service providers, and the general public[10].

1.3 Data Sources and Providers

During a crisis, a variety of sources and providers contribute geospatial data to support response and recovery efforts. It is common for emergency preparedness and response personnel (including government operations) to utilize data from various public, private and civil society sources, which may include imagery, critical infrastructure information, property records, street centerlines, floodplain delineations, among other datasets and derived products. For most emergency events, the geospatial information and services needed for planning and response are thus maintained by a variety of public and private organizations across multiple jurisdictions.

In fulfilling their responsibilities during a crisis, governments often undertake multiple roles concurrently, including data production, ownership, provision, certification, custody, stewardship, and regulation. When governments are unable to generate the required data, their role may shift from data producer to end user. In this case, they are subject to the same terms and conditions as other users. The COVID-19 pandemic highlighted the indispensable role of governments in data collection, analysis, storage, and dissemination for effective public policy responses.[11] Maintaining these capabilities is vital to support public health, citizen services, and infrastructure maintenance over the long term.

Increasingly, public authorities are recognizing the importance of collaborating with non-governmental entities including the private sector, who can provide high-quality data and fit-for-purpose products and services through geographic information systems (GIS), including key layers such as critical infrastructure and imagery. Additionally, in cases where gaps exist in national spatial data infrastructure (NSDI), there is a growing reliance on alternative bottom-up data sharing approaches, such as VGI. Civil society data providers and sources advocate various methods for evaluating geospatial data quality, such as comparing the quality of VGI data with validated datasets or using VGI to complement and triangulate existing data.

Data providers manage data sources, including fundamental data themes required to address a range of events. The UN-GGIM has identified buildings and settlements and orthoimagery[12] as fundamental themes for crisis response. In their capacity as data providers, the public sector often focuses on broad accessibility and regulatory needs, while the private sector emphasizes tailored, value-added commercial-grade solutions and advanced features. For example, remote sensing has become an

[10] Open Geospatial Consortium (OGC) identifies five categories of stakeholders relevant to a disaster SDI: End-users, data producers, data providers, data processors, data handlers, and policy makers. OGC notes the categories are "not mutually exclusive, and many organizations or individuals are members of more than one class." Open Geospatial Consortium (OGC). "Report: Development of Disaster Spatial Data Infrastructures for Disaster Resilience (2018)", 2018, http://www.opengis.net/doc/per/disaster-sdi

[11] Johnson, P. A., & Scassa, T. (2023). Who owns the map? Data sovereignty and government spatial data collection, use, and dissemination. Transactions in GIS, 27, 275–289.

[12] UN-GGIM. "The Global Fundamental Geospatial Data Themes", 2019, https://ggim.un.org/meetings/GGIM-committee/9th-Session/documents/Fundamental_Data_Publication.pdf

essential data source operated by both the public and private sectors, highlighted by international initiatives like the INSPIRE geoportal[13]. The ubiquity of remote sensing coupled with advances in VGI and WebGIS has influenced data production and sharing. As a result, public and private institutions are evolving beyond information sources to coordination hubs for relief agencies and volunteers.

From an emergency preparedness and response perspective, the goal is to harness needed fit-for-purpose data sources to enable planners and responders to foster a shared understanding of the operating picture. This enables responders to make well-informed and timely decisions at critical junctures during the response phase. In the absence of robust, fit-for-purse data, users must work with sub-optimal datasets, making difficult trade-offs in data characteristics that may be necessary to implement a timely response.

1.4 Trade-offs

Crisis scenarios often give rise to a need to redefine or reprioritize traits ("characteristics"[14]) used to designate data as authoritative. During a crisis, authoritative data must above all be easily accessible and reliable, capable of supporting real-time decision-making, and adaptable to various scales and scenarios. Having access to data with these characteristics ensures responders can effectively analyze the situation, plan interventions, and manage resources in a timely and informed manner. The presence of these characteristics contributes to data 'authoritativeness' and plays a crucial role in establishing and maintaining trust with crisis responders.

The reality on the ground is that data users (responders) often encounter trade-offs related to data characteristics, as they face challenges in accessing authoritative geospatial data during the crisis response phase. The urgency introduced in acute scenarios means that responders rely on whatever data is available in the moment when it is needed. When data accessibility and timeliness become the preeminent considerations, users may need to adjust their criteria for selecting data deemed authoritative or fit for purpose. Ideally, countries would have a pre-established framework of laws and policies supporting their spatial data infrastructure to enable rapid access to fit-for-purpose data at all times, including during the response stage. Responders in jurisdictions without this enabling legal and policy infrastructure may find they need to make trade-offs related to desired data characteristics in order to respond in a timely manner.

1.41 Timeliness

Near-real-time observations are crucial for addressing crisis response needs, such as monitoring submarine seismic and volcanic activity and tracking tsunami propagation, as well as managing significant

[13] The INSPIRE geoportal was created as an access point to data provided by EU Member States and EFTA countries under the INSPIRE directive. Directive 2007/2/EC of the European Parliament and of the Council of 14 March 2007 establishing an Infrastructure for Spatial Information in the European Community (INSPIRE), http://data.europa.eu/eli/dir/2007/2/2019-06-26

[14] The presence of characteristics is used by some geospatial domains to establish data authoritativeness. Characteristics can be viewed as data traits, and can include quality, accessibility, and timeliness, and others. For an overview of data characteristics discussed in this section, refer to Annex A in "Authoritative Data in an Evolving Geospatial Landscape: An Exploration of Policy and Legal Challenges", UN-GGIM, 2023.

extreme events like wildfires. To meet these requirements, there is a need for systems to offer real- or near-real-time monitoring, early detection, and globally integrated observations.

Data users often face trade-offs between timeliness and other quality dimensions[15]. Timeliness can be compromised by factors such as availability of source data, processing time, statistical rigor, and documentation preparation. While lower resolution data can be obtained quickly and affordably, it may lack important features or contain anomalies. It is thus a challenge to balance the urgent need for data in crisis scenarios against the potential risk of compromising the data's fitness for purpose and impeding effective crisis response. VGI sources offer publicly available, regularly updated geographic information, which may be difficult to obtain through traditional government-provided data collection methods. However, responders harnessing VGI for crisis response may find that that data collected by volunteers varies in accuracy and other quality dimensions[16].

1.42 Quality

For end users, data quality is understood as how well data characteristics align with the needs of users within a particular application and domain. High quality can signal fitness-for-purpose if it means that the data is usable and relevant to any designated contexts of use.[17] Data quality is context-dependent in the sense that a dataset deemed high quality in one context may be considered poor quality in another. Quality is broken down into various dimensions[18], which differ across domains but often include accuracy, completeness, and validity. Because high quality data is often resource intensive and frequently involves restrictions on access or availability, crisis responders seeking fit for purpose data may face trade-offs in one or more dimensions. Three commonly-used quality dimensions (accuracy, completeness and validity) are detailed below. Note that this list is not intended to be exhaustive; data providers and users should follow the guidance of their organizations and domains.

Accuracy: Accuracy refers to the correctness of data, or the extent to which databases and other data products (e.g., maps) portray real-world data. It is vital to ensure that data accurately reflects current conditions (i.e., temporal accuracy), as inaccuracies can result in misguided decisions and ineffective crisis response.

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[15] Schacher, Alice, Erin Roger, Kristen J. Williams, Matthew P. Stenson, Ben Sparrow, and Justine Lacey. 2023. "Use-Specific Considerations for Optimising Data Quality Trade-Offs in Citizen Science: Recommendations from a Targeted Literature Review to Improve the Usability and Utility for the Calibration and Validation of Remotely Sensed Products" *Remote Sensing* 15, no. 5: 1407. https://doi.org/10.3390/rs15051407

[16] Tavra, Marina, Anka Lisec, Morena Galešić Divić, and Vlado Cetl. 2024. "Unpacking the Role of Volunteered Geographic Information in Disaster Management: Focus on Data Quality." *Geomatics, Natural Hazards and Risk* 15 (1). doi:10.1080/19475705.2023.2300825.

[17] Jayawardene, T.J. Huggins, R. Prasanna, B. Fakhruddin. (2021). The role of data and information quality during disaster response decision-making. *Prog. Disaster Sci*., 12, Article 100202.

[18] Lush, Victoria, Bastin, Lucy and Lumsden, Jo (2012). Geospatial data quality indicators. IN: *Proceedings of the 10th international symposium on spatial accuracy assessment in natural resources and environmental sciences*. Vieira, Carlos; Bogorny, Vania and Aquino, Artur R. (eds) BRA: International Spatial Accuracy Research Association.

Completeness: Completeness describes the representation of real-world features within a dataset and its metadata[19]. Incomplete data can create knowledge gaps, impeding effective response planning and execution. Though not ideal, depending on the extent of data gaps, design of information systems and users' ability to work around the missing data, incomplete datasets can still be harnessed to facilitate an effective response.

Validity: Validated data provides a solid foundation for decision-making and action, instilling trust in the information being used. Validity encompasses data suitability for intended tasks, as well as adherence to specified ranges or formats. Data validation can help to promote quality control while minimizing misinformation and information gaps in crisis response. Notably, processes used to validate data may be time consuming and may not be feasible to execute after a crisis has begun. Data users benefit from data that is validated in advance, which helps them avoid a trade-off between timeliness and validity in a crisis.

The relative weighting of quality dimensions, like accuracy and completeness, varies based on the data's intended use. During crises, trade-offs between quality dimensions and other characteristics may be inevitable; for example, data may be readily accessible but less accurate. However, with effective information system design and decision-making enabled via robust policy and legal frameworks, available data can support successful crisis response tasks. Liability risks associated with trade-offs in data quality are discussed in *2.14*.

Timeliness vs. Quality

Harnessing VGI Sources to Fill Gaps in Government Datasets

Crowdsourced or VGI providers can offer rich sources of critical geospatial data during crisis or disaster. For jurisdictions facing gaps in government-provided data, the timely aspect of crowdsourced data is particularly appealing.

Data collected by citizens is increasingly viewed by NMAs as a valid source of information[20]. The quality of VGI data can be nonetheless challenging to assess, as volunteers possess varying levels of skill and proficiency[21]. Similarly, in the absence of knowledge of the contributors, including volunteer expertise, potential biases are difficult to identify and counteract. Notably, higher-risk regions with vulnerable populations, which tend to be more reliant on VGI sources for crisis response, are often underrepresented in VGI sources. In other words, gaps in data quality may be more pronounced in

[19] Razniewski, S., Nutt, W. (2013). Assessing the Completeness of Geographical Data. In: Gottlob, G., Grasso, G., Olteanu, D., Schallhart, C. (eds) Big Data. BNCOD 2013. Lecture Notes in Computer Science, vol 7968. Springer, Berlin, Heidelberg.

[20] Linda See, Ana-Maria Olteanu-Raimond & Cidália Costa Fonte (2025) Recent advances in Volunteered Geographic Information (VGI) and citizen sensing, International Journal of Digital Earth, 18:1, 2480220, DOI: 10.1080/17538947.2025.2480220

[21] Azariasgari, Elaheh, and Farhad Hosseinali. "Evaluating the VGI Users' Level of Expertise: An Application of Statistical and Artificial Neural Network Approaches." IJAGR vol.14, no.1 2023: pp.1-16. https://doi.org/10.4018/IJAGR.316770

jurisdictions with the greatest reliance on VGI data. The presence of these data gaps during a crisis can magnify pre-existing inequalities in disaster-prone jurisdictions with limited economic capacity. As well, incomplete demographic data (e.g., missing Indigenous community boundaries) can lead to misallocated resources, disproportionately impacting marginalized groups. Pre-crisis equity audits of datasets can identify and address such gaps.

Some VGI providers have designated teams for assisting with deployment of geospatial tools for crisis response and other community applications (e.g., Humanitarian OpenStreetMap Team). These teams can identify quality gaps and issue calls for volunteers to address them. For example, an article published to the Humanitarian Open Street Map website in May 2025 asked volunteer contributors to develop a comprehensive dataset of building footprints in Khartoum, Sudan to supplement satellite data collected by the European Space Agency[22]. This kind of oversight of VGI sources, including regular appraisal of gaps in needed data, can help to mitigate quality trade-offs.

1.43 Accessibility

Having readily accessible data is essential for crisis management and response efforts. Accessibility refers to the ease with which users can obtain and utilize data and metadata. Easily accessible data and metadata are typically identified using relevant labels, keywords, and tags, which make them electronically discoverable. They are available in commonly used data formats and software, and accessible through transparent or navigable processes. Accessibility involves minimizing barriers to access, including costs (both financial and privacy-related), intellectual property and licensing challenges.

During the crisis response phase, accessible data become particularly crucial for data users lacking direct access to geospatial tools. Establishing mechanisms to facilitate accessibility, whether through open data initiatives or specialized access, ensures that decision-makers, responders, and affected communities can access and utilize the data when required. Enhanced data access can also promote transparency by making crisis-related information publicly available, fostering trust among stakeholders and partners, and supporting monitoring and reporting efforts. According to the FAIR principles[23], accessible data provides users with clear instructions for retrieval, which may involve authentication and authorization processes. The aim is to promote transparency and clarity regarding access and reuse conditions. It is worth noting that adherence to FAIR principles does not necessarily imply openness; data can be FAIR aligned even if it is private or accessible only to limited practitioners (e.g., due to security concerns). In other words, the FAIR principles' definition of data accessibility can vary according to circumstances and therefore has utility in the crisis scenario.

[22] Humanitarian OpenStreetMap Team. "OpenStreetMap Contributors Needed to Map Khartoum Ahead of New Radar Satellite Imagery". (27 May 2025). https://www.hotosm.org/updates/openstreetmap-contributors-needed-to-map-khartoum-ahead-of-new-radar-satellite-imagery-2025/

[23] The 'FAIR Guiding Principles for scientific data management and stewardship' are guidelines for improving the Findability, Accessibility, Interoperability, and Reuse of digital assets, including geospatial data.
Wilkinson, M., Dumontier, M., Aalbersberg, I. *et al.* The FAIR Guiding Principles for scientific data management and stewardship. *Sci Data* **3**, 160018 (2016). https://doi.org/10.1038/sdata.2016.18

1.44 Privacy and Security

In some cases, responders may face pressures to make concessions on security principles to ensure timely access to critical data. Ideally, however, security measures adapt dynamically to context and changing circumstances. For instance, information reported by first responders must be securely integrated into the GIS infrastructure. In a crisis scenario, this presents possible trade-offs between ensuring timely and open data access on one hand and protecting security and privacy on the other. In some cases, responders may face trade-offs between validation and privacy. This is illustrated in the example of population data, which is commonly needed for crisis response. Validating population data is challenging due to confidentiality constraints that protect individual- and household-level information. Depending on the jurisdiction, accessing confidential data may require special permissions, which in turn carries implications for timeliness. Trade-offs between data accessibility and security may also occur during real-time crisis response. On one hand, granting citizens access to crisis data increases transparency and can foster trust in decision-making. On the other hand, increasing the scope of access also raises security and privacy considerations, with potential legal implications. Understanding these privacy and security trade-offs can inform policy and legal oversight of authoritative data used in crisis response, which is discussed in *Part II*.

Open-source data offered by private sector providers can be beneficial for users in resource-limited settings. It is important for users of private open-source data to remain aware of potential trade-offs and long-term implications, including the loss of control and data sovereignty[24], as well as increased dependency on third-party datasets.

Accessibility vs. Privacy and Security

Covid-19 tracing applications

During the Covid-19 pandemic, some governments developed opt-in cell phone applications that harnessed GPS-based surveillance and contact tracing to limit the spread of the virus. These applications, which prioritized the health of the broader population over individual privacy rights, provided responders in government health agencies with timely access to geospatial data, enabling real-time tracing that helped limit viral transmission[25].

Severe weather warnings

Many governments issue severe weather warnings and other alerts of potential threats (e.g., active shooter alerts) to mobile devices of at-risk populations based on geographic location. These types of

[24]According to the practice paper entitled The CARE Principles for Indigenous Data Governance, data sovereignty (or "Indigenous Data Sovereignty") refers to "an assertion of the rights and interests of Indigenous Peoples in relation to data about them, their territories, and their ways of life". Carroll, Stephanie Russo, Ibrahim Garba, Oscar L. Figueroa-Rodríguez, Jarita Holbrook, Raymond Lovett, Simeon Materechera, Mark Parsons, et al.. 2020. "The CARE Principles for Indigenous Data Governance". Data Science Journal 19 (1): 43. https://doi.org/10.5334/dsj-2020-043.

[25] Massari, A., D'Addosio, V., De Nicolò, V.C. and L'Abbate, S. (2024) Privacy Protection in COVID Data Tracking: Textual Analysis of the Literature. Applied Mathematics , 15, 235-255. https://doi.org/10.4236/am.2024.153013

alert systems weigh the more imminent threat to affected populations' safety against the typically less urgent and less severe threats to individuals' privacy and security.

Approaches like these ones, which place the good of the broader public ahead of individual rights, are heavily context-dependent and should be subjected to appropriate scrutiny throughout the policy cycle[26]. Where possible, measures should be taken to limit risks, including through anonymization or de-identification of location data[27]. When considering trade-offs to privacy and security during a crisis, decision makers can begin by consulting legislation in their jurisdiction(s) and its treatment of relevant rights and protections. Decision makers may also wish to consult laws outlining provisions for emergency response, including any relevant temporary authorizations that come into effect during extraordinary circumstances upon the meeting of a pre-defined threshold.

[26] UN-GGIM Working Group on Legal and Policy Frameworks. "Concept Paper on Geospatial Data for Public Good", 2024, https://ggim.un.org/meetings/GGIM-committee/14th-Session/documents/ConceptPaper-GeospatialDataForPublicGood-Final-Draft-25July2024.pdf

[27] Scholars have identified barriers to successful de-identification of geospatial data points. For further details, see Calacci, Dan & Berke, Alex & Larson, Kent & Alex, & Pentland,. (2019). The trade-off between the utility and risk of location data and implications for public good. *Computers and Society*, 10.48550/arXiv.1905.09350.

2. MINIMIZING TRADE-OFFS: LAWS, POLICIES, INSTITUTIONAL ARRANGEMENTS

The previous section highlighted data sources and providers implicated in crisis response and outlined trade-offs and challenges that users and decision-makers may encounter in obtaining or utilizing data in real time. This section will build on the previous one by outlining policy and legal considerations and instruments, in addition to institutional arrangements in the pre-crisis, response, and post-crisis phases, with the overarching goal of minimizing these trade-offs and promoting transparency in a manner that fosters trust between data producers/providers and users.

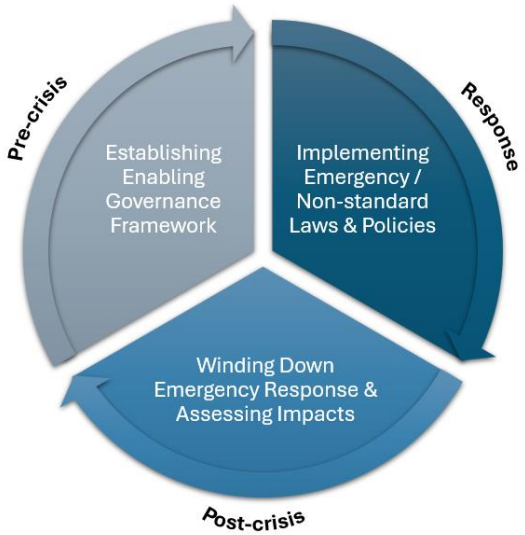

***Figure 2**. Phase of a crisis and corresponding authoritative data governance approaches.*

The authoritative data governance approaches corresponding to each crisis phases are illustrated in *Figure 2*. In the pre-crisis phase, law and policymakers have the opportunity to establish robust governance frameworks, including enabling policy and legal tools and institutional arrangements, in preparation for worst-case scenarios. An effective regulatory framework can help to minimize the trade-offs outlined in Part I, and includes provisions for intellectual property, data privacy and security, liability, legal interoperability, licensing, data quality and equity.

In the response phase, these pre-established enabling legal and policy tools and institutional arrangements are "put to work", facilitating access to data in real time. During this phase, it may be necessary to implement temporary emergency or non-standard[28] laws and policies to expedite data sharing and access. In these extraordinary circumstances, policy and lawmakers must be aware of new trade-offs that may be introduced by such measures, which can involve the temporary suspension of protections (e.g., privacy) to ensure seamless data access for crisis responders. As this section will note,

[28] Staronova, Katarina, Nina Lacková, and Matúš Sloboda. "Post-Crisis Emergency Legislation Consolidation: Regulatory Quality Principles for Good Times Only?" European Journal of Risk Regulation 15, no. 3 (2024): 637–55. https://doi.org/10.1017/err.2023.69.

it is important for law and policymakers to remain aware of potential risks that may be associated with this type of trade-off.

In the post-crisis phase, any temporary non-standard legal and policy measures introduced to facilitate an effective response that involve trade-offs in data characteristics should be reversed, with steps taken to restore the rule of law to baseline "pre-crisis" status where necessary. The post-crisis phase also affords policymakers an opportunity to conduct an impact assessment of the response efforts. This can include an appraisal of impacts to humans, re/sources and infrastructure, with demographic data providing insight into response outcomes the broader population as well as for marginalized groups. In this phase, policymakers can also take note of which laws and policies produced an enabling versus hindering effect on facilitating timely data access, and initiate any necessary adjustments.

2.1 Legal and Policy Considerations and Tools

The paragraphs below outline policy and legal considerations and tools for data users and producers across the three crisis phases. These legal and policy tools are aligned with the "control" end of the control-trust continuum (*Figure 1*) due to their formalization and government oversight. When established and implemented pre-crisis, robust governance tools and arrangements can help mitigate the trade-offs in data characteristics outlined in Part I. *Figure 3* illustrates the foremost policy and legal considerations in each crisis phase. As this section will discuss, several of these considerations (i.e., intellectual property, equity in disaster response, data privacy and security, licensing, and liability) remain relevant across all three crisis phases. Legal interoperability considerations, in contrast, are most notable in the pre-crisis and response phases, whereas considerations related to data quality assurance and VGI data are highlighted in the response and post-crisis phases. The diagram also highlights the importance of conducting an impact assessment of the fitness for purpose of data harnessed during a crisis and the resultant effectiveness of the response in the post-crisis phase, which will be discussed in Part IV of the paper.

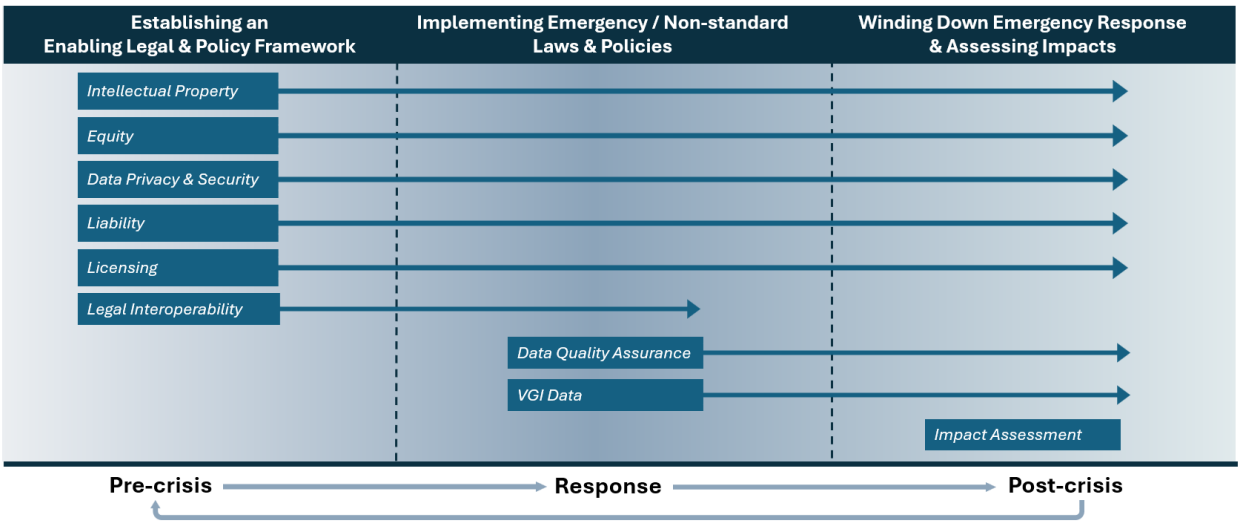

Figure 3. *Primary legal and policy considerations across the pre-crisis, response, and post-crisis phases.*

2.11 Data Privacy and Security

Data privacy and security are important considerations for producers and users of personal information and other sensitive critical data and information throughout all three crisis phases. Pre-crisis, legal and policy tools established through deliberative processes can go a long way toward ensuring data privacy and security standards are upheld during the more urgent response phase. The Concept Paper on Geospatial Data for Public Good[29] identifies that high levels of risk must be met with proportionate legal protection. For this reason, security and privacy are key and must be prioritized. When data is shared in the public interest, as is the case during the crisis response phase, some datasets may be kept public, while access to others may be limited or heavily protected. Laws and policies upholding privacy (e.g., regulations preventing the misuse of personal information[30]) must be reflected in the NSDI in order to effectively manage protected datasets.

As noted in Part I, during a crisis, data accessibility and timeliness are top of mind. In the interest of the public good, laws and policies must balance responders' need for data access with upholding the protection of individual privacy and data security[31]. Without legal protections in place, sensitive information such as building ownership or critical infrastructure could become publicly accessible. Given

[29] UN-GGIM Working Group on Legal and Policy Frameworks. "Concept Paper on Geospatial Data for Public Good", 2024, https://ggim.un.org/meetings/GGIM-committee/14th-Session/documents/ConceptPaper-GeospatialDataForPublicGood-Final-Draft-25July2024.pdf
[30] UN-GGIM Working Group on Legal and Policy Frameworks. "Legal Aspects of Availability of Geospatial Information – White Paper", 2020, https://ggim.un.org/meetings/GGIM-committee/10th-Session/documents/E-C.20-2020-32-Add_2-White-paper-legal-aspects.pdf
[31] UN-GGIM Working Group on Legal and Policy Frameworks. "Concept Paper on Geospatial Data for Public Good", 2024, https://ggim.un.org/meetings/GGIM-committee/14th-Session/documents/ConceptPaper-GeospatialDataForPublicGood-Final-Draft-25July2024.pdf

the number of people and organizations involved in crisis response, security measures must be taken to ensure that sensitive data is shared with users and applications on a need-to-know basis.

During the response phase, governments may determine that extraordinary circumstances call for temporary emergency or non-standard laws and policies to enable rapid data access[32]. In such cases, policymakers are advised to take steps to ensure that these measures are indeed necessary and proportionate to the risk that is posed. When risks are heightened, governments may see a need to suspend certain provisions in data privacy and security legislation in order to ensure seamless access for crisis responders. When these trade-offs are deemed necessary to facilitate access, it is critical that policymakers have a plan in place to dispose of personal data post-crisis. As well, users harnessing open-source data should be mindful of trade-offs in privacy or security of those implicated in the datasets. Crowdsourced data, for example, often lacks provisions for ensuring subjects' privacy and data security. In the event that crowdsourced data does include protections for privacy in their conditions of use, these terms are often difficult to enforce.

Post-crisis, policymakers ensure that any emergency measures or permissions granted to provide responders with necessary data are appropriately wound down, with privacy and security protections restored to pre-crisis baselines. As a check-and-balance on the use of limited and targeted legal provisions to facilitate data access, post-crisis impact evaluations can include an assessment of privacy and security effects of emergency measures for those implicated.

2.12 Intellectual Property

Intellectual property refers to the rights of creators to define the use of their original works using legal tools like patents, copyright and trade secrets. Spatial data holds significant value as intellectual property, which can incentivize producers to pursue exclusive rights. As some governments step away from the traditional role of data provider, they increasingly become end users subject to the same terms and conditions as non-state entities when accessing licensed data. Having an established, robust policy and legal framework in place pre-crisis can help resolve questions related to data ownership and intellectual property rights of both data providers and users of geospatial information that may arise during a crisis[33].

While patents must be applied for and granted by an authorizing agency, in geospatial domains, copyright is typically established automatically through the creation of original, creative assets. In other words, intellectual property rights may be enacted even without the knowledge of the creator. This can create complications for geospatial practitioners, who increasingly use data combined from a variety of sources. It is important to note that intellectual property rights associated with geospatial data tend to be weaker than those of other types of non-tangible assets (e.g., software). This is because copyright protection often does not apply to works lacking originality or amounting to "a simple compilation of facts", as non-creative works are often described in legal contexts. For this reason, more generic forms of

[32] 33rd International Conference of Data Protection and Privacy Commissioners *Resolution on Data Protection and Major Natural Disasters* (2011) calls for data protection and privacy laws that "a. limit the permissible purposes for disclosure of personal information held by organisations; but b. allow the disclosure of information in certain exceptional circumstances, although such exceptions are often narrowly drawn." 33rd International Conference of Data Protection and Privacy Commissioners. "*Resolution on Data Protection and Major Natural Disasters", 2011,* Mexico City.

[33] UN-GGIM Integrated Geospatial Information Framework. "Strategic Pathway 2: Policy and Legal", 2020, https://ggim.un.org/UN-IGIF/documents/SP2-Policy-and-Legal-23Feb2020-GLOBAL-CONSULTATION.pdf

geospatial data organized into datasets lacking originality (e.g., directories organized alphabetically) may be excluded from copyright protections[34].

Data produced by government is typically not subject to copyright, though its sharing may be limited due for other reasons (e.g., privacy and security, discussed in *2.11*). During a crisis, confusion among data providers and users about intellectual property rights can create artificial constraints on data sharing that limit access to critical data during the response phase. Among non-governmental data producers, uncertainty surrounding the application of intellectual property rights in geospatial contexts can have implications for licensing. For example, data producers may establish complex data licenses in an attempt to protect their intellectual property rights via contract rather than relying on legal protections granted automatically. To facilitate data access, it is necessary for data users and producers to understand the intellectual property provisions of any data that may be harnessed in the response phase.

Though intellectual property is governed at the national legal, as cross-border sharing becomes more common, the need for international coordination has grown. This has led to the establishment of international treaties addressing intellectual property considerations to facilitate transboundary data sharing[35], such as those administered by the World Intellectual Property Organization (WIPO). These kinds of transboundary agreements promote legal interoperability (*2.13*) and can facilitate data access when established in the pre-crisis phase.

Intellectual property laws may not adequately address Indigenous data and cultural knowledge,. The United Nations Declaration on the Rights of Indigenous Peoples (UNDRIP) affirms Indigenous data sovereignty through a broader understanding of knowledge and ownership, which is further supported by the CARE Principles for Indigenous Data Governance. These principles recognize that safeguarding Indigenous intellectual property requires alternative mechanisms tailored to Indigenous contexts. Governments can contribute to this effort by aligning their policies and practices with the CARE Principles, and working directly with communities to establish trust . Pathways to safeguarding Indigenous knowledge and interests might also involve the creation of an Intellectual Property Rights Agreement (IPRA) between Indigenous communities and data users or providers. In one example in Australia[36], the Yorta Yorta Nation Aboriginal Corporation and university researchers developed an IPRA and GIS Protocol, which included consultation at each project stage, retention of ownership and copyright for Indigenous knowledge, the right to maintain secrecy of cultural knowledge, ongoing access to and inspection of database contents, and control over future exploitation or use of data through approval processes and intellectual property agreements.

2.13 Licensing and Legal Interoperability

Licenses are contracts used to establish terms for the use of intellectual property assets including software and some kinds of geospatial databases. When organizations integrate data for the purpose of crisis response, they can face challenges related to the legal implications of merging assets with different

[34] Alexander, I., & Jankowska, M. (2018). Rights in geospatial information : a shifting legal terrain. Melbourne University Law Review, 41(3), 957–998. https://search.informit.org/doi/10.3316/agispt.20182435

[35] Pomfret, K.D. Geospatial Law, Policy and Ethics, Where Geospatial Technology is Taking the Law, Routledge, New York 2025.

[36] Eland, S., Lynch, A., Bischoff-Mattson, Z., Joachim, L. and Johnson, N.," All Strings Attached". *Geographical Research*, 52(2014), 296-308.

license terms. These challenges may be exacerbated by the use of artificial intelligence and machine learning, as legal frameworks fail to keep pace with rapid advancements in data transformation and integration technologies. Legal interoperability is thus a critical consideration for data providers and users compiling data for crisis response applications, defined as "a functional environment in which:

- differing use conditions imposed on datasets drawn from multiple disparate sources are readily determinable, typically through automated means, with confidence,
- use conditions imposed on datasets do not disallow creation of derivative products that incorporate data carrying different use conditions, and
- users may legally access and use the data of others without seeking permission on a case-by-case basis"[37].

Legal interoperability ensures that the legal rights, terms, and conditions of databases from multiple sources are compatible, allowing users to combine data without compromising the data sources' legal protection. Licenses, which establish permissions and conditions for the use of data protected by IP rights, play a crucial role in enabling legal interoperability by explicitly stating reuse rights for both machines and humans.

Achieving legal interoperability is often a lengthy and meticulous process. This is evident in global public health emergencies like COVID-19, where cross border sharing of critical data may be delayed in the absence of an enabling legal infrastructure. In the pre-crisis phase, international geospatial communities can improve legal interoperability by negotiating a common data governance structure, including treaties, shared policies, processes, and safeguards to ensure compliance with diverse legal requirements.

Licensing terms restricting or limiting the utilization and distribution of data by users can seriously impact legal interoperability in the response phase. [38] Combining public and private data sources involves navigating the complexities of different licensing agreements. While users of paid private data may avoid some privacy and security pitfalls, they must abide by limitations imposed by copyrights and licenses that restrict how the data is used, including potential restrictions on data replication or merging with external sources. During crisis response, restrictive licenses can impede users from gaining immediate access to key information. Given the ongoing need for interoperability or integration of multiple datasets during a crisis, incompatible proprietary systems or limiting terms and conditions can hinder the development of a comprehensive understanding of a situation. Combining, for example, an open license and restricted commercial license data may raise ambiguities about whether the combined data can be lawfully used and shared. When licensing agreements are violated, the rights holder may revoke access to geospatial data or initiate a lawsuit to recover compensation for lost business.

[37] Onsrud, Harlan. "Legal Interoperability in Support of Spatially Enabling Society." (2010). In Abbas Rajabifard, Abbas, Joep Crompvoets, Mohsen Kalantari, and Bas Kok, *Spatially Enabling Society: Research, Emerging Trends and Critical Assessment*, 163-172.

[38] See "Data Protection, Licensing, and Sharing" in the United Nations Integrated Geospatial Information Framework (UN-IGIF) Strategic Pathway 2: Policy and Legal.

To address licensing challenges, the UN-GGIM White Paper "Legal Aspects of Availability of Geospatial Information" suggests that a mapping agency, within its sphere of authority, can adjust licensing models. This can involve introducing regulations requiring data providers to support critical government functions in crisis scenarios[39]. Efforts to develop flexible licensing frameworks in the pre-crisis phase serve to enable real-time data sharing during the response. Jurisdictions may also introduce compulsory licensing for crisis management through regulatory amendments.

Open data licensing has gained traction over the years as a means of promoting data sharing and accessibility. Open data is an appealing cost-free option for users facing barriers to data access during the response phase. However, users of open data should note that many open data sources are still subject to licensing agreements. For example, datasets licensed under Creative Commons or Open Database License (ODbL) impose restrictions on data use, sharing and modification. Government users may find these terms of use limit their ability to integrate open data with their own data sources. Additionally, harnessing open license sources like Open Street Map for crisis response may require users of the tool to cede control of their data. For further discussion of the use of open data for crisis response, see section *2.16*.

2.14 Liability

The UN-GGIM Compendium on Licensing of Geospatial Information notes that in addition to granting rights from the licensor to the licensee, geospatial information license agreements are also used to allocate operational and legal risks between parties, known as "liability". Liability is defined as a responsibility "to pay or compensate for something by law, or to be otherwise legally responsible".[40] There are various sources of liabilities for geospatial practitioners, most of which relate to data quality. These include contractual liability, negligence, product liability and professional liability.[41] In crisis applications of geospatial data, it is important to consider the question of who will be held responsible in the event that someone is injured due to data misuse or mishandling that leads to poor data quality (e.g., inaccuracy, incompleteness) or a lack of timeliness.

Establishing liability fosters trust between users and producers because it entrenches a sense of responsibility for the data's fitness for purpose in the law. When weighing compromises in data characteristics that are sometimes necessary during the crisis response phase (raised in *Part I* of this paper), it is necessary to consider who may be liable if trade-offs lead to a poor outcome. Establishing liability is relatively simple in the context of Business to Business (B2B) or Business to Governments (B2G) relationships. These transactions are part of a typical supply chain or a well-established government procurement process. It can be more challenging to establish liability in Business to

[39] UN-GGIM Working Group on Legal and Policy Frameworks. "Legal Aspects of Availability of Geospatial Information – White Paper", 2020, https://ggim.un.org/meetings/GGIM-committee/10th-Session/documents/E-C.20-2020-32-Add_2-White-paper-legal-aspects.pdf

[40] UN-GGIM Working Group on Legal and Policy Frameworks "Compendium on Licensing of Geospatial Information", 2018, https://ggim.un.org/documents/E-C20-2018-9-Add_2-Compendium-on-Licensing-of-Geospatial-Information.pdf

[41] For details on these liabilities, how they can arise and appropriate mitigating measures, see Kevin D. Pomfret, Geospatial Law, Policy and Ethics, Where Geospatial Technology is Taking the Law, Routledge, New York 2025, pp.48-57.

Consumer (B2C) transactions chiefly conducted online, where new challenges emerge related to data security, order fulfillment, and fraud potential.

Geospatial commodities may be treated as a product or a service (or both), which has implications for liability[42]. Geospatial data treated as a product is most often subject to tort liability, while those viewed as services are more often subject to contract law liability or tort liability under a negligence framework. If a geospatial data producer and user enter into a contract, the data must meet a specified quality level. When data fails to meet the quality standard, the user may have grounds for a breach of contract claim. In cases where data is accessed without a contract (e.g., in the case of some publicly available or open data sources), users are left unprotected. Tort liability, in contrast, establishes duty between parties (e.g., the data user and producer) in the absence of a contract. Under a negligence framework, tort liability establishes a breach of duty between parties if it can be demonstrated that one party (i.e., the producer) has caused another party (i.e., the user) harm. Under a strict liability framework, only a breach of duty must be demonstrated; there is no requirement to demonstrate negligence. Both government and private producers may be held liable for data quality issues. It should be noted that data users are not immune to liability risks; they may be held liable in cases where erroneous or outdated information is knowingly used. This risk may be elevated in the high-stakes crisis response phase, when users harness whatever data is available data in the moment.

In the pre-crisis phase, governments can take steps to mitigate liability concerns for data producers and users. Legal and policy tools can be used to establish requirements for availability of geospatial data quality metrics. For example, data producers and providers can be required to ensure that spatial data is always supplied with accompanying detailed quality metrics. Such a requirement can also prevent data quality information from becoming decoupled from the data itself in the event that it is moved, modified or combined with other datasets. Additionally, in order to fulfill duty to warn of risks associated with using relevant datasets, producers can take steps in the pre-crisis phase to ensure responders have been sufficiently trained on the potential for error and margin of error, as relying on low quality data can lead to errors in decisions making. In cases where a warning is insufficient to mitigate risks of misuse, producers may wish to take steps to limit data availability, for example, restricting data sharing to experts and authorized parties. This should be reserved for situations in which the risk of data misuse outweighs the data's utility.

2.15 Data Quality Assurance

Data quality is often difficult to verify in the urgency of crisis response. Guidelines and standards for data quality are thus best established in the pre-crisis phase to ensure data fitness for purpose and to avoid liability concerns in the response phase. It is common to see quality requirements in domains in which authoritative data has a legal status. In domains without legally embedded quality standards for authoritative data, effective data quality assurance policies outline standards and procedures for

[42] Nicole C. Molner, "Negligence and Geospatial Data: A Fair Distribution of Liability Notes", *46 Fla. St. U. L. Rev. 457* (2022). https://ir.law.fsu.edu/lr/vol46/iss3/5

verifying accuracy, reliability, and timeliness of geospatial data to ensure its fitness for purpose[43]. The reliability of geospatial information hinges on the quality of available data. An absence of established standards and processes supporting quality assurance and control may lead to inconsistencies and inaccuracies in the data, which can adversely affect analyses, creating delays in time-sensitive response scenarios[44]. Inconsistent or absent data standards, and incompatible or poor data quality can also hamper inter-organisational geospatial data sharing.

Data quality approaches can be tailored to specific data types or organizational needs. Implementing a shared framework can strengthen data governance by establishing common standards, enhancing coherence in data quality policies and standards, enabling interdepartmental data sharing, and encouraging data use that is ethical and aligns with the data's predetermined purpose. Policies can also encourage user best practices to avoid misuse or mishandling of data (e.g., warnings are easily accessible, written in plain language).

Data users often look to governments to provide fit-for-purpose data, placing a high level of trust in its provenance. This trust in publicly provisioned data is borne out of an assumed professional competency and adherence to quality assurance procedures among public sector authorities, in addition to the lack of profit motive commonly associated with government actors. Space agencies, for example, tend to employ a high standard of verification and validation to products made available online. This verification by state-led agencies instills confidence that data they provide is of high quality and fit for purpose. Of course, governments are not the only organizations that employ quality assurance policies and procedures. Implementing transparent data quality assurance procedures can help organizations establish trust with data users, which in turn helps to mitigate trade-offs.

2.16 Open Data Sources

During the response phase, users may face barriers to accessing to necessary data in real time. These challenges can be magnified for users operating on tight budgets, where the added expense of acquiring proprietary data or layers can present financial challenges. In such cases, open data offers a low- or no-cost solution, with fewer restrictions from copyright or other mechanisms of control. Having real-time access to current geospatial information enables responders to rapidly assess the situation, identify affected areas, coordinate relief efforts, and allocate resources efficiently. Open data policies are widely recognized as a tool to foster government transparency and ensure accessibility. Pre-crisis, governments can compile a database of openly available resources in anticipation of future disasters, ensuring the data possesses the necessary characteristics that make it fit for crisis applications.

Community or crowd-sourced open databases like OpenStreetMap, while easily accessible and frequently updated, are not always subject to rigorous quality control processes, which can limit data

[43] Integrated Geospatial Information Framework (IGIF). "Strategic Pathway 4: Data", 2020, https://ggim.un.org/meetings/GGIM-committee/9th-Session/documents/IGIF_SP4-Data_FIRST_DRAFT.pdf#:~:text=This%20strategic%20pathway%20establishes%20a%20geospatial%20data%20framework,appropriate%20to%20ensure%20cross%20sector%20and%20multidisciplinary%20collaboration.

[44] A.H. Selmy, Salman, Dmitry E. Kucher, Yujian Yang, and Francisco Jesús García-Navarro, "Geospatial Data: Acquisition, Applications, and Challenges", *Exploring Remote Sensing - Methods and Applications*(2024), doi:10.5772/intechopen.1006635.

fitness for the purpose of crisis response[45]. It is important for responders harnessing open data including crowd-sourced data to be mindful of liability implications in the event that open data used during a crisis leads to a decision that causes harm. During the crisis phase, responders may have to move quickly to identify alternate data sources to fill critical data gaps, and may be unable to mitigate potential risks associated with using unverified data sources in real time. However, it is important to be aware of risks that may be associated with crowdsourced data, including higher margins of error[46]. Additionally, overreliance on open data may exclude populations with limited digital access (e.g., rural communities), exacerbating inequities.

To mitigate the above challenges, users can develop policies for open data use in the pre-crisis phase. For example, frameworks can be established to assess the risks associated with harnessing open data and to develop guidelines for addressing situations where less reliable or unverified open data sources are the only available datasets. Partnerships with local NGOs can help ground-truth and contextualize crowdsourced inputs. Users and producers can also work in tandem to proactively validate needed data for at-risk areas. Collaborations with community mappers with in-built validation protocols (e.g., as seen in Doctor's Without Borders Missing Maps Project discussed in *3.6*) can help to foster trust in the available data. When aiming to combine open data sources with other available data, users and providers can work collaboratively to confirm the compatibility of different licensing terms and work through any limitations they may impose. Post-crisis, the effectiveness and reliability of crowdsourced or VGI data harnessed during the response phase can be assessed, and policies can be adjusted or revised where necessary.

2.17 Equity in Disaster Response

When geospatial data does not accurately represent the demographic diversity of a given area, crisis may disproportionately impact marginalized populations. For example, scholars have observed that the mortality rate for women in natural disasters is significantly higher than that of men[47]. In addition to gender, scholars have found pre-crisis risk analyses that inform risk reduction policies fail to account for inequitable distribution of impacts across race, income level, age and physical ability [48]. Pre-crisis, policymakers can take steps to limit inequity in crisis impacts, including conducting risks assessment to identify vulnerable populations and establishing guidelines for the collection of demographic data to reduce disproportionate impacts of a crisis on marginalized groups. Users harnessing open data VGI sources during the crisis response phase may find that these platforms are able to be more adaptive and responsive to urgent equity considerations than government providers[49]. Post-crisis, when impact data disaggregated by gender, racial background, or income is not collected, data users are unable to track or

[45] OpenStreetMap Foundation, "Terms of Use", n.d., https://osmfoundation.org/wiki/Terms_of_Use
[46] Filip Biljecki, Yoong Shin Chow, Kay Lee, "Quality of crowdsourced geospatial building information: A global assessment of OpenStreetMap attributes", *Building and Environment*, Volume 237 (2023), https://doi.org/10.1016/j.buildenv.2023.110295.
[47] Rahiem, Maila D.H., et al. "Why Did so Many Women Die in the 2004 Aceh Tsunami? Child Survivor Accounts of the Disaster." International Journal of Disaster Risk Reduction, vol. 55, Mar. 2021, p. 102069
[48] Robert Soden, David Lallemant, Manveer Kalirai, Celine Liu, Dennis Wagenaar & Sophia Jit, "The importance of accounting for equity in disaster risk models", *Commun Earth Environ* 4, 386 (2023), https://doi.org/10.1038/s43247-023-01039-2
[49] Dr. Robert Soden (assistant professor, University of Toronto) in discussion with the author, February 2025.

assess the presence of inequities in response. Collecting demographic data alongside geospatial data can enable the assessment of trends in impacts across marginalized groups, the results of which can be applied to amend laws and policies to increase equity in responding to future crises. Both pre- and post-crisis, law and policymakers can work with individuals belonging to marginalized groups who have been impacted by crises to ensure their experiences are adequately reflected in data collection policies and practices.

Examples of Policies that can be Implemented Pre-crisis to Enable Timely Access to Fit-for-purpose Data

Member states are encouraged to establish operational policies that complement established legal frameworks. The types of policies that may be needed to facilitate access to fit-for-purpose data during a crisis are highly context-dependent. Examples that can be implemented pre-crisis to facilitate timely access during the response phase include:

- Frameworks for real-time validation of VGI sources
- Guidance targeted to specific types of crises and disasters (e.g., drawing from established UNDRR Hazard Information Profiles (HIPs))
- Guidelines supporting the implementation of pre-established frameworks (e.g., FAIR Principles, CARE principles), including pre-crisis equity audits
- Guidelines for post-crisis evaluations
- Minimum standards (e.g., for accuracy, completeness, date of last update) for characteristics of data harnessed for crisis response
- Data-sharing protocols to enhance coordination across organizations and jurisdictions
- Guidelines for integrating data from different domains (e.g., terrestrial, maritime, built, cadastral)
- Resource allocation and financing arrangements to meet technological needs
- Training for GIS coordination teams or points-of-contact for emergency response

2.2 Institutional Arrangements

A governance framework that encompasses institutional arrangements (including pro-active purchase of data from non-government entities) leverages needed fit-for-purpose data sources and providers and mitigates open data and private sector licensing challenges. Institutional arrangements can help increase accountability for all parties, thereby fostering trust between providers and users. These arrangements play a key role in resolving the trade-offs raised in *Part I*.

This section outlines relevant institutional arrangements that help to mitigate trade-offs in real-time crisis response while increasing transparency and trust in data sources. According to the United Nations Integrated Geospatial Information Framework (UN-IGIF) *Strategic Pathway 1: Governance and Institutions,* institutional arrangements are "the formal and informal cooperation structures that support and link public and private institutions and/or organizations to fulfill their mandate. They are used to establish the organizational, legal and productive frameworks to allow for the sustainable management of an entity".[50]

Institutional arrangements are central to ensuring that infrastructure and systems deliver fit-for-purpose data for crises when needed. The institutional arrangements described in this section are ideally supported by defined roles, mandates and responsibilities for government agencies, emergency management organizations, and other stakeholders involved in crisis response. They are best implemented alongside capacity building and training measures to enhance technical skills and competencies of personnel involved in data management and analysis, as well as ongoing monitoring and evaluation mechanisms that assess the performance of infrastructure and systems delivering fit-for-purpose data during crises. Institutional arrangements harnessed alongside adaptive management and learning processes can empower users to respond to evolving challenges and emerging threats.

To improve the effectiveness of crisis response, institutional arrangements are best established in the pre-crisis phase. If post-crisis impact assessments unearth gaps in the response phase not being addressed in the current governance system, governments can respond by establishing new institutional arrangements (as well as laws and policies) where needed. Depending on the level of formalization and oversight by government versus non-state entities, institutional arrangements tend to be positioned between the middle and "trust" endpoint of the control-trust continuum introduced in *Figure 1*. Part IV will explore the positioning of specific examples of institutional arrangements outlined below.

2.21 Collaborative Partnerships

In the crisis response phase, there is often a need to share data across borders, jurisdictions, organizations and sectors. Cross-border, cross-sectoral and inter-organization data sharing can be facilitated using agreements and protocols established in the pre-crisis phase to harmonize systems and enhance interoperability. During the response phase, geospatial data users lacking these types of enabling policy and legal tools may face challenges related to interoperability and accessibility when seeking high-quality, readily available data. To ensure value for users, policy and legal tools must reflect this need for alignment and cooperation across jurisdictions and sectors. This need is intensified by the rapid pace of advancement in geospatial technology and growing demand for authoritative data.

Ensuring the tools and technical expertise required for data management align with the above priorities may surpass the capabilities and resources of some governmental bodies. In these cases, bilateral and multilateral initiatives with other governments, and other institutional arrangements with private-sector entities, NGOs and Indigenous Communities offer a promising solution. These types of collaborations can also allow participants to share costs associated with acquiring and analyzing data.

[50] Integrated Geospatial Information Framework (UN-IGIF). "Strategic Pathway 1: Governance and Institutions", 2022, https://ggim.un.org/UN-IGIF/documents/SP1_Governance_and_Institutions_Refined.pdf

2.211 Interagency/Interorganizational Coordination:

Coordination mechanisms established pre-crisis can facilitate collaboration and information sharing among different government and non-government agencies, departments, and organizations responsible for crisis management during the response phase. Interagency task teams, coordination centers, and formalized partnerships enable stakeholders to work together seamlessly and leverage each other's expertise and resources, sometimes across borders. Strong pre-existing ties among teams and organizations can facilitate effective responses during acute situations while a history of collaboration establishes trust among collaborators who consistently demonstrate reliability through joint efforts. Willingness to collaborate, share information, and uphold shared standards are crucial for successful organizational collaboration.

To enhance collaboration, the Economic Commission for Latin America and the Caribbean (ECLAC) recommends creating a Geospatial Information Management (GIM) unit within the NSDI, supported by an inter-institutional working group and governed by an MOU.[51] ECLAC suggests that this approach supports collaboration between agencies and other stakeholders in the management of spatial data, while empowering geospatial agencies play a lead to role due to their custodianship of key data.

Multilateral state-led initiatives like INSPIRE, Copernicus Programme, International Charter: Space and Major Disasters and Sentinel Asia establish collaborative geospatial data delivery mechanisms. A similar cooperative framework between the United Nations and the European Commission, the Global Disaster Alert and Coordination System (GDACS), connects global disaster managers and information systems to bridge coordination gaps post-disasters and offers real-time access to web-based disaster information systems and coordination tools. These initiatives significantly contribute to emergency response damage assessment across various disaster risk management (DRM) cycles.

In addition, Public-Private partnerships involving private sectors and academia can accelerate GIM infrastructure development and can involve a range of business models and procurement arrangements. An advantage of public-private partnerships is that they afford governments an opportunity to negotiate mutually beneficial terms of use.

2.22 International Standards Collaboration

There are several organisations that develop standards for acquiring, implementing, maintaining and using geospatial information. At an international level, the Open Geospatial Consortium (OGC), the International Organization for Standardization (ISO) and the International Hydrographic Organisation (IHO) work in tandem with broader technology standards organisations to ensure interoperability. Ideally, adherence to standards is established in the pre-crisis phase, as aligning systems and datasets can be time- and resource-intensive.

[51] "Advancing geospatial information management for disaster risk management in the Caribbean", Studies and Perspectives series-ECLAC Subregional Headquarters for the Caribbean, No. 119 (LC/TS.2023/62-LC/CAR/TS.2023/5), Santiago, Economic Commission for Latin America and the Caribbean (ECLAC), 2023

Establishing standards for data formats, metadata, and APIs can facilitate seamless integration of geospatial data from diverse sources. Information exchange during crises can be hindered by the use of incompatible standards, formats, languages, and laws. Standards including interoperability criteria can address differences in concepts and meaning assigned to data by users and systems. Standards can be used to promote data accessibility in crisis scenarios. For example, the OGC Disaster pilot[52] harnessed spatial data sharing standards and online and cloud technologies to demonstrate how these approaches can facilitate collaboration among global stakeholders and provide access to necessary data across all disaster phases. As well, standards can help to minimize trade-offs faced in the crisis response phase (described in *Part I*). IHO's method to visualize the quality of bathymetric data, called the category zone of confidence (CATZOC)[53], provides a quick visual reference for data quality – a similar tool could be applied in crises scenarios to address some of the common data quality trade-offs. Further information about standards can be found in the 3rd Edition of the Guide to the Role of Standards in Geospatial Information Management (the "Standards Guide"), launched by OGC, ISO/TC 211 and IHO and endorsed by the UN-GGIM[54].

2.23 Validation Frameworks for VGI Sources

VGI sources, such as Humanitarian OpenStreetMap Team, and similar types of open-source crowdsourced datasets can be a saving grace for responders encountering critical data gaps that hinder real-time response efforts. VGI can provide rapid, barrier-free access to comprehensive and regularly updated data fit for the purpose of crisis response. This is particularly attractive to any users facing resource constraints and other barriers to acquiring necessary data in the moment. validation frameworks can be used to avoid potential trade-offs in quality of crowdsourced data. These frameworks can involve, for example, a comparison of VGI quality to that of other trusted datasets, the overlaying of VGI data onto aerial/satellite imagery, or the implementation of a rating of feedback system for expert user input on VGI contributions.[55] Pre-crisis, data providers can establish validation frameworks to improve quality metrics of data and to create synthesized maps with the potential to provide real-time data during the response phase. Because VGI data tends to be frequently updated, it can also be used in the post-crisis phase to revise maps to reflect changes brought on by a disaster[56]. It should be noted that the utility of validation frameworks often depends on the availability of equivalent reliable and authoritative data sources to conduct a quality assessment[57]. This can present a limitation for those relying on VGI sources to fill gaps in scarce or incomplete authoritative data sources.

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[52] Open Geospatial Consortium (OGC), "Disaster Pilot 2023". https://www.ogc.org/initiatives/ogcdp23/

[53] "International Hydrographic Organization (IHO), "Mariners' Guide to Accuracy of Depth Information in Electronic Navigational Charts (ENC)", 2020, https://iho.int/uploads/user/pubs/standards/S-67/S67%20Ed%201.0.0%20Mariners%20Guide%20to%20Accuracy%20of%20Depth%20Information%20in%20an%20ENC_EN.pd

[54] UN-GGIM, "UN-GGIM's Online Guide to the Role of Standards in Geospatial Information Management, Edition 3", 2022, https://standards.unggim.ogc.org/index.php

[55] UN-GGIM, "Strategic Framework on Geospatial Information and Services for Disasters 2016–2030", https://ggim.un.org/documents/UN-GGIM_Strategic_Framework_Disasters_final.pdf

[56] Edward Rollason, Louise J. Bracken, R. .J. Hardy, Andy R.G. Large, "The importance of volunteered geographic information for the validation of flood inundation models", *Journal of Hydrology,* Volume 562 (2018), 267-280

[57] Reza Hosseini, Daoqin Tong, Samsung Lim, Gunho Sohn, and Gyozo Gidófalvi, "A framework for performance analysis of OpenStreetMap data in navigation applications: the case of a well-developed road network in Australia", *Annals of GIS*, 1–18 (2025). https://doi.org/10.1080/19475683.2025.2468184

3. EXPLORING THE USER AND PRODUCER PERSPECTIVES THROUGH CASE STUDIES

This section includes four case studies detailing examples of policy and legal instruments or institutional arrangements that facilitate timely data access throughout a crisis. Three of the examples discussed here are multi-lateral and/or cross-sectoral endeavors, while the fourth provides a window into one country's approach to facilitating data access for flood events. Where relevant, the case studies highlight the distinctive data producer and user perspectives, as well as the crisis phase in which each instrument must be established.

3.1 International Charter: Space and Major Disasters

The International Charter: Space and Major Disasters is a government-led multi-lateral, non-binding collaborative institutional arrangement that facilitates access to critical geospatial data during a crisis, in addition to providing users with access to expert consultation. The Charter is a key provider of Earth-observation satellite data, supported via collaboration with experts, which delivers data products to aid crisis response efforts of relief organizations. There are currently 17 active charter members providing data sourced from 270 satellites in 35 constellations. Adhering to a principle of universal access, the Charter authorizes national disaster management agencies to be registered as authorized users, provided necessary criteria are met.

The Charter provides users with free and timely access to critical data resources during the response phase. Registered authorized users can "activate" the Charter by reporting a disaster using a portal that operates 24 hours a day, 7 days a week. Upon activation, users can receive satellite data, including analyzed disaster maps, in a matter of days or hours. Throughout a charter activation, users can access continuous satellite data, which provides insight into the ongoing crisis that could not be obtained at location. In addition to enabling the swift harnessing of satellites for disaster response applications including real-time imagery analysis, activation promotes international collaboration by connecting the sponsoring user to global experts and decision makers.

When signed onto in the pre-crisis phase, the charter acts as a tool to promote trust in the data being shared by formalizing the linkage between data users and providers. The resources provided by the Charter are most effectively harnessed against the backdrop of a pre-established national governance framework that defines institutional functions, activation criteria, and distribution mechanisms, with the technical capacities to interpret and use the data products. This framework is necessary to ensure that satellite data reaches the relevant response actors in a timely manner, avoiding bottlenecks, delays, or excessive dependence on a single institutional node.

3.2 ASEAN Leaders' Declaration on Disaster Health Management

Established pre-crisis, state-led multilateral agreements can be useful tools for overcoming legal interoperability challenges that disrupt data sharing and coordination between jurisdictions during a crisis. One example is the Association of Southeast Asian Nations (ASEAN) Leaders' Declaration on Disaster Health Management[58], which was signed on November 13th, 2017. The ASEAN includes Brunei Darussalam, the Kingdom of Cambodia, the Republic of Indonesia, the Lao People's Democratic Republic, Malaysia, the Republic of the Union of Myanmar, the Republic of the Philippines, the Republic of

[58] Association of Southeast Asian Nations, "Declaration on Disaster Health Management", 2017, https://asean.org/wp-content/uploads/2017/11/4.-ADOPTION_2017_ALD-on-DHM_Endorsed-13th-AHMM.pdf

Singapore, the Kingdom of Thailand, and the Socialist Republic of Viet Nam. Disaster health management refers to "regional cooperation and national capacity in preparedness for and response to health-related aspects of disasters, public health emergencies, and relevant crises."[59]

In broad terms, the Declaration strengthens coordination and collaboration among ASEAN sectoral bodies and partners, supports enhancing national and regional capacity for disaster health management, encourages public and private investment in disaster risk reduction, and mobilizes financial resources to address gaps in national response, among other provisions. It includes a commitment to facilitating data sharing by developing a national Standard Operating Procedures for an International Emergency Medical Team (I-EMT) as well as tools to enable smooth operation of the I-EMT, as well as a coordinating body, information management and logistic system.

The Declaration's Plan of Action (2019 – 2025)[60] focuses on promoting regional cooperation, information sharing, and capacity development for health emergencies and disaster response. The Plan identifies five priority areas, including integration of disaster health management frameworks into national and regional legal and regulatory frameworks, strengthening regional collaborative frameworks, encouraging multi-sectoral participation in disaster health management, promoting investment in health infrastructure, and knowledge management for disaster health management. The Plan also establishes a Regional Coordination Committee on Disaster Health Management to operationalize these priorities.

The ASEAN Leaders' Declaration enshrines accountability into a formalized agreement, helping to establish trust among users and producers that the shared data can be effectively harnessed to support sound decision making during a crisis. Because multilateral tools that facilitate data sharing like the Declaration take time to negotiate and ratify, they are best established in the pre-crisis phase.

3.3 Humanitarian Data Exchange (HDX)

The Humanitarian Data Exchange (HDX) is an open-source platform established in 2014 to facilitate humanitarian data sharing between data producers and users during crisis events. The exchange is overseen by United Nations Office for the Coordination of Humanitarian Affairs (OCHA) Centre for Humanitarian Data and aims to facilitate collaboration between humanitarian actors to promote effective crisis response. The initiative is multilateral and includes formal and informal organizations from governments, the private sector and civil society. To date, HDX datasets have been accessed by users in more than 250 countries and territories. The HDX identifies three types of "humanitarian data" that can be exchanged via their portal: 1) data that describes the context in which a crisis is taking place, including baseline data, impact assessments, and geospatial data; 2) data that describes those affected by the crisis and their needs; 3) data that captures the crisis response from organisations and others seeking to help those who are affected.

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[59] Shuichi Ikeda and Nurfirda Mahni, "Enhancing Disaster Health Management Capacity in ASEAN", *ASEAN magazine,* Issue 29, September 2023, https://theaseanmagazine.asean.org/article/enhancing-disaster-health-management-capacity-in-asean/#:~:text=Disaster%20health%20management%20%28DHM%29%20has%20emerged%20as%20a,of%20disasters%2C%20public%20health%20emergencies%2C%20and%20relevant%20crises

[60] ASEAN. "Plan Of Action to Implement the ASEAN Leaders' Declaration on Disaster Health Management (2019-2025)", 14th ASEAN Health Ministers Meeting (AHMM), 2019, https://asean.org/wp-content/uploads/Plan-of-Action-to-Implement-ALD-on-DHM-2019-2025.pdf

HDX demonstrates how curated open data repositories, combined with quality assurance protocols, can provide reliable crisis data while maintaining accessibility. The platform only permits data sharing through verified organizations[61], a category which includes both legal entities and informal groups. Data sharing through the exchange may be conducted publicly, privately or by request. Public data is accessible to all HDX users, with licensing considerations in mind. Private data is data shared within organizations, with access controlled by those organizations' appointed administrators within the system. Data shared by request only is provided to registered HDX users approved by the provider organization. The exchange requires that data designated as sensitive is shared via secure channels. As well, HDX has established a rigorous system for ensuring data quality[62], reviewing each dataset manually to assess relevance, timeliness, interpretability and comparability features. HDX's manual review includes cross-checking metadata against ISO 19115 standards and flagging datasets with incomplete provenance.

Curated open-source platforms like HDX can help fill critical gaps by providing access to timely, validated and secure data during the response phase. Users should note, however, that HDX's reliance on digital access can exclude local actors with limited connectivity. At-risk jurisdictions are advised to assess data needs in the pre-crisis phase so that they may plan around these potential limitations.

3.4 Flood Mapping in Canada

Flood mapping is primarily a sub-national (i.e., provincial/territorial) responsibility in Canada. The federal government plays an important role as well, providing access to foundational datasets and real-time maps of floods and river ice break-up with critical information for emergency response, developing new tools, analytical methods, and applications related to flood mapping, in addition to collaborating with the flood mapping community to advance flood hazard mapping.

As part of these efforts, Natural Resources Canada (NRCan), which houses the country's national mapping authority, has published a Federal Flood Mapping Guidelines Series. The series encompasses a range of standards including a land use guide for flood risk areas, geomatics guidelines for flood mapping and an Indigenous engagement guideline. As well, working in tandem with regional governments, the federal government has developed a Flood Hazard Identification and Mapping Program, which aims to create accessible flood hazard maps of high risk areas across the country. These maps enable emergency planning by informing the development of evacuation routes, as well as aiding land use planning by identifying locations for building critical infrastructure and flood mitigation structures including dikes. The program also includes funding for implementation of regional modelling facilitated through MOUs.

During a flood event, the national mapping authority is responsible for providing authoritative monitoring, forecasting, notification, and/or scientific and technical information and advice to data users and responders, including federal, regional, and municipal government actors and Indigenous agencies. As well, the national mapping authority provides technical foundational geospatial data, including

[61] The HDX "verifies all organisations to ensure they are trusted and have relevant data to share with the HDX user community." United Nations Office for the Coordination of Humanitarian Affairs (OCHA) Centre for Humanitarian Data, "Frequently Asked Questions", n.d., https://data.humdata.org/faq

[62] United Nations Office for the Coordination of Humanitarian Affairs (OCHA) Centre for Humanitarian Data, "HDX Quality Assurance Checklist", n.d., https://data.humdata.org/dataset/2048a947-5714-4220-905b-e662cbcd14c8/resource/658d5c4f-1680-4cb5-9fbf-10a0a64e2c39/download/hdx-qa-checklist.pdf

remote sensing imagery. During ice break-up and flooding events, Emergency Geomatics Services (EGS) provides critical data to government users and responders in real time, available to the public on Open Maps and GEO.ca, a platform that coordinates and curates authoritative geospatial data and content from federal, provincial and territorial sources, including data related to flood mapping. These responsibilities are outlined in the *Emergency Management Act*, the *Department of Natural Resources Act* and the *Resources and Technical Surveys Act*.

In Canada, it is common for Indigenous communities and organizations to conduct their own flood mapping and emergency management efforts. The Canadian government recognizes Indigenous data sovereignty, and continues to engage with Indigenous communities, for example, through funded studies exploring the integration of traditional knowledge into flood mapping.

3.5 Caribbean Disaster Emergency Management Agency (CDEMA)

Established in 1991, the Caribbean Disaster Emergency Management Agency (CDEMA) is an inter-governmental agency for disaster management representing 20 participating states in the Caribbean region[63]. The Agency espouses the principles and practice of Comprehensive Disaster Management (CDM), which takes an integrated and proactive approach to crisis response. CDEMA aims to minimize the risks associated with disasters, including natural and technological crises in addition to climate-related events, with a view to promoting regional sustainable development. The agency plays a key role as a data provider for participating states during crises, a role which is exercised via the Caribbean Risk Information System (CRIS). CRIS a virtual platform providing stakeholders with access to risk management data for analysis and research, as well as promoting awareness of risk management and climate change adaptation in the region. The platform is comprised of three components (GeoCRIS, Virtual Library and Databases) offering information products targeted to CDEMA's 19 participating states. GeoCRIS is the platform's geospatial database component, which grants users access to geospatial data needed for risk and hazard mapping, in addition to supporting disaster preparedness and response operations. Data from the World Bank Caribbean Handbook on Risk Information Management (CHaRIM) is integrated into the GeoCRIS database to support empirical decision making.

The CDEMA's emphasis of disaster preparedness means it is best suited for implementation in the pre-crisis phase. This emphasis is evident in CDEMA's active projects targeting the pre-crisis stage, such as the Early Warning Systems (EWS) Project, which aims to bolster integrated early warning systems for disaster risk reduction in the Caribbean region via collaboration with United Nations Development Program (UNDP) and the International Federation of the Red Cross and the Red Crescent (IFRC).

3.6 Missing Maps Project: Doctors Without Borders Collaboration

The Missing Maps project is a non-governmental multilateral initiative. It is an open collaboration including Doctors Without Borders, the American Red Cross, British Red Cross, and the Humanitarian OpenStreetMap Team (HOT). The project invites volunteers to map regions at heightened risk of natural disasters, conflicts and epidemics, aiming to improve crisis preparedness and response efforts. These

[63] CDEMA current includes Anguilla, Antigua and Barbuda, Cayman Islands, Commonwealth of the Bahamas, Barbados, Belize, Commonwealth of Dominica, Grenada, Republic of Guyana, Haiti, Jamaica, Montserrat, St. Kitts & Nevis, Saint Lucia, St. Maarten, St. Vincent & the Grenadines, Suriname, Republic of Trinidad & Tobago, Turks & Caicos Islands and the Virgin Islands. Caribbean Disaster Emergency Management Agency (CDEMA).n.d. "About Us: Who We Are." https://www.cdema.org/index.php/about

volunteers work remotely to capture satellite imagery using OpenStreetMap. This data is supplemented by community members who conduct field mapping, incorporating additional details to reflect regional priorities and contexts. Once the maps have been validated to a standard specified by the tasking manager[64], humanitarian organizations use them for risk reduction and crisis response purposes.

A recent investigation[65] explored the perspectives of OpenStreetMap users and producers involved in humanitarian mapping efforts. The results unearthed a communication gap between data users and producers; while users emphasized the important role of local data, noting in particular their need for complete building and road data for affected areas, producers identified the date that datasets were last edited as the most impactful quality marker. Both users and producers agreed on the need for data validation, though producers emphasized that in order to validate maps, they require an understanding of the data's intended use, the local context and user needs. These findings illustrate the role of collaborative initiatives like the missing maps project in establishing linkages between users and producers of VGI resources to increase alignment between data provided by volunteers and data that is needed for crisis response.

[64] Missing Maps. (n.d.). "How to Validate Mapping". https://www.missingmaps.org/assets/downloads/Validating_Data_EN.pdf

[65] Scholz C, Jaime C, Raju E, Coughlan De Perez E and van Aalst M (2024) Off the grid: Utilizing OpenStreetMap for early warning and early action in conflict settings in Sudan. Front. Clim. 6:1439940. doi: 10.3389/fclim.2024.1439940

4. GUIDANCE FOR DECISION MAKERS, PROVIDERS, AND USERS

4.1 Revisiting the Control-Trust Continuum

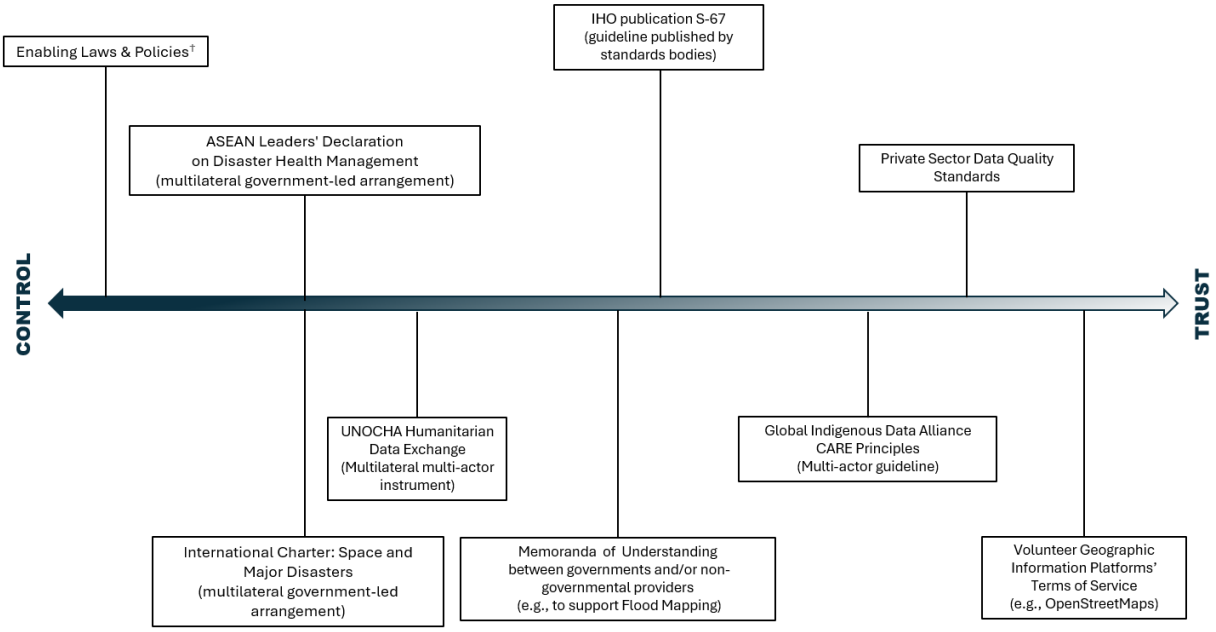
State and non-state data producers and users can act pre-crisis to effectively mitigate trade-offs in data characteristics. Governments can implement policy and legal tools to address key considerations and bilateral and multilateral institutional arrangements as needed to mitigate or limit trade-offs, including those related to timeliness, accessibility and quality characteristics. Achieving public policy goals, including effective crisis response, is at the forefront of government mandates and activities. While non-state data users and providers often have goals beyond general public interest ones (e.g., fiduciary duty of private sector providers to prioritize value creation for shareholders), they are among an array of stakeholders needed to execute an effective crisis response.

Figure 4 presents a modified version of the control-trust continuum, first seen in the UN-GGIM paper "Authoritative Data in an Evolving Geospatial Landscape: An Exploration of Policy and Legal Challenges". The continuum is a representation of the range of public sector, private sector, civil society and multilateral governance instruments that can be established in the pre-crisis phase to facilitate access to fit-for-purpose data. It is not intended to be used as a diagnostic tool. Member states are best positioned to identify instruments suited to addressing their unique national contexts and crisis risks. They are most equipped to develop and implement legal and policy tools as well as institutional arrangements that meet their particular data needs in planning for and responding to crises.

The continuum below is adapted to illustrate the placement of selected examples of policy and legal tools and institutional arrangements discussed in *Part II* and case studies presented in *Part III* between the endpoints of "control" and "trust". Instruments positioned towards the "control" endpoint follow a more conventional governance approach, are typically state-led and tend to be more legally binding in nature. Initiatives positioned toward the "trust" endpoint are less tightly controlled, with more voluntary participation and/or compliance. In *Figure 4*, the enabling laws and policies outlined in *2.1*, following a state-led, conventional governance approach, are located closest to the "control" end of the continuum. The formalized multilateral institutional arrangements outlined in *Part III* (*International Charter: Space and Major Disasters*, and *ASEAN Leaders' Declaration on Disaster Health Management* and UNOCHA Humanitarian Data Exchange), are positioned slightly to the right of the enabling laws and policies due to their less binding nature and/or involvement of non-state entities. In *Figure 4*, we can see some examples of the more informal institutional arrangements discussed in *2.2* (VGI terms of service, private sector quality standards, and CARE Principles of Indigenous Data Governance) positioned closest to the "trust" end of the spectrum. Two of the instruments are positioned closer to the centre of the continuum, MOUs facilitating flood mapping collaboration (discussed in the Canadian flood mapping case study in *Part III*) and the guidelines developed by standards bodies (e.g., IHO Publication S-67) due to possessing traits that align with both ends of the continuum (i.e., more formalized but non-binding or voluntary in nature).

In crisis applications of authoritative data, economic, political and legal contexts may influence the combination of instruments used to facilitate data access. For example, in resource-constrained countries with less robust or reliable public authoritative data sources, responders may rely on external sources with access facilitated via institutional arrangements (e.g., UNOCHA Humanitarian Data Exchange). Alternatively, private or civil society providers positioned closer to the "trust" end of the continuum may emerge to fill data gaps. In such cases, an increased reliance on low-cost or free sources

like OpenStreetMaps may be necessary. As noted in *Part I*, regions at greater risk of experiencing crises are often underrepresented in VGI sources. It may thus be necessary to supplement VGI data with secondary sources to improve response outcomes. Validation of VGI sources may also be accomplished via collaboration of government responders with non-governmental organizations, as seen in the Missing Maps project.



† "Enabling laws and policies" encompasses the range of policy and legal tools outlined in Part 2 of the paper.

Figure 4. *Control versus trust continuum of authoritative data governance instruments for crisis applications.*

The current paper discusses trade-offs on characteristics that users may face obtaining fit-for-purpose data in real time crisis response scenarios. These types of involuntary trade-offs can erode trust between data users and providers. Trust is a cornerstone of reliable data management, crucial for fostering relationships between public, private and civil society entities, and spanning international borders.[66] Establishing a strong underpinning governance framework in the pre-crisis phase can help mitigate the need for compromises in data characteristics, while supporting transparency and establishing the pre-conditions for trust between data users and providers.

The time sensitive nature of crisis response means that absent clear and transparent legal, policy, and institutional guidance, data users are left to react to quality, accessibility, privacy and security issues as they arise. They may face difficult decisions including potential compromises in the characteristics of data used to execute a response. As emphasized in *Part II* of the paper, establishing policy and legal tools and institutional arrangements in the pre-crisis phase can help responders mitigate or avoid these types of trade-offs. Robust legal and policy tools form part of a data governance system including an array

[66] Opinion of the European Economic and Social Committee on the 'Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions — Building a European Data Economy' (COM(2017) 9 final) (2017/C 345/22)

of instruments (depicted in *Figure 4*) that establish trust as a pre-condition for authoritativeness of geospatial data harnessed for crisis response applications. Operating with the support of enabling laws, policies and institutional arrangements, providers and users are able to meet the demands of a crisis, while limiting trade-offs in characteristics of critical data resources.

4.2 Guidance for Data Providers and Users

The checklist below (*Table 1*) offers general guidance for data providers and users (including responders) seeking direction on governance considerations for authoritative data in crisis applications. The guidelines can be adapted where necessary to align with national circumstances. The list builds on and can be used in combination with the "Guidelines for Effective Authoritative Data Governance" presented in the UN-GGIM paper "Authoritative Data in an Evolving Geospatial Landscape: An Exploration of Policy and Legal Challenges". While most of checklist items apply to non-state as well as state-led data user and provider agencies, some of the guidance is necessarily directed at governments due to its focus on legal/policy and state-led bilateral/multilateral tools and considerations.

Table 1. *Checklist for data providers and users on governance considerations for authoritative data in the pre-crisis, response and post-crisis phases.*

a. Precrisis	
Understanding Data Sources and Providers	✓ Have potential sources and providers of authoritative data during a crisis been identified? ✓ Which of the following categories do providers fall into? – Government departments or agencies (national/regional/local) – Bilateral/multilateral organizations or instruments – Private Sector members – Civil society / non-governmental organizations – Volunteer Geographic Information (VGI)
Minimizing Trade-offs in Data Characteristics	✓ Have data characteristics that make the data fit for the purpose of responding to a crisis been identified? ✓ *Accessibility and Timeliness:* – Have potential barriers to responders' timely access of fit for purpose data during a crisis been identified? – What steps have been taken to eliminate or mitigate these barriers? – In the event that a dataset becomes unavailable or is deemed unfit during the response phase, are alternate sources available? ✓ *Quality:* – What quality metrics are being used to assess the data? E.g., accuracy, completeness, validity – What steps are in place to ensure data is collected and maintained at the necessary quality level? – Under what circumstances are trade-offs in data quality permitted during crisis response? – Are quality assurance programs and tools currently in place or do they need to be established?

	✓ *Privacy and Security:* – What are the security and privacy considerations for the identified datasets? – Under what circumstances are trade-offs in data privacy and security permitted during crisis response?
Legal and Policy Considerations	✓ *Data Privacy and security*: – Do laws and policies effectively balance responders' need for data access with the protection of individual privacy and data security? – What security measures are in place to ensure that sharing of sensitive information is conducted on a need-to-know basis? – Do legal and policy provisions exist to grant users access to sensitive data as needed in emergency circumstances? – What checks and balances exist to prevent or limit abuse of enabling emergency provisions? ✓ *Intellectual property:* – How do existing intellectual property laws define geospatial data ownership? – How do intellectual property laws and regulations apply to datasets identified for use during crisis response? ✓ *Licensing and legal interoperability:* – Have mechanisms for cross-border sharing been established (e.g., a common data governance structure)? – Do licensing models require data providers to support critical government functions in crisis scenarios? – If open data is included among the datasets identified for crisis response applications, do the licenses impose restrictions on data use, sharing and modification? ▪ Does the open data license permit integration with other sources? ✓ *Liability:* – Have potential sources of liability for data producers/providers and users (including responders) been identified? – Have legal and policy tools been established to limit liability for data providers and users? E.g., requirements for availability of geospatial data quality metrics – Has a duty to warn of potential risks been established? – Have responders received training on potential for error and margin of error? – In cases where associated risks cannot be mitigated, have steps been taken to limit data availability? ✓ *Demographic Data:* – Is there an existing policy requiring collection of demographic data alongside geospatial data used for crisis response? – If such a policy does exist, does the demographic data being collected reflect the diversity of populations inhabiting the jurisdiction(s) in question?

	– Are the following categories included in demographic data linked to geospatial data? ▪ Gender ▪ Race ▪ Age ▪ Income ▪ Disability
Institutional Arrangements	✓ *Collaborative Partnerships (Inter-agency coordination):* – Are existing agreements and protocols established to facilitate cross-border, cross-sectoral and inter-organizational data sharing being effectively harnessed? – Can interagency or interorganizational partnerships be used to address data gaps? – What other opportunities exist to facilitate collaboration and information sharing among different governmental and non-governmental agencies, departments, and organizations responsible for crisis management? ✓ *International standards collaboration:* – Have relevant international standards for collecting, implementing, maintaining and using geospatial data been identified and implemented? – If relevant standards are in place, is adherence being tracked/maintained? ✓ *Validation Frameworks for VGI Sources:* – Are validation frameworks being used to limit potential trade-offs in quality of VGI data?
b. Response	
Considerations for Users (including Responders)	✓ Are available fit for purpose data sources being successfully harnessed? ✓ Has a protocol been developed for overcoming unexpected barriers to data accessibility? ✓ If critical data gaps emerge in real-time, are steps being taken to minimize trade-offs in data characteristics when seeking alternate data sources? ✓ Do users have a framework for identifying alternative fit for purpose datasets when gaps in needed data emerge? ✓ Do alternate data sources meet an acceptable quality standard to facilitate real-time crisis response? ✓ Are all available real-time data quality assurance tools being leveraged? ✓ Are responders aware of any deficiencies in the quality of datasets they are using? Do they understand the margins of error and associated risks? ✓ Where applicable, are users adhering to intellectual property standards and licensing agreements (e.g., Terms and Conditions of Use)
Considerations for Providers	✓ Are data providers available to offer technical support and guidance to responders as needed?

	✓ Where applicable, are providers adhering to agreed upon terms for providing data that is timely, up-to-date, and adheres to established quality standards? ✓ For government providers only: Have the legal criteria to activate emergency response measures granting special access to sensitive or protected data been met?
c. Post-crisis	
Winding Down Emergency Measures	✓ Have emergency law and policy measures introduced or activated during the crisis been appropriately wound down? ✓ Have rights, privileges or protections that were suspended to facilitate data access during crisis response been restored? – E.g., If security and privacy protections were temporarily suspended to enable limited and targeted access to critical data under emergency conditions, have these measures since been restored? ✓ Have law and policymaking procedures and processes returned to baseline? ✓ Has normal order and rule of law been restored, with standard levels of regulatory oversight and checks and balances reinstated?
Reviewing Lessons Learned	✓ Is there an established procedure for conducting impact assessments post-crisis, including a review of authoritative data resources? ✓ Did data providers and users adhere to applicable laws, regulations and policies in their handling of critical authoritative data harnessed for crisis response? ✓ Did government providers and users fulfill their established roles and obligations during the response phase? ✓ Did responders face barriers to accessing critical data during the response phase? How can gaps in data access be mitigated in future crises? ✓ Did responders make any trade-offs in data characteristics during the response phase due to data availability/timeliness? If so, what was the nature of these trade-offs, and how can they be avoided or mitigated in future crises?

4.3 Additional Considerations

Table 2 highlights some additional considerations for practitioners to help determine whether data can be lawfully harnessed for crisis response purposes. The checklist draws from the policy and legal considerations outlined in *Part II*, and includes prompts to assess potential privacy and security, liability and licensing issues. The list should not be viewed as exhaustive; data providers and/or users who lack clear responses to the questions outlined in *Table 2* or who have additional questions should consult with legal experts. Ideally, the questions should be addressed pre-crisis before data needs become urgent, though they may also be relevant during the response phase.

Table 2. *Checklist with additional policy and legal considerations to assess whether datasets can be harnessed for the purpose of responding to a crisis.*

Can the data be harnessed for crisis response applications?
✓ Is the data sensitive? – If so, do laws and/or policies limit the sharing of this data? ✓ Is the dataset limited in any way that could hinder its effective use for crisis response? – If so, are these flaws clearly noted in the metadata? E.g., accuracy, completeness – Are the limitations described in clear, non-technical language? ✓ Are you authorized to share the data? – Is the data licensed? – If so, are you able to locate the licensing terms in the metadata? – Do the licensing terms impose limits on your sharing of the data with crisis responders?

CONCLUSION

When sourcing data during a crisis, users are asked to rapidly assess their needs while determining which producers or providers are best suited to meeting them. At the same time, are also asked to assess the presence of desired data characteristics for the event in question while contending with often complex legal and policy considerations, including intellectual property rights, licensing, privacy and security, among other concerns.

In Part I, we established that in the absence of robust, enabling legal and policy tools and supporting institutional arrangements, users may face some avoidable compromises in the characteristics used to determine a dataset's fitness for crisis response applications. *Part II* of the paper highlighted that in the pre-crisis phase, governments can take steps to lessen the burden for data users and responders during a crisis, by building a solid foundation of legal and policy tools and engaging in bilateral and multilateral institutional arrangements that address key considerations. The value of having pre-established systems in place pre-crisis is evident in the case studies outlined in *Part III*, all of which require forethought for planning, implementation or engagement. *Part IV* of the paper introduces an adapted version of the control-trust continuum, which arranges examples of policy and legal tools and institutional arrangements discussed in the paper between the endpoints of "control" and "trust". The "control" endpoint corresponds to more conventional, state-centric and binding instruments, while the "trust" endpoint aligns with less binding and less tightly-regulated initiatives with little to no state involvement. As well, it establishes trust as a pre-condition or principle underpinning the authoritativeness of geospatial data harnessed for crisis response applications established through data governance. When governments establish transparent and effective laws, policies and institutional arrangements pre-crisis, they are better equipped to address the needs of data providers and users during the response phase and limit the trade-offs between characteristics of critical data resources. The paper concludes with guidance for data users and providers on governance considerations for authoritative data in crisis applications.

A global consultation on an earlier draft of this paper generated a breadth of feedback from Member States and other stakeholders. Some of these comments, while relevant to the mandate of the UN-GGIM Working Group on Policy and Legal Frameworks for Geospatial Information Management, were ultimately determined to be out of scope for this particular document. Drawing from this valued feedback, future activities of the working group may wish to explore policy and legal tools for addressing biases in datasets (e.g., underrepresentation of rural/Indigenous areas) harnessed for crisis response, inclusive governance approaches with specific recommendations for protecting marginalized groups' data rights and access, policy and legal implications of using artificial intelligence and machine learning to address trade-offs in data characteristics during a crisis.

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