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Data interoperability for disaster risk reduction in Europe

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Abstract

Purpose – The purpose of this paper is to discuss how, despite increasing data availability from a wide range of sources unlocks unprecedented opportunities for disaster risk reduction, data interoperability remains a challenge due to a number of barriers. As a first step to enhancing data interoperability for disaster risk reduction is to identify major barriers, this paper presents a case study on data interoperability in disaster risk reduction in Europe, linking current barriers to the regional initiative of the European Science and Technology Advisory Group.

Design/methodology/approach – In support of Priority 2 ("Strengthening disaster risk governance to manage disaster risk") of the Sendai Framework and SDG17 ("Partnerships for the goals"), this paper presents a case study on barriers to data interoperability in Europe based on a series of reviews, surveys and interviews with National Sendai Focal Points and stakeholders in science and research, governmental agencies, non-governmental organizations and industry.

Findings – For a number of European countries, there remains a clear imbalance between long-term disaster risk reduction and short-term preparation and the dominant role of emergency relief, response and recovery, pointing to the potential of investments in *ex ante* measures with better inclusion and exploitation of data.

Originality/value – Modern society is facing a digital revolution. As highlighted by the International Council of Science and the Committee on Data for Science and Technology, digital technology offers profound opportunities for science to discover unsuspected patterns and relationships in nature and society, on scales from the molecular to the cosmic, from local health systems to global sustainability. It has created the potential for disciplines of science to synergize into a holistic understanding of the complex challenges currently confronting humanity; the Sustainable Development Goals are a direct reflectance of this.

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Interdisciplinary is obtained with integration of data across relevant disciplines. However, a barrier to realization and exploitation of this potential arises from the incompatible data standards and nomenclatures used in different disciplines. Although the problem has been addressed by several initiatives, the following challenge still remains: to make online data integration a routine.

Keywords Disaster risk management, Interoperability, Digital revolution, Data, Regional platforms, Science–policy interface

Paper type Research paper

1. Introduction

Increasing data availability from satellites, radars, airborne or ground-stationed sensors, demographic registries and digital footprints along with a wide range of outputs from model simulations unlocks unprecedented opportunities in disaster risk management. Forecasting systems with sufficient lead-time allow for prevention and preparedness measures; continuous monitoring, data assimilation and model state-updating enhance real-time control and operational risk management; and remote sensing products can be used to efficiently direct response and recovery efforts to areas most in need. However, data interoperability remains a challenge due to a number of barriers that preclude exploitation of available data for disaster risk reduction before, during or after a hazard has materialized into a disaster. As goes unsaid, there is potential for higher efficiency and effectiveness of risk reducing measures and management strategies if barriers to data interoperability are overcome; a first step to achieving this is identifying the most pressing barriers.

The European Science and Technology Advisory Group (E-STAG) is a regional initiative from the European Commission, supported by the United Nations Office for Disaster Risk Reduction (UNDRR, former UNISDR), established to provide technical and scientific support for implementation of the Sendai Framework for Disaster Risk Reduction 2015-2030 (UNISDR, 2015) (hereafter referred to as the Sendai Framework) and contributing to reaching the extended connections of the Sustainable Development Goals (SDGs) (UN DESA, 2018). In support of Priority 2 ("Strengthening disaster risk governance to manage disaster risk") of the Sendai Framework and SDG17 ("Partnerships for the goals"), this paper presents a case study on barriers to data interoperability in Europe based on a series of reviews, surveys and interviews with National Sendai Focal Points and stakeholders in science and research, governmental agencies, non-governmental organizations and industry. The aim of this paper is to consolidate current challenges in data interoperability on regional level, and give recommendations based on lessons learned from the first mandate year of the E-STAG.

This paper is structured as follows: Section 2 reviews the role of data in disaster risk reduction (Section 2.1), Big Data as a complex resource (Section 2.2) and the role of data in monitoring the Sendai Framework (Section 2.3); Section 3 presents the setup of the survey and interviews used for the case study on Europe; Section 4 presents identified barriers to data interoperability in terms of heterogeneous factors (Section 4.1) and non-exclusive domains (Section 4.2); Section 5 presents the E-STAG as a regional initiative in support of the Sendai Framework and the SDGs; and Section 6 provides recommendations and concluding remarks.

2. Literature review

2.1 The role of data in disaster risk reduction

Timely and reliable information is required for effective and efficient response in emergency situations (Mansourian *et al.*, 2006). Disaster risk reduction is carried out collaboratively by non-profit organizations, government agencies, civil service and emergency units on various administrative levels. As all these actors require timely and reliable information, there is a direct link between disaster risk reduction and data interoperability. However, several barriers to data interoperability are identified (Cutter, 2003). With respect to disaster risk reduction, data interoperability can no longer be coined an "unexploited potential"; rather, it is becoming a "critical issue." Indeed, both natural hazards – such as floods, wildfires and earthquakes – and natural hazard triggered technological disasters – such as dam failures and reactor explosions – have devastating impacts on human livelihoods and assets due to the lack of data interoperability, as prevention and preparation actions are precluded by lack of information or stagnant information flows.

2.2 Big Data: a complex resource

The growth of social networks and the accelerated pace of modern communications have placed a renewed emphasis on global interconnections and scale in the field of international development (United Nations, 2018). These notions are particularly relevant to understanding the complex nature of vulnerability, as well as the ability of systems – such as individuals, households, communities or countries – to cope with, adapt to and potentially transform in the face of shocks and stressors. The digital revolution modern society is facing is accompanied by an increasing availability of large data sets; in the digital revolution, data are a driver of growth and change. Big Data has emerged as a multifaceted phenomenon that substantially changes data collection, processing and distribution procedures (Crawford *et al.*, 2013). The term "Big Data" is commonly used to refer to large or complex volumes of data for which traditional data processing applications are inadequate. However, the term has evolved to encompass more than that. Older definitions highlight the "four Vs" of Big Data: volume, velocity, variety and veracity (Laney, 2001), which have allowed new approaches to predictive analytics, user behavior analytics and other methods to visualize and to extract information from data. More recently, the Data-Pop Alliance (2015) defined Big Data as follows: "a new socio-technological phenomenon resulting from the emergence and development of an ecosystem made up of the new kinds of data crumbs about human behaviors and beliefs generated and collected by digital devices and services, ever more powerful computing power and analytics tools, and a vibrant community of actors in this field".

While there is a growing body of literature and practical applications in the intersection of Big Data and development (UN Global Pulse, 2012) – particularly in the field of humanitarian emergencies (Ali *et al.*, 2016) and the SDGs (UN Global Pulse, 2017) – there is a critical knowledge gap regarding the use, potential and challenges of Big Data in resilience programming. The amounts of data being collected both actively and passively with technological tools and devices require resilience practitioners to rethink design, implementation, monitoring and evaluation of projects, including the role of ethics, privacy, security, governance and sociocultural contexts in data collection, processing, distribution and usage (United Nations, 2018).

2.3 The role of data in monitoring progress of the Sendai Framework

Monitoring progress of the Sendai Framework requires access to accurate data. In adopting the Sendai Framework, Member States of the United Nations committed to the systematic and cyclical measurement, monitoring and reporting of progress on achieving the goals of the four key priorities. At the global level, progress is measured against the seven targets using 38 associated indicators. These indicators were formulated in 2016 by the Members States and observers of the Open-ended Intergovernmental Expert Working Group on Indicators and Terminology relating to Disaster Risk Reduction to quantify progress on the prevention of new, and the reduction of existing, disaster risk, as well as the strengthening of resilience of individuals, businesses, communities and countries (United Nations General Assembly, 2016). Clearly, monitoring the progress of the Sendai Framework heavily depends on the availability of and accessibility to quality-controlled data. These data are collected from multiple sources via numerous mechanisms, including – but not restricted to – national disaster loss accounting systems, national statistical services, household surveys and routine administrative data.

To assess the status quo, UNISDR reviewed the readiness of countries to report against the global targets; 87 Member States across all continents assessed their state of readiness to monitor and report, and specifically, the availability of national disaster-related data, disaster-related data gaps and the type of resources required to fill data gaps identified. In terms of availability, well-established disaster loss accounting protocols exist in many countries, resulting in populated loss data repositories. However, loss data on physical damage and human impacts dominate these repositories, reflecting less consistent data collection, synthesizing and distribution on economic losses, losses of specific assets and infrastructure, cultural heritage and disruptions to basic services. As could be expected, data availability is lower in countries where there is no national system for disaster loss accounting protocols.

Data quality is also essential for effective monitoring of the Sendai Framework. Here, it is important to note that the integration of disaster-related data within national statistical systems can bring quality dividends through applying the fundamental principles of official statistics, and at the same time facilitate integrated reporting to the SDGs and the Sendai Framework using multi-purpose data sources – thereby reducing the reporting burden on Member States.

Besides availability and quality, accessibility and interoperability are considered key elements. While data may be available, access to the data may be impeded, for instance, by tariffs or payments for which there are no resources. In other circumstances, lack of accessibility to existing data sets may simply be a function of established malpractice or the absence of data distribution protocols, mechanisms and appropriate data governance arrangements.

Based on this status quo, UNISDR developed and launched the Sendai Framework Monitoring System (https://sendaimonitor.unisdr.org/) in 2018, with the aim to offer a user-friendly online platform, interoperable at the global level with quantitative data fully compliant with the indicators agreed by Member States. The Sendai Framework Monitoring System allows national authorities to configure the data collection process in line with their existing national structures for data collection. Each indicator of the Sendai Framework can be treated independently by the national agency or responsible institution. The objective of the Sendai Framework Monitoring System is to ensure systematic collection of loss data by geographic location at the municipal level, considering age, gender, level of income and disabilities. The principles of the system also encourage the systematic disaggregation of data, which is a core component of understanding systemic risk. In order to achieve the global Sendai Framework Monitoring process, UNISDR supports the implementation of national disaster loss data collection systems. These systems, compatible with the Sendai Framework Monitoring System (such as DesInventar Sendai; Moriyama *et al.*, 2018), enable local and national authorities to systematically report intensive and extensive disasters, on the basis of data entry cards for each event. Aligned with the indicators and the terminology agreed by Member States, these systems include all mandatory fields for accounting losses and disaggregating information. The use of compatible national disaster loss data collection systems allow for automatic data export to the global monitoring systems such as Sendai Framework and the SDGs. These systems also facilitate international exchange of information and transboundary cooperation at the regional level.

As of August 2018, 48 countries have initiated reporting in the Sendai Framework Monitoring System, acknowledging their capacity for identifying, obtaining and using relevant data linked to disaster losses and measures for disaster risk reduction. Although factors explaining the status of the remaining 147 countries are complex and intertwined, there is no doubt that availability and reliability of data is a part of the challenges faced by authorities (Zaidi, 2018). Therefore, the sustainable efforts made by the scientific community, governments, non-governmental organizations, industry other stakeholders for improving the availability, accessibility, quality and interoperability of disaster data comprise a key factor dictating the monitoring of the Sendai Framework.

3. Surveys and interviews

Depending on what priorities of the Sendai Framework are considered and which stakeholders are involved, various actions can be taken to support global strategies for disaster risk reduction. Examples of such actions include: investment and implementation of measures and policy instruments, delineation of socio-economic mechanisms to catalyze on partnerships and cooperation, and preparation to increase resistance and resilience in advance of anticipated disasters. These actions may require one or more data types for implementation:

(1) disaster footprint-related data (e.g. hazard type, magnitude, duration and spatial coverage);

(2) territorial data (e.g. intervention procedures, methodological approaches, means, resources, technologies and tools);

(3) loss data (e.g. damage assessments, socio-economic impacts and local/national economic drivers, from governments, municipalities, health services and insurance companies);

(4) socio-economic data (e.g. income, education, profession and disabilities); and

(5) other data, including – but not limited to – management strategies, policies and outputs from model simulations.

An online survey was sent to 56 respondents from academia, industry, science and research, national and local authorities, non-governmental organizations and civil society in Armenia, Austria, Belarus, Belgium, Bulgaria, Croatia, Denmark, Finland, France, Germany, Greece, Hungary, Italy, Luxembourg, Macedonia, Montenegro, Norway, Portugal, Russia, Slovenia, Spain and the UK. The survey consisted of a combination of 13 open and closed questions regarding collection, processing, distribution and use of data in disaster risk reduction.

Additionally, in-person or virtual interviews were conducted with National Sendai Focal Points in Croatia, Italy, Montenegro, the Netherlands, Norway, Russia, Slovenia and Sweden. The interview guide consisted of 20 open and partly open questions (with alternatives) regarding use of data in disaster risk reduction. Where applicable, the interviews were translated to and conducted in the official language of the country by an E-STAG member with citizenship or particular experience with the country at hand. The interviews were transcribed in English and collectively analyzed.

4. Barriers to data interoperability

Barriers to data interoperability arise due to complex and intertwined reasons. Although these reasons differ on local, national, regional and global scales, four heterogeneous factors can be identified along with six non-exclusive domains of origin.

4.1 Heterogeneous factors

The first factor relates to the high number of actors involved, such as civil protection, firefighters, healthcare services, municipalities and non-governmental organizations among others. Ensuring an effective cooperation between these actors through efficient data exchange and collaborative operations is particularly important during emergency operations. In a continuously globalizing world, effective cooperation is particular challenge in international emergency management, where actors involved use different languages;

emergency management systems and software; disaster classifications; alert codes; methods to measure disasters impacts; protocols and regulations for intervention priorities; means of management strategies; policies and decision-making chains (e.g. local and national actors with different roles and action field); and communication channels. Hence, effects of local and national disaster risk reduction and management strategies are linked to the broader field of international disaster risk management; local and national aspects limit potential exchange data, compromising the effectiveness of international disaster risk reduction.

A second factor relates to lack of standardization in data collection, processing and distribution. Mapping the required data to support each specific disaster risk reduction-oriented action is thus a complex, non-standardized process, which limits the interoperability during emergency relief.

A third factor relates to the process of data collection, processing and quality assessment. Data collected, processed and distributed by a wide range of actors using different routines, standard and requirements make up a gradual distribution that can limit accessibility and interoperability. The challenge aggravates when such granular distributions are used in disaster risk assessment processes, whereby inconsistent data impede common understanding of disaster risk and systematic inclusion of disaster risk in policy making, decision making and investments on reasonable grounds; this furthermore affects transboundary cooperation in emergency response operations. Even when actors are aligned, and informed on data types required to implement specific disaster risk reduction-oriented actions, end-users of data must be aware of:

(1) where and how the selected data were obtained, identifying and taking notes of intended use and limitations;

(2) how to assess accuracy, reliability, processing and data handling procedures, and compliance with intended use in disaster risk reduction-oriented actions;

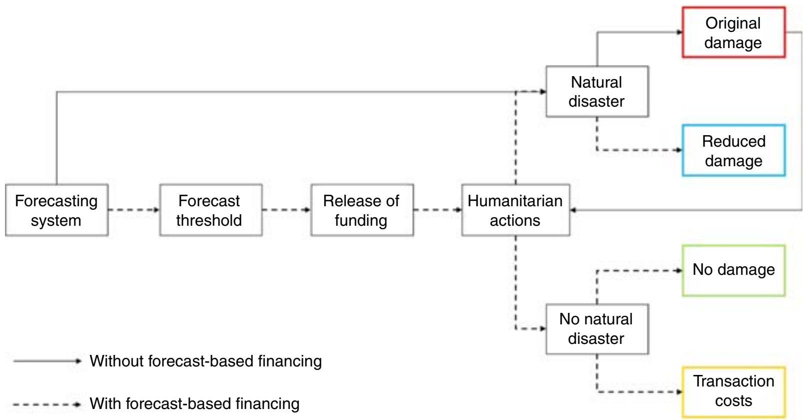
(3) how to identify and circumvent potential obstacles in data usability, such as language, ontology, compatibility, structure, metadata, format and size;

(4) how to extract, post-process and exploit data, including accessing, downloading, storing, visualizing, sharing and applying data with available software; and

(5) how to assert the effectiveness of the use of a certain type of data, quantifying the added-value of the data with respect to specific disaster risk reduction-oriented actions.

A fourth factor relates to the availability of data to support the realization of new initiatives in disaster risk reduction. Over time, humanitarian aid for disaster risk reduction has evolved into two distinct branches: long-term disaster risk reduction and emergency relief. This has left a gap in humanitarian aid for disaster risk reduction right before a disaster occurs; forecast-based financing is a financial mechanism recently developed by The International Federation of the Red Cross and National Societies to reconcile long-term disaster risk reduction and emergency relief. Forecast-based financing consists of a forecasting system, with data, models and forecast dissemination; forecast thresholds to trigger release of pre-allocated funds for humanitarian aid; and standard operating procedures describing actions to be taken once funding is released (Wilkinson *et al.*, 2018). In principle, forecast-based financing can be implemented with respect to any forecastable natural hazard; what is needed is a reliable forecasting system and pre-allocated funds (see Figure 1).

Several pilot projects have been implemented to reduce disaster risk in the "window of opportunity" arising before an anticipated event materializes. Worldwide, support is given by the American Red Cross, the Australian Red Cross, the Belgian Red Cross, the British Red Cross, the Danish Red Cross, the Finnish Red Cross, the Netherlands Red Cross and the German Red Cross. More recently, The International Federation of the Red Cross has



Source: Sjåstad Hagen (2018)

Figure 1. Principle of forecast-based financing for disaster risk reduction

extended the scope of the global financial instrument, the Disaster Relief Emergency Fund, to provide flexible funding for forecast-based financing.

However, forecast-based financing is limited to pilot projects, currently in 17 countries. To significantly contribute to reducing global mortality rates (Global Target A of the Sendai Framework) and stimulate global partnerships (SDG17), forecast-based financing needs upscaling. As previously mentioned, one of the largest constraints in implementation of forecast-based financing is data availability. Data are needed to set up and run models in forecasting systems and to understand causal relationships between (forecasted) natural hazards and resulting damage. As an example, flood forecasting with hydrological models requires weather forecasts, generated with atmospheric models, and a large number of parameter values, obtained from optimization procedures or *in situ* measurements. Consequently, problems arise where data records are sparse (Nash and Sutcliffe, 1970; Bárdossy, 2007; Li *et al.*, 2018).

Other examples of new initiatives include novel agricultural insurance policy schemes, whereby funds are allocated and automatically released to farmers affected by flood or drought, and interdisciplinary and transboundary collaborations between insurance companies and stakeholders in disaster risk reduction. An example of the latter can be found in Norway, where the insurance industry now opens up for sharing insurance data for third-party purposes of disaster risk reduction.

Climate change, population growth, migration and land use change are all external drivers potentially increasing natural hazards, vulnerability and exposure in the future. While the future is uncertain, it is certain that disaster risk cannot be eliminated. However, disaster risk reduction can increase resistance and resilience and reduce vulnerability and exposure. With the rise of new initiatives building on previously unexploited data, the need for systematic data collection and data interoperability is evidently urgent, not only to reduce the economic damage following disasters, but also to save lives before they strike and reduce secondary effects in regional market chains. Categorizing the abovementioned factors and their contribution to specific barriers to data interoperability is challenging, as they concurrently can originate in several domains; an elaboration of the most evident domains is provided in the proceeding sub-section.

4.2 Non-exclusive domains

Some barriers to data interoperability originate in the social domain: low public awareness of risks; lack of trust in authorities and central institutions; lack of risk assessments; cultural impacts on risk perception; and inadequate training and aversion toward technology and change are interesting examples of social barriers.

Other barriers are linked to the political domain: lack of standardization; inconsistent procedures for data collection, processing and distribution; requirements for information security; and conflicting national interests are the most evident examples of political barriers. Furthermore, the dynamic political landscape in and between countries stimulates new drivers, interests and catalysts for disaster risk reduction: some data which today are considered fundamental for risk analysis may not have been exploited or available a few years ago; this results in sparse data records with respect to historical archives.

Clearly, the economic domain strongly affects all aspects of data handling – starting from data collection to processing and distribution. Although limited to Member States of the European Union, the INSPIRE Directive (INSPIRE 2007/02/CE) was enforced in 2007 to enable sharing of environmental spatial data among public sector organizations and facilitate public access. Application cases (Migliorini *et al.*, 2015) have shown that a substantial effort is required from both public and private local data owners to align already existing data sets with European data standards, making funding key to enable data interoperability.

Incompatible data structures, formats, resolutions, software, user-interfaces and technical requirements give rise to barriers connected to the technological domain. Technological development fosters and unwraps both new opportunities and new barriers to data interoperability; as a recent example, applications of cloud-computing data introduce another barrier, namely, the crucial need for internet access during emergencies. Data are hence the inaccessible if connection is lost – which often is the case during severe emergencies with power outlets or physical damage to infrastructure.

Some barriers originate in the geographical domain, such as language, resources and geographical distribution of natural hazards. Certain hazards are more prevalent in some countries, whereby which vulnerability and exposure dictate efforts and investments in risk reduction measures, leading to accumulation of expertise and a refined system for collection, processing and distribution for the relevant hazard. Examples of this include flood risk management in the Netherlands, drought in Spain and landslides in Norway. These barriers can extend on spatiotemporal scales not following country borders, thereby interconnecting nation in disaster risk reduction measures (see, for instance, the European Flood Alert System for transnational river basins; Thielen *et al.*, 2009).

Finally, the scientific domain reflects present and past paradigms. The paradigms differ in time and across disciplines. This also gives rise to barriers. While a gap exists between scientists and practitioners, data, information and knowledge may reside in either domain without offering practical use to drive scientific research and practical applications further. Sharing data, information and knowledge can add value to both scientific research and practical applications while at the same time giving rise to positive feedback effects – like guiding science toward new areas of research (for instance, by identifying short-comings or knowledge gaps in emergency management) and using scientific insight optimize disaster risk reduction (for instance, by using knowledge of spatiotemporal variability of vulnerability and exposure).

The most commonly reported barriers in Europe are associated with the technical, economic and political domains – such as lack of standardization, data disaggregation and data protection. Several countries expressed a need for a stronger science–policy interface. Furthermore, transboundary cooperation, policy-making process, and public and private investments are specific areas for which more targeted data exploitation is foreseen to improve disaster risk reduction on national level. While most countries do have organizational protocols, methodologies and national databases in place for disaster risk assessments, data are often collected for one specific purpose, partly precluding or limiting the use of the data for other disaster risk reduction-oriented actions.

5. E-STAG: a European initiative

The E-STAG was established on 25th of April, 2018, in Sofia, Bulgaria, as an initiative from the UNDRR and the European Commission's Joint Research Centre to support implementation of the Sendai Framework and tackle emerging challenges related to the SDGs, focusing in particular on improving knowledge and awareness of disaster risk in 55 countries across Europe and Central Asia. During the first mandate year, the E-STAG split into two working groups, one of which focused on the role of data in disaster risk reduction (hereby referred to as Data E-STAG). During the first mandate year, the Data E-STAG embraced the following objectives:

- to work in coordination and as linkage between national and global disaster risk reduction platforms, partners or networks;
- to identify current challenges with respect to data in disaster risk reduction by direct interaction with National Sendai Focal points and stakeholders from science and research, authorities, non-governmental organizations and industry;
- to showcase data requirements for new initiatives in disaster risk reduction; and
- to enhance efforts through the links to existing regional science and technology networks.

Starting from the 7 global targets and 38 related indicators of the Sendai Framework, Data E-STAG focuses on delineating mechanisms and requirements to ensure effective collection, processing and distribution of data for disaster risk reduction in support of implementation and monitoring of the Sendai Framework. Data E-STAG has investigated main sources of data used for disaster risk reduction-oriented action in Europe, and identified major barriers to data interoperability and mapped possible solutions based on interviews with National Sendai Focal Points. Data E-STAG has furthermore contributed to positioning the group as an asset for National Sendai Focal Points. From a practical point of view, Data E-STAG moves along three operational activities:

(1) identifying barriers to data interoperability in Europe;

(2) analyzing and classifying identified barriers to data interoperability; and

(3) mobilizing knowledge transfer to relevant stakeholders through conference talks, contributions to the recent Global Assessment Report (GAR) (UNDRR, 2019) and mapping of suggested solutions from National Sendai Focal Points.

Identifying and classifying the barriers are only a first step toward obtaining data interoperability; the real challenge lies in overcoming those barriers. While barriers can be categorized, the solutions as to how to overcome them are not generic, due to the fact that barriers are interlinked and differ from place to place, country to country and region to region. Moreover, several natural hazards may materialize concurrently. For instance, storm surges often occur concurrently with hurricanes. In these cases, several agencies work concurrently and a wide range of data (and models) are needed. For dissemination of timely and reliable information to all stakeholders involved in disaster risk reduction and emergency management, data interoperability is essential. Due to the aforementioned barriers to data interoperability, solutions may be both case specific and local, while regional strategies may provide frameworks under which specific solutions can be formed. In other words, Data E-STAG should be viewed as part of a larger network of initiatives, complementing and extending the potential of existing platforms, knowledge and ideas to the European and Central Asian countries.

As a regional initiative contributing to enhancing data interoperability for disaster risk reduction, the Data E-STAG can be linked to several existing initiatives. With support from the United Nations Environment Program and UNDRR, an online geoportal called Project for Risk Evaluation, Vulnerability, Information and Early Warning (PREVIEW – Global Risk Data Platform) was set up to facilitate access to geospatial data (Giuliani and Peduzzi, 2011). The PREVIEW – Global Risk Data Platform provides access to more than 60 interoperable data sets, including data on tropical cyclones, storm surges, droughts, earthquakes, wildfires, floods, landslides tsunamis and volcanic eruptions. However, if limitations and needs on end-user level are not taken into account, data interoperability fails to enhance disaster risk reduction (Cutter, 2003). This highlights the need for a bottom-up approach with close collaboration between practitioners and scientists, in which the most important research questions are derived from practitioners. With direct contact with practitioners and National Sendai Focal Points, this links the role of Data E-STAG to initiatives like the PREVIEW – Global Risk Data Platform.

Another example of existing initiatives is the Roadmap, Showcase and Guide, as part of a toolkit developed for practitioners by UNDRR and partners for the Making Cities Resilient campaign (www.unisdr.org/we/campaign/cities). These tools are oriented toward the Ten Essentials for Making Cities Resilient, a ten-point checklist developed for the Making Cities Resilient Campaign by leading urban resilience experts. The Ten Essentials comprise three pillars – enabling, operationalizing and building back better – and serve as a practical guide to stimulate commitment to improving urban resilience. Over 3,500 cities worldwide have signed up for the campaign and committed to using the Ten Essentials in building resilience, which essentially support implementation the Priority 4 ("Enhancing disaster preparedness for effective response") of the Sendai Framework at local level. Within a European context, Data E-STAG may stimulate to continuous commitment to initiatives like these by addressing state-of-the-art data-related issues that arise.

A third initiative worth mentioning is the work carried out by the Global Volcano Model and the International Association of Volcanology and Chemistry of the Earth's Interior, which were jointly commissioned by UNDRR to report on volcanic hazard and risk for the GAR on Disaster Risk Reduction 2015 (UNISDR, 2015). Before 2015, volcanoes had not been considered in GARs. Since volcanic activity and associated hazards and risks are unevenly distributed, with prevalence in certain regions of the world, data interoperability may require regional links similar to the E-STAG, from which these regional initiatives again may benefit from in terms knowledge transfer, organization and approach.

However, while regional initiatives on data integration do exist, the primary challenge addressed in this paper still remains: How can online data integration for disaster risk reduction become a routine? The work of Data E-STAG described in this paper is a step toward answering this question at regional level, laying down foundations on which further regional initiatives can build. The next step involves unifying data collection, processing and dissemination standards to formulate guidelines promoting interdisciplinary use of data for disaster risk reduction, particularly targeting implementation and monitoring of the Sendai Framework.

6. Conclusion

Modern society is facing a digital revolution. As highlighted by the International Council of Science (https://council.science/) and the Committee on Data for Science and Technology (www.codata.org/), digital technology offers profound opportunities for science to discover unsuspected patterns and relationships in nature and society, on scales from the molecular to the cosmic, from local health systems to global sustainability. It has created the potential for disciplines of science to synergize into a holistic understanding of the complex challenges currently confronting humanity; the SDGs are a direct reflectance of this. Interdisciplinary is obtained with integration of data across relevant disciplines. However, a barrier to realization and exploitation of this potential arises from the incompatible data standards and nomenclatures used in different disciplines. Although the problem has been addressed by several initiatives, the following challenge still remains: to make online data integration a routine.

This paper presented a case study on the role and use of data in disaster risk reduction in Europe, identifying current barriers as a first step toward enhancing data interoperability in Europe. It is argued that regional links with National Sendai Focal Points can be a valuable asset in the implementation of the Sendai Framework and furthermore contribute to progress on the SDGs on regional level – particularly SDG17; the E-STAG is a clear example of this.

The Sendai Framework Technical Guidance Note for monitoring and accounting progresses on targets is reportedly being used in Europe. However, several barriers to data interoperability preclude not only disaster risk reduction-oriented actions, but also the monitoring of progress on the Framework. The most prevalent domains in which these barriers originate are the technical, economic and political domains, but heterogeneous factors are also found in the scientific, geographical and social domain.

In order to generate outputs of practical value, close collaboration with National Sendai Focal points is advocated. Not only does this allow for a two-way communication between global and national levels through a regional link, but it also extends a wider connection to the SDG17 in stimulating global partnerships. E-STAG is currently involved with the newly formed Technical Working Group on Sendai Hazard Definitions and Classification (https://council.science/current/news/technical-working-group-on-sendai-hazard-definitions-and-classification-to-be-launched) of the UNDRR. Future work of the E-STAG may focus on one or more of the following topics: evidence-based policy making, awareness of disaster risk reduction or vulnerability; the definitive topics will be decided upon after consultation with National Sendai Focal Points in Europe.

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