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Learn to Be Resilient

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Collection of EU good practices in the usage of new technologies and innovative approaches in prevention, preparedness and response to earthquakes

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Evaluation

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WP5/*D5.3*

Contents

1 Introduction

The need for increased application of innovation and technology for disaster risk reduction (DRR) has never been greater to foster new development and implementation of more effective evidence-based approaches. Tremendous DRR efforts have been ongoing for many years; however, further improvements and new methods of DRR beyond conventional and traditional initiatives are urgently required, especially those related to serious underlying causes such as climate change, poverty, urbanization, population density, and environmental degradation. Further, the Sendai Framework for Disaster Risk Reduction encourages better access and support for innovation and technology as well as increased investment in DRR to develop new innovations that are both cost-effective and beneficial when applied in all disaster management phases: response, recovery, mitigation, and preparedness. In addition, strong collaboration between various stakeholders such as government, academia, NGOs, and the private sector is crucial to the application of technology and innovations. A series of discussions about many forms of potential collaboration continues to take place.

The implementation of creative and appropriate ideas is also called innovation, as are processes that combine knowledge with new ideas in a creative way [1]. Thus, innovations are not always products but can also take any form: process, approach, framework, concept, and other types. DRR innovations are categorized into several groups: “innovation through interdisciplinary concepts, such as resilience; technological innovation, such as maintaining and strengthening geospatial information technologies; innovative ways to enhance the uptake of scientific knowledge in policymaking and operations, such as sharing platforms; community-based innovation, such as integrating local information into DRR decision making; innovation through inclusiveness and participatory approaches, such as the perspective of young scientists; and innovation through policy coherence and improved monitoring” [2]. Technological advancement and innovation have created new opportunities for enhancing disaster resiliency and risk reduction.

The implementation of disaster risk reduction practices in use can be divided into two categories:

- Approaches defined by governmental decisions and implementation will be backed up with government subsidies needed to trigger the implementation in the private sector
- Research and technologies used in disaster risk reduction that doesn’t need to be supported by regulatory processes

A further subchapter was added, as a wide scope of approaches and technologies haven’t necessarily made it into the implementation. These mentioned worthy technologies have been listed in the chapter “Technologies that can be used in DRR”.

1.1 Approaches

The adoption of the Sendai framework for disaster risk reduction for all UN member states has introduced a completely new and holistic approach at the global level. SFDRR, with its expected goals and outcomes, requires a "strong commitment and involvement of political leadership in every country at all levels in the implementation and follow-up of the present Framework and in the creation of the necessary conducive and enabling environment" pushing all member states to at least create and use a disaster risk reduction strategy at the national level [3]. Further on, an important new contribution of the SFDRR is the definition of seven global targets. These seven targets are "measured at the global level and are complemented by work to develop appropriate indicators. National targets and indicators contribute to the achievement of the outcome and goal of the present Framework." [3].

The INSPIRE Directive aims to create a European Union spatial data infrastructure for the purposes of EU environmental policies and policies or activities which may have an impact on the environment. This European Spatial Data Infrastructure enables the sharing of environmental spatial information among public sector organizations, facilitate public access to spatial information across Europe and assists in policy-making across boundaries. The Directive came into force on 15 May 2007 and will be implemented in various stages, with full implementation required by 2021. [4] As part of the ISA Programme, the EC Joint Research Centre (JRC) established A Reusable INSPIRE Reference Platform (ARE3NA), which aims to support the Member States through guidance, collaboration, sharing of best practices and approaches and a reference implementation of common open source components to aid INSPIRE implementation and the reuse of interoperability components that INSPIRE can share with other sectors [5].

In 2018, Montenegro started to use UN DesInventar Sendai as its national disaster loss data collection system, integrating all Indicators of targets A to E of the Sendai Framework, also corresponding to Sustainable Development Goals indicators from Goals 1, 11 and 13. In addition to comprehensive disaster accountability, DesInventar Sendai is expected to provide the means for decision-making support for further development of disaster risk reduction policies and plans, preparedness measures, planning and response. A number of initial steps were defined in order to achieve this national level achievement: 1. Thorough analysis and definition of responsibilities among national and local actors. 2. Development of plans of general regulation and update of urban plans in accordance to new Law on Spatial Development and Construction of Structures (2018), including all hazards endangering citizens and environment in Montenegro. 3. Implementation of a National Strategy for DRR (December, 2017). 4. Implementation of the Action Plan for the National DRR Strategy 2018-2023 (March, 2018). [6]

Addressing the need for high quality data for disaster risk reduction, Norwegian authorities initiated an innovative public-private partnership, aiming to develop a knowledge bank relevant for risk assessments and decision-making processes. Structured around a Memorandum of Understanding between national authorities and Finance Norway, the initiative is coordinated by the national platform for DRR, and gathers different sources of data from the local level, insurance companies, and disaster risk reduction actors into a national level data platform. In this integrated approach, the data platform would receive information about hazards, vulnerabilities, vital functions, societal values, and losses. The platform ensures the interoperability of data, its storage and systemizes the collection process. [6]

Making risk related data and information more largely available is essential to strengthen risk awareness and develop well-informed prevention policies. Too often data and information is scattered across different agencies and the private sector, particularly the insurance companies. Privacy protection or competition issues may hamper data pooling and limit the possibility of data sharing in the absence of an honest booker. Following the tragic Xynthia storm in Charente-Maritimes a parliamentary report pointed out the insufficient exchange of risk information and recommended the creation of a neutral observatory gathering information from the public and private sector grounded on a solid partnership. The French National Observatory for Natural Hazards (ONRN) is a platform for collecting, sharing and disseminating data and indicators related to natural hazards. It was set up in 2012 jointly by the Ministry of Ecology, Sustainable Development and Energy, the Central Reinsurance Company, and the Association of French Insurance Undertakings for Natural Risk Knowledge and Reduction with the aim to connect suppliers and users of risk information from the public and private sector. Its key missions are to structure, provide access and add value to existing knowledge, produce national and local indicators and develop broad-based partnerships towards improving the risk knowledge and culture. The ONRN web platform provides an inventory of existing public databases with easy access by topic and/or by territory to a large series of risk-related information on hazards, exposure and vulnerabilities, losses, and prevention projects and initiatives across the French territory. An interactive map proposes to visualize these information at the scale of the municipalities [7].

As in many OECD countries, crises affecting the UK have become more complex as a result of increased interconnectedness of our modern societies, the emergence of new threats, and the evolution of several risk factors. SAGE has been set up to meet the needs of Cabinet Office strategic crisis managers when confronted with complex crises. The understanding of this complex risk landscape requires thinking across sectors, identifying potential cascading impacts and evaluating uncertainties. Having access to the best available advice in a timely fashion is key to effective crisis management decision-making. To ensure a full range of issues are considered, advice needs to stem from a range of disciplines, including scientific, technical, economic and legal. Thus, it is crucial to set up a specific group which can quickly mobilise and peer-review multidisciplinary scientific expertise during crises. The UK Scientific Advisory Group in Emergencies (SAGE) is an independent support group that provides science-based expertise for the management of complex and unprecedented crises for the UK cabinet. SAGE convenes in situations that require cross government co-ordination, notably when the Cabinet Office, in consultation with the Prime Minister, decides to activate the Cabinet Office Briefing Room (COBR). The SAGE provides scientific and technical advice on the development of a crisis, and on potential scenarios and their impacts. Under the authority of the Government Chief Scientific Advisor, SAGE includes experts from all sectors and disciplines to analyze data, to assess existing research, or to commission new research. To inform UK cross-government decision-making during the emergency response and the recovery phases, the SAGE submits policy option papers which outline scientific and technical solutions, their pros and cons and response scenario papers. At all stages, SAGE representatives attend the COBR to explain scientific issues [8].

The National Earthquake Strategy and Action Plan of Turkey (UDSEP-2023) is a national legal instrument that aims at reducing earthquake related losses and achieve an earthquake resistant and resilient country by 2023. The strategy has been in effect since 2012, focusing on reducing earthquake risks and enabling the society to be better prepared by examining the institutional framework. Every action within the UDSEP-2023 has an overall target of achieving earthquake loss reduction. In order to realize the actions of UDSEP-2023, the strategy's document also defines primary targets and identifies priorities for Research and Development topics. Multi-stakeholder participation together with realistic and manageable actions are key in both preparation and management of the UDSEP-2023. The legislation adopted on the 27th of April 2012 also established the National Earthquake Research Fund (UDAP) with the aim of supporting scientific research projects in geological, geophysical and earthquake engineering disciplines. This helps create new technologies and build information on earthquake investigations. UDAP also supports projects in social sciences. [9]

Romania introduced a proactive form of seismic protection that has been in place in Romania since 1994, when a decree was issued imposing an obligation to assess the seismic hazard of existing buildings. In order to implement this decree, in 1997 the Republic of Romania issued an order to all provinces to classify all buildings in its region according to construction time, type of construction and seismic risk, and to make a list of priority buildings for reinforcement. The regulation further stipulates that all buildings classified as first-degree buildings must be strengthened, with the state fully bearing the costs of strengthening those buildings whose owners have incomes below the average, and owners who do not belong to this group receive favorable loans from the state for retrofitting implementation [10].

1.2 Research and technology used for DRR

Cloud to Street is an example of a platform adopting this approach by combining the daily imagery from microsatellites with information from citizens reporting in the field to create maps that show the extent and duration of flooding events. These maps can be used both by first responders and by decision-makers to understand where flood risks are located, and how situations progress over time. [11]

Advances in machine learning and artificial intelligence can also provide benefits to disaster risk management. For example, algorithms have been developed to analyze scientific data on earthquakes (shaking parameters, soil and seismic hazard characteristics, building characteristics) with real-time responses (digital media, tweets, and on-the-ground reports) to predict how new structures will respond to ground tremors and quakes. One Concern, a startup out of Palo Alto, has developed a web platform that will alert users when an earthquake occurs, and provide a map of likely structural damage based on machine learning modelling on a block-by-block basis. The algorithm also details what structures could be impacted before, during, and immediately after an earthquake. [11]

The European Facilities for Earthquake Hazard and Risk (EFEHR) is a non-profit network of organisations and community resources aimed at advancing earthquake hazard and risk assessment in the European-Mediterranean area. EFEHR is not replacing national or local efforts, it is supporting and enriching them. EFEHR constitutes one of the three service domains in the Thematic Core Service (TCS) Seismology within the European Plate Observatory System (EPOS). The two others are ORFEUS (waveform services) and CSEM-EMSC (seismological products services) [12].

Since its establishment in 1991 Slovenia has developed a community-based system of prevention which has roots in the Yugoslav tradition and has been constantly upgraded especially after joigning the EU and NATO, and with active involvement in the work of the 3rd United Nations World Conference on Disaster Risk Reduction in 2015. With the latest update on flooding damages, this national damage record system (AJDA[13]) can be used to report to Sendai Framework Monitor. AJDA is a technical tool to perform damage recording, facilitating data entry at the municipal level, controlling data at the regional and the national level. The system is used to prepare materials for evaluations of damage to crops and property, for the completion of applications by victims to allocate funds, and to address the consequences of disasters. It also enables other government agencies that assess damage to enter estimates. In this way, the procedures for allocating funds to victims have been significantly shortened. The program is intended for disaster relief planning, but can also be used for other analyses.

Only 5 per cent of the Small and Medium Enterprises (SMEs) in the UK were reported in 2011 to have Business Continuity Management Plans in place. Raising SME's awareness of the importance of business continuity planning and how to do it appeared to be a priority of the resilience policy in the UK, in order to reduce economic losses caused by natural hazards and threats. Instead of establishing a government regulation or guideline, reflections with the Business Continuity Institute led to this idea of using a popular brand (the series “For Dummies”) to develop this practical guide, to make it more attractive to businesses and to catch a wider audience. Business continuity for dummies is a straight-forward and user-friendly book proposing detailed business continuity guidelines for companies and most particularly SMEs published in 2011. Written by several experts sponsored by the UK Cabinet Office, the Business Continuity Institute and the Emergency Service Planning, it uses the well-known series “For Dummies” which is an extensive series of instructional/reference books intended to present non-intimidating guides for readers new to the various topics covered. The book provides guidance and basic practical tips in building resilience for small and medium enterprises (SMEs). More in details, it helps identifying key products and services as well as the critical activities that underpin them. Moreover, it delivers accessible, affordable and achievable tips allowing to easily raise awareness on business continuity and resilience [14].

The first documented use of aerial drones was in 2005 after Hurricane Katrina in the United States of America. Because roads were blocked by trees, drones were deployed to search for survivors and assess river levels. Aerial drones are currently used for different disaster phases: preparedness, such as monitoring volcanic activity in order to determine when warnings should be issued; response, such as delivering equipment to locations where ground-based transportation has been disrupted; and recovery, such as photographing disaster areas for damage assessments. Underwater drones were used during the 2018 Hurricane Florence in the United States of America, measuring ocean heat fuelling the hurricane and transmitting data to the National Weather Service. The data filled in gaps left by satellite images, thus improving hurricane modelling. The data also enhanced forecasting the intensity and route of the hurricane, and sensors attached to the drones measured salinity levels to determine how much water from rain and rivers was mixing in the ocean [15].

The spatio-temporal frequency of damaging earthquakes has, up to date, restricted the use of UAVs to post-earthquake research and work, but UAVs provide a precious post-earthquake survey tool to collect perishable data, especially for building that aren’t safe to approach or inspect. UAVs are a complement to larger manned-aircraft photography and photogrammetry, because they can provide rapid solutions with virtually no infrastructure, like airport and airspace control. UAVs are also ideal to detect small-scale changes and cracks in buildings and on the ground. Indeed, low-cost solution UAVs usually can’t cover large areas, but they provide a different dataset with an increased resolution. This pattern was demonstrated during the recent Kumamoto earthquake in South Japan (Kyushu Island), in the aftermath of which the authorities used small UAVs to survey the surface rupture of the fault (https://youtu.be/DXTAAvVB2M8). The authorities of Japan also used UAVs to evidence historical building impacts that are difficult to see from a traditional aircraft, such as collapsed walls and structure with large trees around obstructing the nadir view (https://youtu.be/BcWlJN9lnHs). Images captured from UAVs can then easily converted into 3D models. In the aftermath of L’Aquila earthquake in Italy, the state of the build environment was evaluated using UAV combined with the photogrammetric method of SfM. UAV-based imagery can also be the source of more complex remote sensing methodologies to determine the impacts of earthquakes. The use of UAVs also goes beyond visual observations. In the Fukushima area for instance, the Japanese authorities have used UAVs to fly above and around the Fukushima power plant in order to measure radiation levels. It can be also used for the delivery of emergency goods, such as medical products, but also food and other vital items, especially when roads and other communication infrastructures have been profoundly damaged [16].

1.3 Technologies that can be used in DRR

You never know when a disaster earthquake or some other event will happen. The faster you find somebody that means the faster they can be rescued. FINDER, which stands for Finding Individuals for Disaster and Emergency Response, is a collaboration between NASA's Jet Propulsion Laboratory, Pasadena, California, and the Department of Homeland Security's Science and Technology Directorate in Washington. FINDER sends a low-powered microwave signal – about one-thousandth of a cell phone's output -- through rubble and looks for changes in the reflections of those signals coming back from tiny motions caused by victims' breathing and heartbeats. In tests, FINDER has detected heartbeats through 30 feet of rubble or 20 feet of solid concrete. A rescue worker with FINDER, using a rugged laptop running the FINDER software, can specify a minimum and maximum range for detecting heartbeats in the vicinity. The program identifies whether the signal is stronger from the left or right as well, to further home in on victims' locations. The FINDER device weighs less than 20 pounds, so it can easily be transported by car or plane. FINDER detects the small motions using algorithms similar to those that JPL uses to measure the orbits of satellites at Jupiter and Saturn, or changes in Earth's surface from orbiting satellites. It then displays the detected heart and respiration rates and a reliability score. FINDER's software can distinguish between the heartbeats of a human and those of animals or mechanical devices [17].

An avalanche of data is being generated by sensors, closed-circuit television, smartphones, financial transactions and Internet activities, to name just a few. While many of these data are being mined by businesses for commercial purposes, Big Data analytics holds enormous potential for crisis management. The volume of seismic data has increased dramatically, providing fuel for solutions to detect and locate earthquakes. Scientists have based detection on continuous seismic records, searching for repeating signals that provide information on upcoming earthquakes. Analysing many years of earthquake waveforms requires considerable computing power. A new approach uses AI to reduce waveform analysis processing. Based on convolutional neural network computer learning, the software is trained to analyse large waveform data sets, and distinguish between noise and true earthquake signals, while preserving location information. Compared with other methods, the convolutional neural network method is faster and retains location information with a high degree of accuracy [3].

A Geographic Information System (GIS) is a computerbased tool for mapping and analyzing feature events on earth. GIS technology integrates common database operations, such as query and statistical analysis, with maps. GIS manages location-based information and provides tools for display and analysis of various statistics, including population characteristics, economic development opportunities, and vegetation types. GIS allows you to link databases and maps to create dynamic displays. Additionally, it provides tools to visualize, query, and overlay those databases in ways not possible with traditional spreadsheets. These abilities distinguish GIS from other information systems, and make it valuable to a wide range of public and private enterprises for explaining events, predicting outcomes, and planning strategies. Remote sensing is the art and science of making measurements of the earth using sensors on airplanes or satellites. These sensors collect data in the form of images and provide specialized capabilities for manipulating, analyzing, and visualizing those images. Remote sensed imagery is integrated within a GIS [18].

Social network service/system (SNS) are playing a greater role during disasters. Twitter has been widely used by the relief community in a number of disasters to coordinate response. Unlike text messages, users can follow tweeters; 'cards' can be included with links to photos, videos and other media; and hashtags help quickly receive or find tweets on a specific topic. The Facebook Crisis Response app allows users to mark themselves as safe, reassuring friends and family, provide or seek help, donate money, and receive information [15].

The social network service/system (SNS), often termed as "social media," is an online space for making connections with others. SNS users create a profile and connect with others through file-sharing, emails, messages, or comments. Traditionally, disaster information was passed on through radio and television. The first SNS, namely SixDegrees.com, started in 1997 and was soon followed by Friendster, MySpace, Facebook, YouTube, Google Plus, Instagram, Twitter, LinkedIn, Reddit, Snapchat, Tumblr, Pinterest, and Vine. The development of computers, smart phones, and tablets allows for the proliferation of SNS use. Recently, SNS has become an important tool for DRR that can make communities and societies more resilient to disasters and crises. It offers opportunities to educate people, especially the youth, on knowledge of hazards; allow collection of disaster data; give voice to people, especially during an emergency; and provide information on logistic and humanitarian needs. However, some negative effects of SNS have been observed in relation to disaster information. The use of the SNS in DRR has changed the way people perceive and respond to disaster information and even to decision-making processes by government or other organizations working in disaster management. In most disasters, the first responders are the public, who then gather social capital, either directly or through SNS, in the form of the mobilization of skills, leadership, networks, and support systems. After the Haiti earthquake in January 2010, people posted texts, photos, and personal experiences via SNSs, which led to the pouring in of resources in a very short time and a costeffective way for donations. Through mass participation, correct information was used much more prominently in the aftermath of the Great East Japan Earthquake and Tsunami of March 2011. After an extreme event or immediate attack, SNSs can help create social cohesion and promote therapeutic initiatives through the use of media by people to inform their family and friends that they are safe. Data obtained through social media can be collected and analyzed by researchers for education and decision-making purposes. On the negative side, immediately after the 2010 earthquake in Chile, when information from government/authorities were scarce, rumors circulated about an impending earthquake and tsunami. In Indonesia and Italy, scientists had trouble with the authorities as the information they gave were used and quoted inappropriately, which lead to chaos and insecurity among people [19].

A telemetry system is used to monitor various disaster situations such as earthquakes, volcanos, floods, and environment as well as to operate DRR facilities on a real-time basis. A disaster prevention radio system in Japan, "Bosai musen" aims at sharing disaster information with local residents. The organizations concerned can collect real-time information on disasters and DRR facilities through the telemetry systems. Real-time data is essential in issuing early warning and evacuation orders. Ordinary people can also access information on disasters or upcoming unwanted events on the World Wide Web or through smartphones to prepare for disasters. The organizations concerned can get to understand disaster situations more clearly by collecting image data and large data because of developing technology, such as optical fibers, Closed Circuit TeleVision, digitalization, and climate radars. In the 1960s, before wireless systems had been installed in Japan, observers monitored water and rain gages directly and reported the findings to the organizations concerned through telephones. Local governments can issue disaster information, warnings, and evacuation orders through Bosai Musen. This system started operating in the 1950s in Japan, and consists of central stations at government offices responsible for sending information throughout towns or to individual receivers and households through loud speakers [19].

Japan is a pioneering centre for the use of robots in disasters. The Human–Robot Informatics Laboratory of Tohoku University has developed several types of robots for disaster response, including a snake-like robot with a camera that can crawl over obstacles, follow walls, and make turns in tight spaces. Research is ongoing to augment search-and-rescue dogs using cameras, Global Positioning System (GPS) and inertial measurement units, which are being designed to be small and light to fit on a dog pack. Damage to the Fukushima Daiichi Nuclear Power Plant in the 2011 earthquake triggered significant robot research due to radiation preventing humans from carrying out direct cleanup activities. One of the biggest challenges has been determining what happened to the fuel inside the core of the reactor. Various robots were used to penetrate the core, but without success. Finally, in 2017, a small robot designed to operate underwater with severe radiation exposure succeeded in locating the missing fuel inside the reactor core. Japanese manufacturer Honda is developing a disaster response robot that can walk, scale obstacles and climb ladders. If the prototype reaches fruition, it could have a major impact for rescue operations and clearing hazardous materials [15].

2 Conclusions

It is not always the innovation in technology that leads to innovative approaches in disaster risk reduction and management, but rather the innovative use of already existing tools to aid the needs of disaster risk reduction.

Important efforts have been made in Europe in recent decades to increase structural safety and institutional resilience to natural and other hazards. This has been supported by several UN, EU, and other (inter) national initiatives. All these initiatives benefited from large technological advances (e.g. satellites, real-time data, mobile phones, and unmanned aerial vehicles). However, Europe lags behind new developments in social capacity building and resilience of population and other social and structural systems

Inevitably, the knowledge of disaster risk management is widening with every new day. The expansion of knowledge in disaster risk reduction is mainly caused by the simplified availability of information in the last few decades, but the importance of “smart” guided policies globally and regionally has an immeasurable impact here. Namely, the European Commission and other regional and global GO-s and NGO-s can “guide” researchers in their research aims by investing or subsidizing research in the areas of disaster risk reduction and management. Further on, the research community plays an important role in disaster risk reduction policymaking. However, the governmental bodies need to be welcoming enough to accept and channel expert suggestions and opinions.

The Sendai Framework recognizes the importance of a people-centred preventive approach to DRR that involves all relevant stakeholders in the design and implementation of disaster-related policies, plans and standards. Here, the need for the public and private sectors and civil society organizations, as well as academia and scientific and research institutions, to work more closely together to create opportunities for collaboration and for businesses to integrate disaster risk into their management practices is critical.

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