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D6.4 END-USER ASSESSMENT OF THE NEW TOOLS AND TECHNOLOGIES FOR DISASTER MANAGEMENT

Project acronym: BuildERS

Project title: Building European Communities' Resilience and Social Capital

Call: H2020-SU-SEC-2018-2019-2020/H2020-SU-SEC-2018

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Executive Summary

The overall focus of the BuildERS project is to help reduce vulnerability of European populations to natural and man-made hazards. In this report we will provide foresights on how new technologies and tools could support more sophisticated risk and vulnerability assessments, collecting vulnerability-related data with different means, and sharing this data between crisis management officials. In other words, we have explored how the new emerging technologies and already existing technological solutions (tested tools) could help building more resilient societies.

Our method has been co-creative: we have engaged various stakeholders in the assessment of technologies and ideated together, how they could be of help for the disaster management. The potential end-users of assessed technologies would be crisis managers: civil protection authorities, fire and rescue services, law enforcement, and the service providers of health care, socio-psychological support in crisis. In addition, the technologies could benefit the strategic partners of crisis managers, like the non-profit and civil society organisations active in inclusive and participatory resilience building.

This report presents the process of end-user evaluations. The assessed technologies have been selected from a wider Catalogue of tools and technologies for disaster management (BuildERS project report D2.4) and four case studies. Furthermore, we have further validated the potential of four tools that were tested within BuildERS project case studies. The end-user evaluation and assessment was done by end-user surveys and co-creative workshops for the representatives of authorities, businesses, and civil society organisations.

The results will give insights into the desirability of the new technology but also a critical assessment of potential risks and challenges related to the use of technology in crisis management.

The end-user assessment results presented here will be further analysed and discussed within BuildERS project WP5 when designing policy recommendations and producing a handbook for the practitioners. We will place the technologies in various socio-economic and political contexts and dive deeper into their potential to improve societal resilience in Europe.

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List of Acronyms

5G	Fifth generation (technology standard for broadband cellular networks)
AI	Artificial Intelligence
AIDR	Artificial Intelligence for Disaster Response
BuildERS	Building European Communities' Resilience and Social capital project
CDR	Call data record
D	Deliverable
EMS	Emergency Management Service
EO	Earth Observation
GIS	Geographic Information System
GNSS	Global Navigation Satellite Systems
ICT	Information and communication technologies
IoT	Internet of Things
LBS	Location-based services
MPD	Mobile Positioning Data
NASA	National Aeronautics and Space Administration
NGO	Non-governmental Organisation
SMS	Short message service
T	Task
TRL	Technology readiness level
UAV	Unmanned aerial vehicles
UNISDR	The United Nations (UN) International Strategy for Disaster Reduction Secretariat
WP	Work Package

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1. Introduction

1.1. Content and structure of D6.4

This deliverable report is organised as it follows: Chapter 2 describes the methods and working process carried out to collect information for the end-user evaluation. Chapter 3 provides a more detailed view on four technological themes chosen for the end-user evaluation. Chapter 4 presents the results of the evaluation. Chapter 5 provides the conclusions from the work done.

1.2. Discussion on the objectives of tasks

The overall focus of the BuildERS project is to analyse the multiple factors that make people vulnerable in natural and man-made disasters, empower those who are most vulnerable and strengthen their role in crisis or disaster management. In other words, BuildERS project seeks to measure and mitigate people's vulnerability by developing innovative processes and practical tools for vulnerability assessment and building people's capacity to cope with crises.

Our innovations are primarily targeted for the crisis managers: civil protection authorities, fire and rescue services, law enforcement, and the service providers of health care, socio-psychological support in crisis. In addition, these innovations benefit their strategic partners, like the non-profit and civil society organizations active in inclusive and participatory resilience building.

This report contributes mainly to reaching the BuildERS project's Objective 3 to analyse and provide foresights on how new technologies and tools could support resilience building. Furthermore, BuildERS project has been engaging external stakeholders in the co-creation of practical solutions and validation of policy recommendations Within the WP6 we have discussed the research findings with our Stakeholder Forum comprising of experts of various fields: civil protection, risk and crisis communication, social services, and technology development, to name a few.

This report presents the results of T6.3's end-user evaluation of new tools and technologies for disaster management. The technological themes explored are following:

- Emerging technologies for risk and vulnerability assessments,
- Location-based services,
- Data sharing between authorities for crisis management,
- Crowdsourcing for improving preparedness.

All the results presented in this report will be utilised in BuildERS WP5 and in the making of recommendations how to better raise awareness of crises and improve preparedness.

The aim of T6.3 was to produce "end-user evaluations of the new technologies identified in the Catalogue of tools and technologies for disaster management"[1]. The term *tool* refers to a specific guideline, method or information ICT-based application, which can help in disaster management to improve the resilience of

[1] see more in BuildERS report D2.4 catalogue of tools, technologies and media opportunities for disaster management, BuildERS project website: https://buildersproject.eu/results

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vulnerable people, their communities and society at large. The term *technological enabler* refers here to specific physical capability that can be used for making multiple such tools. For example, the capability to detect the location of physical assets using global positioning system (GPS) is such a technological enabler. The term *emerging technology* refers here to the potential application area which the technological enabler(s) make possible. For example, location based services are such an emerging technology, which can be used to develop multiple different kinds of tools. Later in this deliverable, the term *technology* is applied in the general meaning referring to set of technological enablers and related emerging application area.

The evaluation and assessment were done in two phases. First, three evaluation and assessment surveys were carried out in the BuildERS case studies that included technology testing. Second, evaluation and assessment activities were implemented in co-creative workshops with technology partners, first responders and service providers, officials of cities and local communities, supportive NGOs, and other stakeholders. The results will give insights to the desirability of new technologies, but also a critical assessment of risks and challenges, including ethical issues, that might arise when a certain type of technology is used. The perspective will be end-user centric, thus complementing Task 2.5.

Although the results of the end-user evaluation of technology and tools are presented in this report, the results will be further analysed and discussed in Task 5.3 “Technical tools to improve resilience, innovation prospects”.

The key terms of the report and their definitions are listed below. Terms have been presented more deeply in the BUildERS deliverable D1.2 (Morsut 2020). These definitions were also presented to the end-users who evaluated the technologies in the workshops.

Disaster risk management

“Disaster risk management is the application of disaster risk reduction policies and strategies to prevent new disaster risk, reduce existing disaster risk and manage residual risk, contributing to the strengthening of resilience and reduction of disaster losses” (UNISDR, 2019).

Resilience

Processes of proactive and/or reactive patterned adjustment and adaptation and change enacted in everyday life, and in particular, in the face of risks, crises and disasters.

Risk assessment

“Risk assessment (…) is part of the broader risk management process. Risk assessment in turn consist of three tasks: risk identification, risk analysis, and risk evaluation. Risk identification is the initial process of finding, recognising and recording risks. Risk analysis is about developing an understanding of the risk by developing the consequences and their probabilities for the identified risks. Risk evaluation delineates the significance of the level and type of risk” (Pursiainen, 2018:14).

Social capital

The networks, norms, values and trust that entities (individuals, groups, society) have available, and which may offer resources for mutual advantage and support and for facilitating coordination and cooperation in case of crisis and disasters.

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Vulnerability

Dynamic characteristic of entities (individuals, groups, society) of being susceptible to harm or loss, which manifests as situational inability (or weakness) to access adequate resources and means of protection to anticipate, cope with, recover and learn from the impact of natural or man-made hazards.

Vulnerability assessment

The process of identifying, quantifying, and ranking vulnerabilities in a system.

2. Methods and process

2.1. Data collection

Data collection from end-users has been carried out in two phases with different research methods, in order to get diverse perception to the desirability of the new technology and also their risks and challenges. In the first phase, we invited the external stakeholders to respond to a surveys, and evaluate the potential of a particular tool and the respective enabling technology. The survey participants took part in the BuildERS case studies (within WP4) and also tested the above-mentioned tools in practice during simulation exercises and workshops. The second end-user validation phase was within WP6 and included online workshops and expert interviews. As a facilitation tools we used a digital platform called Howspace, which enables multi-media presentations, chat-type of interactive discussions, and collection of responses to various kinds of polls[2]. This second phase happened about six months after the first round and was conducted with different end-users. In other words, the iteration rounds reported here took further the results of WP4 case studies.

The WP4 case studies that carried out the first phase of end-user evaluation were the following:

- Case study D4.1 in Finland titled: “Managing chemical spill emergency and mis-/disinformation through simulated responses” (Jukarainen et al 2021) provides solutions for how to reduce communication-related vulnerabilities of people who’s cognitive and/or mental conditions might restrict them from perceiving the hazard danger and adopting self-protection measures, and who thus are exposed to higher life or health-threatening risks when a disaster strikes.
- Case study D4.3 in Estonia provides a practical innovation for “applying mobile positioning data for more precise rescue planning and emergency management under cyber-hazard in Estonia” (Võik et al 2021a). Mobile positioning data (MPD) enables to evaluate the mobility patterns of people – where, when, how and how much people move and stay. This information is important in emergency management before and during disasters.
- Case study D4.7 in Indonesia titled: “Using Mobile Operators’ Data to Locate, Protect and Evacuate Tourists and Other Vulnerable Groups in Disasters” (Võik et al 2021) has developed a dashboard using mobile positioning data (MPD), for better awareness about individuals that have fallen into vulnerable situations.

The questionnaire-based survey was implemented as a part of the simulation exercises and workshops conducted in WP4. The survey was built in the Webropol system, which is a web-based survey tool. The

[2] Howspace is an all-in-one digital facilitation platform specifically designed for facilitator-led workshops and events. See more information https://www.howspace.com/. See more of the use of Howspace in BuildERS project in report D6.1 “Online platform open and in operation” (Jukarainen et al. 2019).

participants of the exercise or workshops received a link to the survey, and they were asked to answer the questionnaire right after the exercise or workshop. As all the participants did not answer in the given time, the timeline of the survey was extended for a specific amount of time (from one week to one month to get enough results). The survey was anonymous and personal or identifying information was not collected in the survey. The questionnaire is Annex 1.

The second phase of collecting evaluation data started with an online kick-off event where technology themes and some technological solutions were presented. This stage took further also the results of another case study in Estonia: D4.4. “Integration of public data bases for identifying highly vulnerable people in need of relief prioritisation by the Estonian Rescue Board” (Orru et al 2021a)“ [3]. This case study innovated a vulnerability assessment tool that brings together the varied factors of vulnerability and their representations in public datasets.

After the kick-off event, the online workshops with Howspace-tool were opened for the end-users to comment on and evaluate the technologies. The online workshops were open during 5.10.-30.11.2021. Each workshop consisted of an informative part and an evaluation part. The informative part included written descriptions of technology theme, and its associated technological solutions. This included written descriptions, figures, video recordings, and links to the material elsewhere (e.g. a link to the research project web site). In the evaluation part participants answered questions. There were both questions with answers on the Likert scale ranging from 1-5 and open-ended questions.

Part of the functionality of Howspace-platform is that it enables a participant to comment on other responders’ answers. If there is an answer to an open question, other responders can see it and add their comments. There is no limit on the number of comments that can be added. This makes it possible to co-create ideas and incorporate previous suggestions in an online workshop that is open for a longer time. (Compared to an online workshop where all participants are present at the same time and discuss together. This can be arranged via online Teams meeting, for example.) The features of the Howspace platform also allowed to write comments under a pseudonym, if a person favoured anonymous participation.

The online workshop results were supplemented by expert interviews. In the interviews, the same question format as in the Howspace-platform was used. The interviewer read out loud the question one by one, and the interviewee gave their answer which the interviewer wrote up. The interviews were carried out via Teams-meetings. At the beginning of the interview, the interviewer described shortly all of the technological themes and the interviewee chose the themes they wanted to answer. The interviews lasted between 30-60 minutes.

2.2. Data analysis

The results of questionnaire-based surveys were analysed with quantitative methods. First, the responses were summarised by calculating the frequencies of different responses for each question. Then, basic statistical figures such as N, mean and standard deviation were calculated. Before calculating the statistical figures, responses not belonging to the measurement scale such as responses in category “I do not know” were excluded. The analysis was carried out with SPSS software.

[3] See more in: Orru, K. M. Klaos, K. Nero, F. Gabel, P. Saar, S. Hansson, S. Torpan, E. Tammepõld, A. Alev, J. Ludvigsen (2021a) BuildERS D4.4 integration of public data bases for identifying highly vulnerable people in need of relief prioritisation by the Estonian Rescue Board, BuildERS project.

The results of the online workshops and expert interviews were analysed using content analysis. The analysis focused on what issues, topics and themes emerged from the information: what key issues and typical meanings were covered in the workshop participants' responses and what the interviewees were talking about. The analysis was carried out by researcher-driven and no computer-aided software was utilised.

2.3. Overview of the evaluation process

The process for end-user evaluation of technologies and tools is described in Figure 1. Based on the preliminary evaluation carried out in WP2 (task 2.5), and a collection of a catalogue of different technological fields and solutions, we planned the process of end-user evaluation. This process was carried in parallel within two work packages: WP6 (engagement of stakeholders in the validation and co-creation) and WP4 (case studies in different countries).

The first step was a survey of emerging technologies and tools[4]. During that process, the importance and applicability of emerging technologies were evaluated in a preliminary way and the set of tools were categorized. It is essential to point out that it is here assumed that each emerging technology, such as e.g., location-based services, can be applied to multiple tools in several different ways. Based on the preliminary evaluation carried out in WP2, the end-user evaluation of new tools and technologies for disaster management was planned in detail (to be implemented in WP6). In parallel to this work, Builders WP4 was working with the case studies, and so there was the possibility to include an evaluation of the individual tools applied in the WP4 case studies.

There were three case studies, which tested a specific technological solution. T4.1 used a platform to simulate crisis communication developed for the training purposes called Trasim exercise platform[5]. T4.3 and T4.7 used a dashboard utilizing Mobile Positioning Data (MPD)[6]. These individual tools were evaluated with a questionnaire-based survey of these specific tools applied in the referred WP4 case studies and clarified in the section 2.2 of this deliverable. Work package leaders decided to invite end-users to evaluate the emerging technologies collaborative Howspace workshops. Originally, this was planned to happen in face-to-face workshops in international conferences, however, due to the Covid-19 travel restrictions, work package leaders decided to organize all these workshops in virtual manner.

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[4] See more in: Latvakoski, J., A. Bäck, E. Parmes, R. Öörni, Ö. Ceylan, A. Tominga, K. Orru, E. Siim, M. Klaos, A. Galvagni, A. Schieffelers, M. Myllylä, P. Jukarainen, M. A. Berawi, M. Max (2020) BuildERS D2.4 Catalogue of tools, technologies and media opportunities for disaster management, BuildERS project.

[5] See more in: Jukarainen, P., M. Myllylä, C. Kattelus, R. Mäkelä, S.-T. Ames J. Argillander A. Bäck, T. Lusikka (2021) Managing chemical spill emergency and mis-/disinformation through simulated responses, BuildERS project.

[6] See more in reports: Võik, E.-J., A. Tominga, M. Klaos, S. Silm, K. Orru, T. Lusikka (2021a) BUILDERS D4.3 Practice & product innovation "Applying mobile positioning data for more precise rescue planning and emergency management under cyber-hazard in Estonia", BuildERS project; Võik, E.-J., M. Sari, U. A.V. Salim, M. A. Berawi, T. Lusikka (2021b) BuildERS D 4.7 Indonesian Case "Using Mobile Operators' Data to Locate, Protect and Evacuate Tourists and Other Vulnerable Groups in Disasters, BuildERS project.

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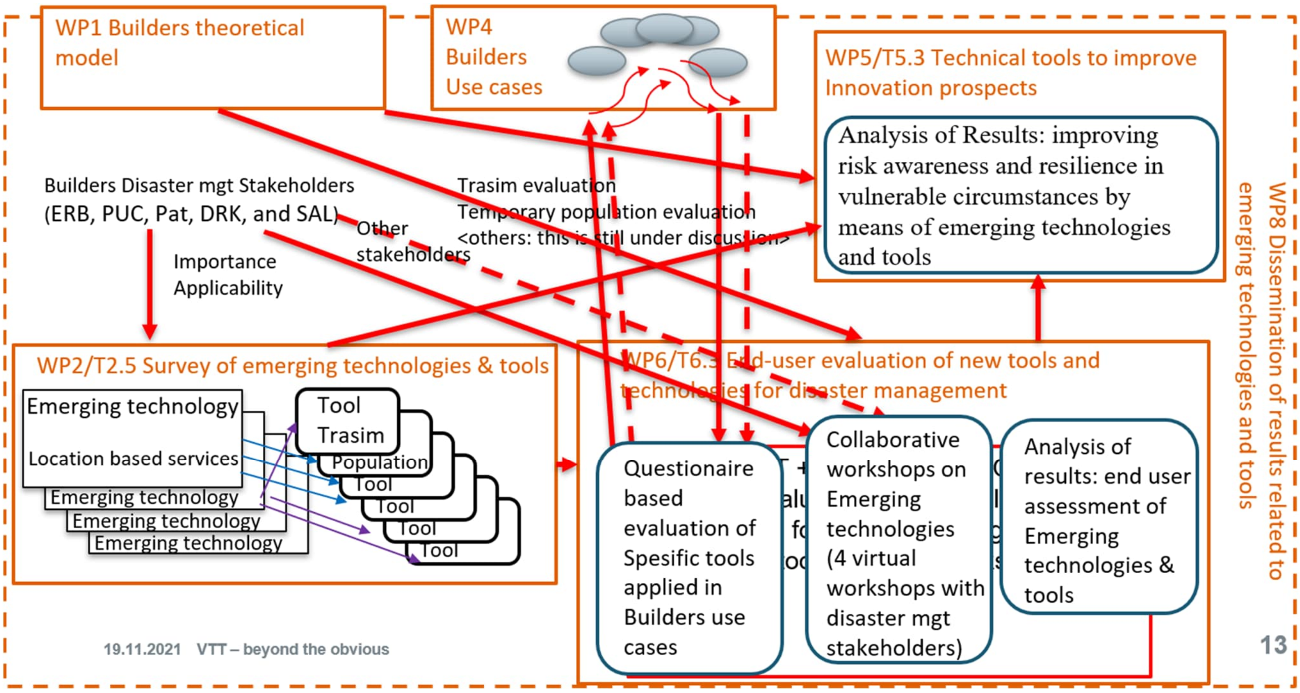

Figure 1. Evaluation process of the technologies and tools.

The evaluation of the emerging technologies was carried out by four international and virtual Howspace workshops with the following themes:

1. Emerging technologies for risk and vulnerability assessments (satellite-based solutions, connectivity (5G and Internet of Things), drones and Artificial Intelligence),
2. Location-Based Services (and positioning technologies),
3. Data sharing between authorities for crisis management,
4. Crowdsourcing for improving preparedness.

Each workshop was targeted to evaluate the critical issues related to the innovation potential of these emerging technologies from such perspectives as desirability and usefulness of the new technology, level of use, importance, applicability, capabilities in pinpointing vulnerable people, risks and challenges, gaps (process, technological, financial etc.), and ethical acceptability.

Background to the assessment of new technologies is provided in Section 2.2. The background was used to formulate the evaluation criteria for the emerging technologies and tools applied in the BuildERS case studies. This deliverable D6.4 also describes the referred evaluation of individual tools applied in the BuildERS case studies in Section 2.3. The evaluation of emerging technologies is clarified in Section 2.4.

Within WP5, we will contextualize various technological solutions in different socio-economic environments, and develop policy recommendations for the European disaster management. The key question will be: What kind of innovation prospects there are and where should be invested?

2.4. Background to the assessment of new technologies

Ethical and moral principles and perspectives regarding technology development are numerous. Ethical issues are probably most easily highlighted in technologies that provide the opportunity to identify and monitor people, as these technologies can oversee behaviour and actions of individuals without individuals' knowledge. Thus, when evaluating technologies there are many ethical and moral principles that need to be considered. For example, the following aspects need to be considered (Leikas 2008):

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- From the perspective of the end-user:
    - dignity, integrity, respect for rights, autonomy, informed consent, right to decline, trust, competence, democracy, equality, justice, respect, identity, participation, protection of user, protected from surveillance, safety, access, do no harm, choice, voluntariness, protection of data and privacy.
- From the perspective of the developer:
    - reliability, protected from surveillance, security, agreement, competence, accountability, respect for intellectual property rights and comprehension.
- From the perspective of the society:
    - equal benefit, cooperation, conventions, freedom from bias, social impact of technology and role in the society.

The technological Readiness Level (TRL) measures the technological maturity of a product or technology (Öörni 2019). TRL method was originally developed by NASA for assessment of the maturity of new technologies in the 1970s. Since then, the European Commission has made their own definition for TRLs. In this research, we have used their TRL definition when evaluating the maturity of the new technologies (European Commission 2017):

- TRL1: Basic principles observed
- TRL2: Technology concept formulated
- TRL3: Experimental proof of concept
- TRL4: Technology validated in lab
- TRL5: Technology validated in relevant environment
- TRL6: Technology demonstrated in relevant environment
- TRL7: System prototype demonstration in operational environment
- TRL8: System complete and qualified
- TRL9: Actual system proven in operational environment.

2.5. Evaluation of tools applied in BuildERS three case studies

The content of the survey was defined based on the objectives expressed in BuildERS work plan. As explained in the description of task 5.3, the high-level objective of the evaluation was to analyse the tools in societal, policy and financial contexts. More specific objectives were defined in the description of task 6.2. These involved (1) studying the innovation potential related to the tools, (2) providing an insight into their desirability, and (3) providing a critical assessment of their risks and challenges.

Different definitions have been provided for innovation, and the innovation potential of a technology or a tool can also be understood in different ways. The innovation potential of different tools was analysed by looking at the combination of the technical readiness of the tool, its potential impact and enablers and barriers for implementation. Technical readiness can also be an important enabler or barrier for adoption of new technology or tool. It was therefore covered as a separate question in the end-user evaluation.

The desirability of a tool was understood as a combination of user acceptance and societal acceptance of the tool. Societal acceptance of a new technology will be affected at least by at least efficiency, effectiveness, absence of unacceptable risk and ethical acceptability. This implies that the desirability of technologies or tools is understood from societal and ethical point of view. For user acceptance, different definitions have been provided in research on adoption of new technologies. In this case, user acceptance was understood as study participants' willingness to use the tool again.

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Based on the objectives for tasks 5.3 and 6.2 and the terminology described above, the following objectives were defined for the survey:

(1) to study the users' acceptance of the tool, defined as
- willingness to use the technology or tool again
- willingness to have the technology or tool in regular use

(2) to study users perceptions on characteristics affecting societal acceptance of the tool, including
- efficiency
- effectiveness
- perceived risks and challenges
- ethical acceptability

(3) to explore desirability of the new technology or tool, based on its user acceptance and characteristics affecting societal acceptance

(4) to study users' opinions on the technical readiness of the tool or technology.

The first part of the survey collected information on respondent's background such as respondent's stakeholder group and experience with the tool. The second part of the survey focused on respondent's opinions on the tool such as its effectiveness in achieving its purpose, efficiency in terms of resource usage, wiliness to have the tool adopted in regular use in respondent's own country, willingness to use the technology or tool again. There were also other statements measuring the perceptions of the respondent on the other characteristics of the tool such as ease of use, clarity of instructions, accessibility and suitability for civil protection, crisis management and disaster risk reduction. Respondents opinions of the tool were measured with five-step Likert scale (1: Strongly disagree, 2, 3, 4, 5: Strongly agree). In addition, there was a response option "I do not know".

The third part of the survey measured the risks and challenges related to the tool. The risks and challenges related to the tool were defined in a technology-neutral way. The list of risks and challenges presented to the respondents covered e.g. the costs and benefits of the tool, its technological maturity, possible adverse impacts on vulnerable groups, regulatory barriers and societal acceptance of the tool.

The fourth part of the survey covered the ethical acceptability of the tool or technology. First, a number of ethical risks had been identified in earlier work carried out in BuildERS. Respondents of the survey were asked to provide their opinions on how likely the risks will be realised and how serious they are. The probability of a risk being realised was measured with a five-step scale: 1 Very unlikely, 2 Unlikely, 3 Likely, 4 Very likely, 5 Certain. A five-step scale was used also for measuring risk severity: 1 Very minor, 2 Minor 3 Moderate, 4 Serious, 5 Very serious.

The fifth part of the survey explored the stages of a crisis in which the tool is relevant, the relevancy of the tool for protecting individuals, specific groups or the whole society and the ways the tool will improve survival in a crisis. The sixth and final part of the survey included questions related to technological maturity of the tool.

Builders case studies were identified as a good opportunity to get reliable information about the used tools from actual users of the tools. As described earlier, we selected three technology-testing case studies that tested technological tools before further analysis.

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Trasim simulation tool[7] developed by Insta Digital can be used for interactive testing of the effectiveness of the crisis management procedures and operating models. It can also be used to train crisis managers to communicate better during acute crisis situations. The tool can be used independently or to support facilitation of table-top exercises as was the case in our preparedness drills. It has also been used amply to support cyber security related functional exercises and major incident management, including testing of operating models between top management, communications units, service business management and Security Operations Centres (SOC) In the case study we explored the potential of Trasim-tool to raise awareness about the accessibility of communication. We tested whether the tool can be used in the training of communication-related vulnerabilities. Within the WP6 we assessed e.g how close to reality were the simulation exercises and the interagency collaboration during the drill. We also explored whether the tool helped participants to learn to protect individuals and groups from targeted bullying and/or hate speech and learn how to interact with vulnerable individuals and groups.

Task 4.3 demonstrated the possibilities of the mobile positioning data (MPD) usage in the crisis management area. BuildERS project partner Positium had built a dashboard that shows historical MPD and can show visually how many people are in different areas and what kind of people are there (people living in the area, people working in the area, people who regularly visit the area, domestic tourists, foreign tourists) and also how many people in the area have a secondary home and how far away it is from the chosen spatial unit. In T4.3 focus was on vulnerability against man-made and other hazards, such as cyber-attacks and extensive storms[8].

Task 4.7 also demonstrated the possibilities of the MPD usage in the field of crisis management, but with different use case. T4.7 focused on natural disasters and temporary population such as tourists. Unlike in the case study 4.3 where historical mobile positioning data (MPD) is used, the Indonesian case study explores how near real-time MPD can be used for crisis management. The dashboard can help rescue services to plan their human and material resources more accurately during crises. Through more exact planning and knowledge of potentially vulnerable people's (like non-native speaker tourists) whereabouts during crisis, the processes of aid and relief during disaster can be faster and more effective. The dashboard currently has simulated event data in it, but it was built and validated as if the data was real. With the help of dashboard, national, regional and local authorities are able to use the country of residence information in communication with foreign consulates to let them know how many people and from which countries were potentially affected by the crisis. With this information authorities can also support rescue services with resource and evaluation planning[9].

In the spirit and guidelines of BuildERS project, questionnaire was translated to Finnish, Estonian and Indonesian, and respondents answered the survey in their native language. The general questionnaire was implemented in all three case studies, but in the Finnish case study, there was one extra section "Questions on the Trasim tool" that included one Trasim specific question that had different statements.

[7] Insta Digital Oy: https://www.insta.fi/en/services/national-security/exercise-activities
[8] For more information about the dashboard tool, see Võik, E.-J., A. Tominga, M. Klaos, S. Silm, K. Orru, T. Lusikka (2021a) BUILDERS D4.3 Practice & product innovation "Applying mobile positioning data for more precise rescue planning and emergency management under cyber-hazard in Estonia", BuildERS project
[9] More about the dashboard tool: Võik, E.-J., M. Sari, U. A.V. Salim, M. A. Berawi, T. Lusikka (2021b) BuildERS D 4.7 Indonesian Case "Using Mobile Operators' Data to Locate, Protect and Evacuate Tourists and Other Vulnerable Groups in Disasters, BuildERS project

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2.6. Evaluation of emerging technologies in Howspace workshops

The purpose of the evaluation of emerging technologies was to identify technologies that hold the most innovation potential for disaster management. The evaluation was end-user centric, and it was done in co-creative workshops with technology partners, first responders and service providers, officials of cities and local communities, supportive NGOs and other stakeholders. The results give an insights into the desirability of the new technology but also a critical assessment of their possible risks and challenges such as ethical issues. The perspective will be end-user centric, thus complementing the Task 2.5. The workshops were organized as virtual workshops in the Howspace platform, and they are described in detail in Chapter 3.

2.6.1. Evaluation questions in the Howspace workshops

Evaluation questions represented in the Howspace workshops were formulated on the basis of the questionnaire-based survey questions which were used in the evaluation of case studies (described in the previous section). These themes were the starting point for the building of a series of questions.

To get a more detailed understanding of the possibilities of technology to identify and assist vulnerable people in crisis, perspectives related to the identification and assessment of vulnerability were included in the series of questions. Future perspectives, innovation potential, and costs related to the benefits of technology in crisis management were also included in the series of questions. At the final version of the series of questions included 18 questions. Final evaluation themes and questions or arguments providing information for each themes are presented in Table 1.

Table 1. Evaluation themes and associated evaluation questions or statements in the Howspace workshops.

Evaluation theme	Evaluation question/argument in the Howspace workshop	Response option
Desirability and usefulness of the new technology	This technology is very useful.	1) strongly disagree, 2) disagree, 3) not agree or disagree, 4) agree, 5) strongly agree
Level of use of the tool/technology now (TRL level, who use, which level the use is etc.)	*Not included, if the estimation is needed, this item will be evaluated by researchers.*	
Importance, potential benefits for the stakeholders	What kind of benefits would this technology offer for crisis management?	Open
Applicability, which life-cycle phases technologies could be used, what process could be improved	How would you use this technology in crisis management?	Open
Capabilities in pinpointing vulnerable people	How could this technology be used in identifying vulnerabilities that are not currently addressed?	Open

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	How could this technology be used to find vulnerable people in crisis situations?	Open
	What kind of data could be gathered using this technology to make vulnerability assessment?	Open
Risks and challenges	What risks do you see in using this technology?	Open
	What challenges do you see in adopting this technology?	Open
Gaps (process, technological, financial etc.)	What kind of gaps do you see related to applying this technology?	Open
Innovation potential related to societal, policy and financial aspects	This technology has great innovation potential.	1) strongly disagree, 2) disagree, 3) not agree or disagree, 4) agree, 5) strongly agree
	Give some examples.	Open
Ethical acceptability	This technology contains major ethical issues.	1) strongly disagree, 2) disagree, 3) not agree or disagree, 4) agree, 5) strongly agree
	Give some examples.	Open
	This technology can increase or create risks for vulnerable people.	1) strongly disagree, 2) disagree, 3) not agree or disagree, 4) agree, 5) strongly agree
	Give some examples.	Open
Cost and benefit (market perspective, monetary values)	This technology has great benefits with regards to its costs.	1) strongly disagree, 2) disagree, 3) not agree or disagree, 4) agree, 5) strongly agree
Future perspectives	This technology should be adopted to regular use in my country.	1) strongly disagree, 2) disagree, 3) not agree or disagree, 4) agree, 5) strongly agree
	This technology will be used widely in crisis management in 5-10 years.	1) strongly disagree, 2) disagree, 3) not agree or disagree, 4) agree, 5) strongly agree
	How do you see the future of this technology?	Open

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2.6.2. Themes of technology evaluation

Technology themes involved in the end-user evaluation were based on the work done in Task 2.5. In T2.5, a survey was carried out to investigate possible technologies to support crisis management (more detailed see D2.4). Identified technologies were linked to the following themes 1) crowdsourcing and social media, 2) media and communication related opportunities, 3) creation and use of location based information, 4) use of drones, 5) automatic analysis of texts and images with machine learning and artificial intelligence, and 6) new technological opportunities (e.g. 5G, IoT, sensor technologies, blockchains etc.). All the above-mentioned technology themes were included in Task 6.3 but categorised slightly different. New themes created by the researchers were: emerging technologies, location-based technologies, data exchange between authorities, and crowdsourcing. Technology themes are described in more detail in Chapter 3.

2.6.3. End-user groups for evaluation

Based on the task description, target groups for evaluating the technology included technology partners, first responders and service providers, officials of cities and local communities, supportive NGOs, and other stakeholders. We defined technology partners as technology developers and service providers focusing on solutions applicable in disaster management. More specifically, these actors could be, for instance, ICT-developers or ICT- project managers. First responders and service providers are agencies working in the first wave during acute disasters. Officials of cities and local communities could be agencies of strategic civil protection and crisis management or operational civil protection and crisis management. They could also be contact points for risk assessment and/or preparedness planning or more communication-oriented agencies like communication specialists. Supportive NGOs typically act in the second wave of disasters and they usually provide aid right after official rescue organisations. Other stakeholders could be agencies focusing on, e.g., education, consultancy services or legal services.

The above-mentioned target groups were selected as they are potential actors involved in crisis management. They are also actors who would benefit from the use of emerging and novel technologies, services, applications, and tools supporting crisis management. Suitable end-users were identified in almost all partner countries. Actors may vary, as the organisation and implementation of crisis management varies country by country. Only Sweden was left out from this task because the Swedish partners had their own surveys going on at the same time.

It was decided that each partner would send invitations for end users from their own email address so that we would get as many responses as possible. The invitation was also sent to all people who participated in the kick-off event, which pre-dated the opening of the Howspace workshops. In Task 2.5 (Catalogue of tools and technologies for disaster management), a survey of emerging technologies and tools was carried out. An invitation was also sent to all suitable emerging technology and tool developers to participate in the Howspace workshops. A total of about 260 invitations was sent.

2.6.4. Motivation factors to improve participation in the evaluation

It is well-known that it is not easy to get respondents to take part in research surveys or polls. We decided to overcome this challenge by offering compact and novel information on technology and some insights of possibilities of technology in disaster management to the end-users that we were hoping to participate in the Howspace workshops.

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The first motivational action was to organise an online event where we could present and discuss the technology being evaluated with end-users. The online kick-off event of end-user evaluation was arranged on 5th October 2021 via Teams. In the event, both BuildERS partners and some external experts gave short presentations on technological solutions applicable to disaster management. The audience had an opportunity to make comments, ask questions and discuss. The Howspace platform was presented for the audience and guidance on platform functionality was given. The audience was encouraged to register themselves on the platform, answer questions, and share their thoughts. The time limit (one month) of the Howspace workshops was announced to the audience. The agenda of the event is Annex 2.

The second motivational action of end-users to participate in the evaluation process was to offer information on each technology theme and chosen technological solutions in the Howspace platform. We built informative sections at the beginning of each technology theme where end-users could find information about relevant technology. Our target was to strengthen participants' willingness to answer the evaluation questions by offering them information and the opportunity to possibly learn about new issues.

Several reminder messages were sent during the Howspace workshops were open (from 5th October to 30th October). Our experience is that it is difficult to get participants even to online workshops that are open for a long time. Even though people have a possibility to participate when it is the most suitable for them, there seem to be obstacles to participation. Our guess is that during the Covid-19 situation the amount of online events and surveys have increased enormously so people may found it time-consuming to participate.

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3. Technological themes

Four technological themes were selected for the evaluations. These themes were emerging technologies, location-based technologies, data exchange between authorities, and crowdsourcing. A specific area was set up for each of these technologies.

3.1. Emerging technologies for risk and vulnerability assessment

Four technologies were selected for emerging technology evaluation: Satellite-based solutions, Connectivity, Drones, and Artificial Intelligence (AI). A specific section was created for each of these topics. Each section consisted of a brief introduction of the technology and how it could be used in crisis management, one or two videos giving additional information, and the evaluation questions.

3.1.1. Satellite-based solutions

Satellites provide a way to monitor large areas of the Earth. Earth-orbiting remote-sensing satellites and meteorological satellites provide information both for hazard risk mapping and for hazard detection, monitoring, and mapping. Their passive optical instruments measure the reflected or emitted visible and infrared radiation, while thermal instruments measure the temperature, and active Save And Rescue (SAR) or radar instruments measure distances and the backscattering intensity (intensity value of the reflection of waves, particles, or signals back to the direction from which they came).

Typically, floods and wildfires can be mapped accurately from optical images, landslides and earthquakes from SAR images, and heat waves and storms from meteorological satellites. The critical parameters of satellite images are spatial resolution (or pixel size) and timeliness. The spatial resolution spans from 0.3 m to several kilometres. The timeliness of the satellite images is a challenge as only few organizations have possibility to direct the satellites toward the hazards areas, so satellites are not always in optimal locations for SAR.

Copernicus is the European Union's Earth observation program, which looks at our planet and its environment to benefit all European citizens. It offers information services that draw from satellite Earth Observation and in-situ (non-space) data. Based on satellite and in-situ observations, the Copernicus services deliver near-real-time data on the global level that can also be used for local and regional needs to help us better understand our planet and sustainably manage the environment we live in. The Copernicus Emergency Management Service (Copernicus EMS) provides all actors involved in the management of natural disasters, man-made emergency situations, and humanitarian crises with timely and accurate geospatial information. This information is derived from satellite remote sensing and completed by available in-situ or open data sources. The mapping component of the service (Copernicus EMS – Mapping) has worldwide coverage and provides the above-mentioned actors (mainly the Civil Protection Authorities and Humanitarian Aid agencies) with maps based on satellite imagery. The Copernicus EMS also has early warning components that consist of flood awareness system, a forest fire information system and drought observatory.

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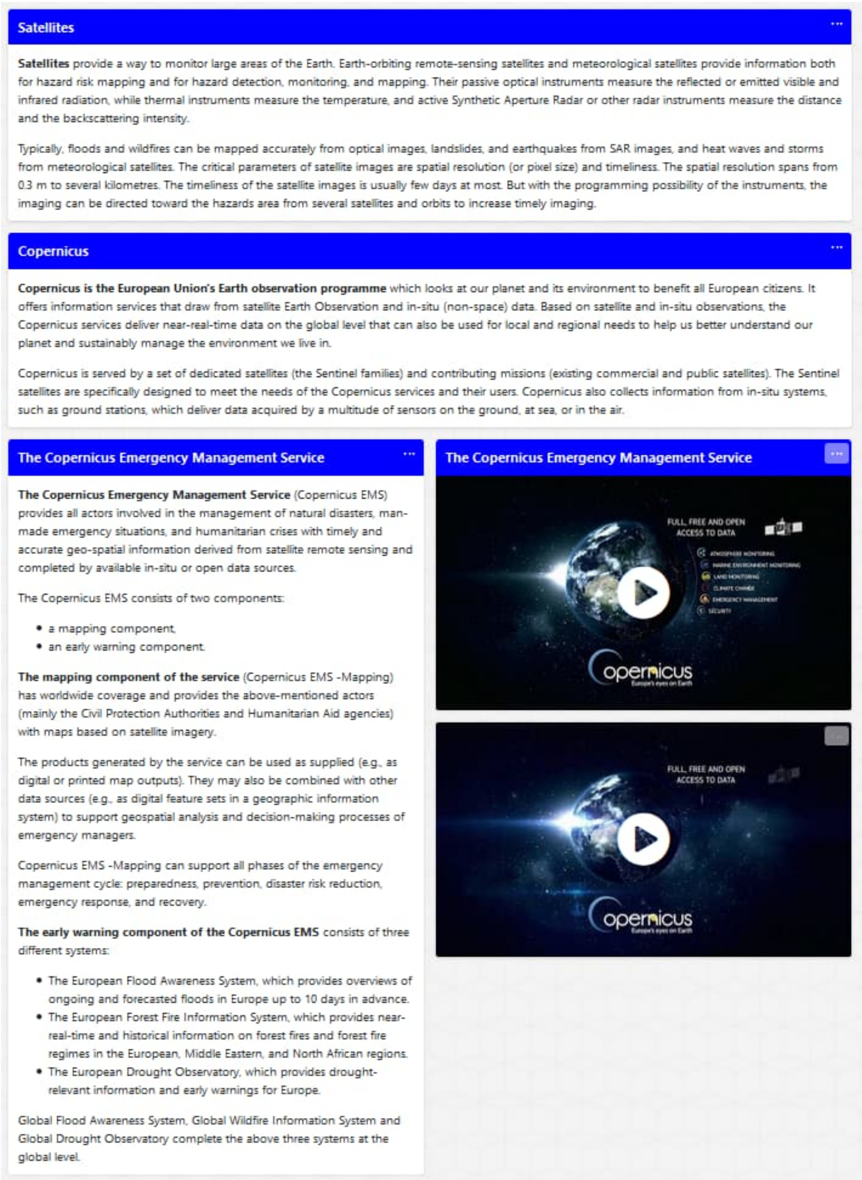
Satellites

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Typically, floods and wildfires can be mapped accurately from optical images, landslides, and earthquakes from SAR images, and heat waves and storms from meteorological satellites. The critical parameters of satellite images are spatial resolution (or pixel size) and timeliness. The spatial resolution spans from 0.3 m to several kilometres. The timeliness of the satellite images is usually few days at most. But with the programming possibility of the instruments, the imaging can be directed toward the hazards area from several satellites and orbits to increase timely imaging.

Copernicus

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Copernicus is served by a set of dedicated satellites (the Sentinel families) and contributing missions (existing commercial and public satellites). The Sentinel satellites are specifically designed to meet the needs of the Copernicus services and their users. Copernicus also collects information from in-situ systems, such as ground stations, which deliver data acquired by a multitude of sensors on the ground, at sea, or in the air.

The Copernicus Emergency Management Service

The Copernicus Emergency Management Service (Copernicus EMS) provides all actors involved in the management of natural disasters, man-made emergency situations, and humanitarian crises with timely and accurate geo-spatial information derived from satellite remote sensing and completed by available in-situ or open data sources.

The Copernicus EMS consists of two components:

- a mapping component,
- an early warning component.

The mapping component of the service (Copernicus EMS -Mapping) has worldwide coverage and provides the above-mentioned actors (mainly the Civil Protection Authorities and Humanitarian Aid agencies) with maps based on satellite imagery.

The products generated by the service can be used as supplied (e.g., as digital or printed map outputs). They may also be combined with other data sources (e.g., as digital feature sets in a geographic information system) to support geospatial analysis and decision-making processes of emergency managers.

Copernicus EMS -Mapping can support all phases of the emergency management cycle: preparedness, prevention, disaster risk reduction, emergency response, and recovery.

The early warning component of the Copernicus EMS consists of three different systems:

- The European Flood Awareness System, which provides overviews of ongoing and forecasted floods in Europe up to 10 days in advance.
- The European Forest Fire Information System, which provides near-real-time and historical information on forest fires and forest fire regimes in the European, Middle Eastern, and North African regions.
- The European Drought Observatory, which provides drought-relevant information and early warnings for Europe.

Global Flood Awareness System, Global Wildfire Information System and Global Drought Observatory complete the above three systems at the global level.

The Copernicus Emergency Management Service

Figure 2. Copernicus service was presented as an example of satellite technology.

3.1.2. Connectivity

The so-called 5G has been under development since the year 2012 within wireless communities around the world. The target of 5G has been to facilitate a broadband-connected society via high-capacity optical networks for the backbone of 5G (virtual networks, network function virtualization, and network slicing). This allocates an additional spectrum for wireless communications and specification of the new 5G radio interface using the referred spectrum. On a practical level, actions have been taken related to detailed specifications for the new 5G radio interfaces, strategies to increase the use of radio spectra, and efficiency of emerging 5G systems and their realization in companies in the field. Today, many countries are deploying 5G. Telecom operators in about 50 countries are working and aiming to provide services for 5G before the end of 2022.

From the technological capabilities' perspective, 5G technology has a higher capacity, it is faster, and it has lower latency than previous generations. Therefore, it seems to be an essential enabler for more real-

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time communications with mobile assets such as vehicles, robots, drones, cameras, and other sensors, and this produces a large amount of data and requires low latencies in interaction with infrastructures. The mobile assets can be more effective if large amounts of data can be transmitted in real-time instead of having to wait until they return to their base. In addition, the mobile assets may even be controlled remotely based on the referred information streams. This means that 5G can provide essential novel opportunities, especially in increasing situational awareness and the real-time onsite operation of first responders in disaster situations.

The use of sensors for monitoring conditions that could trigger disasters dates back several years. Improvements in cloud computing, broadband wireless networks, the sensors themselves, and data analysis have led to the emergence of powerful, integrated, and real-time systems referred to as the Internet of Things (IoT).

Several definitions of IoT can be found online. The term generally refers to a worldwide network of interconnected objects having a unique identity and communicating digitally using standard protocols. Disaster management is an ideal place for IoT applications since sensors can send alerts about potentially dangerous situations. Tree sensors can detect if a fire has broken out by testing temperature, moisture, and carbon dioxide levels. Ground sensors can detect earth movements that might signal earthquakes. River levels can be monitored by sensors for possible flooding. From an implementation point of view, IoT is utilized by establishing a system that connects and feeds data to a main server or centers. The collected data in that aspect is then transformed and easily accessible by first responders and government officials.

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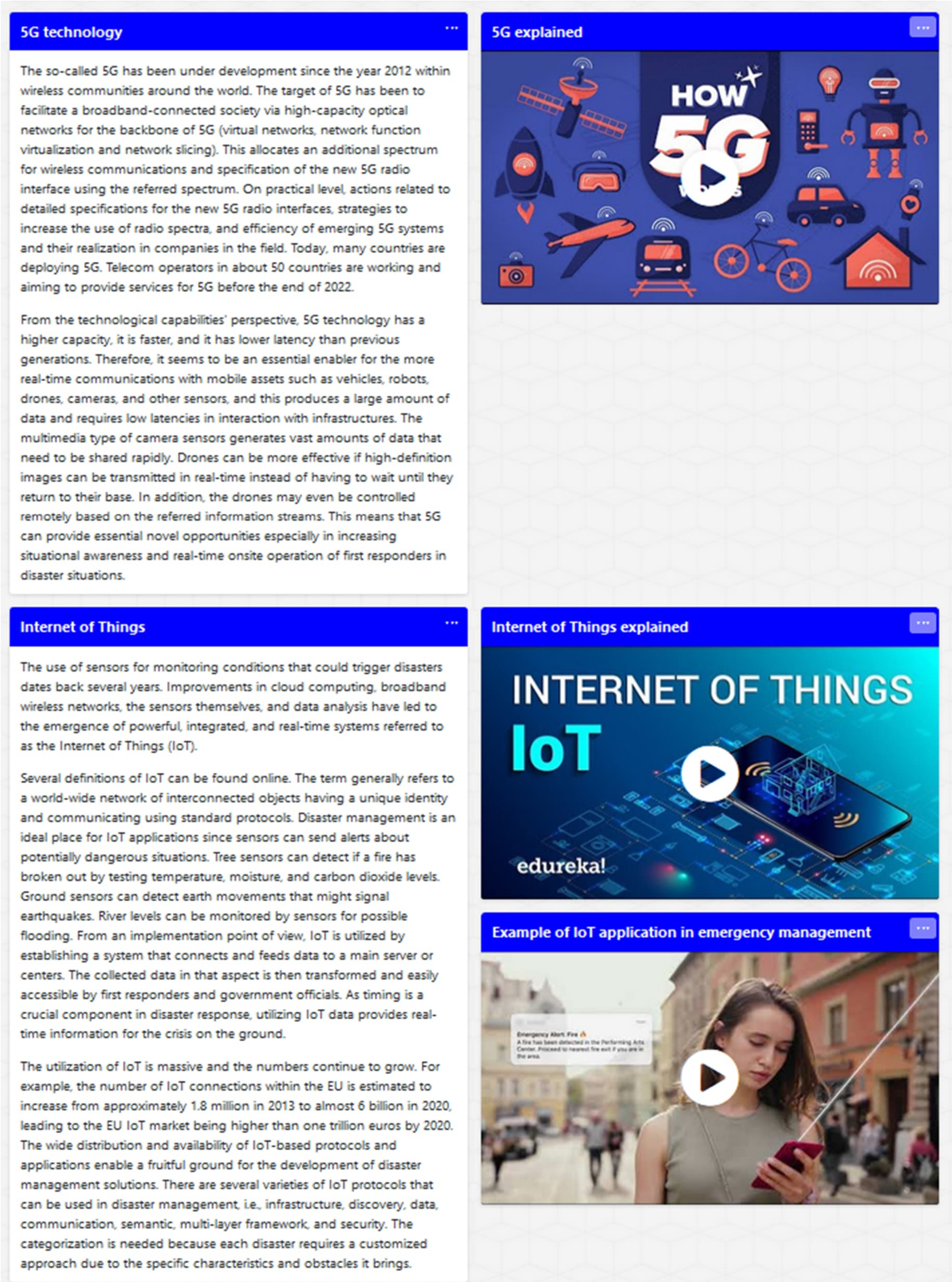
As timing is a crucial component in disaster response, utilizing IoT data provides real-time information for the crisis on the ground.



5G technology

The so-called 5G has been under development since the year 2012 within wireless communities around the world. The target of 5G has been to facilitate a broadband-connected society via high-capacity optical networks for the backbone of 5G (virtual networks, network function virtualization and network slicing). This allocates an additional spectrum for wireless communications and specification of the new 5G radio interface using the referred spectrum. On practical level, actions related to detailed specifications for the new 5G radio interfaces, strategies to increase the use of radio spectra, and efficiency of emerging 5G systems and their realization in companies in the field. Today, many countries are deploying 5G. Telecom operators in about 50 countries are working and aiming to provide services for 5G before the end of 2022.

From the technological capabilities' perspective, 5G technology has a higher capacity, it is faster, and it has lower latency than previous generations. Therefore, it seems to be an essential enabler for the more real-time communications with mobile assets such as vehicles, robots, drones, cameras, and other sensors, and this produces a large amount of data and requires low latencies in interaction with infrastructures. The multimedia type of camera sensors generates vast amounts of data that need to be shared rapidly. Drones can be more effective if high-definition images can be transmitted in real-time instead of having to wait until they return to their base. In addition, the drones may even be controlled remotely based on the referred information streams. This means that 5G can provide essential novel opportunities especially in increasing situational awareness and real-time onsite operation of first responders in disaster situations.

5G explained

Internet of Things

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The utilization of IoT is massive and the numbers continue to grow. For example, the number of IoT connections within the EU is estimated to increase from approximately 1.8 million in 2013 to almost 6 billion in 2020, leading to the EU IoT market being higher than one trillion euros by 2020. The wide distribution and availability of IoT-based protocols and applications enable a fruitful ground for the development of disaster management solutions. There are several varieties of IoT protocols that can be used in disaster management, i.e., infrastructure, discovery, data, communication, semantic, multi-layer framework, and security. The categorization is needed because each disaster requires a customized approach due to the specific characteristics and obstacles it brings.

Internet of Things explained

Example of IoT application in emergency management

Figure 3. Presentation of Connectivity opportunities through 5G and Internet of Things technologies.

3.1.3. Drones

Drones are basically unmanned vehicles that usually have no human occupants on board. Usually, the word “drone” refers to unmanned aerial vehicles (UAVs), but drones can also be applied to underwater or on-ground vehicles. The drones can also be classified as robots, which can be autonomous, semi-autonomous, and/or remote controllable cyber-physical entities.

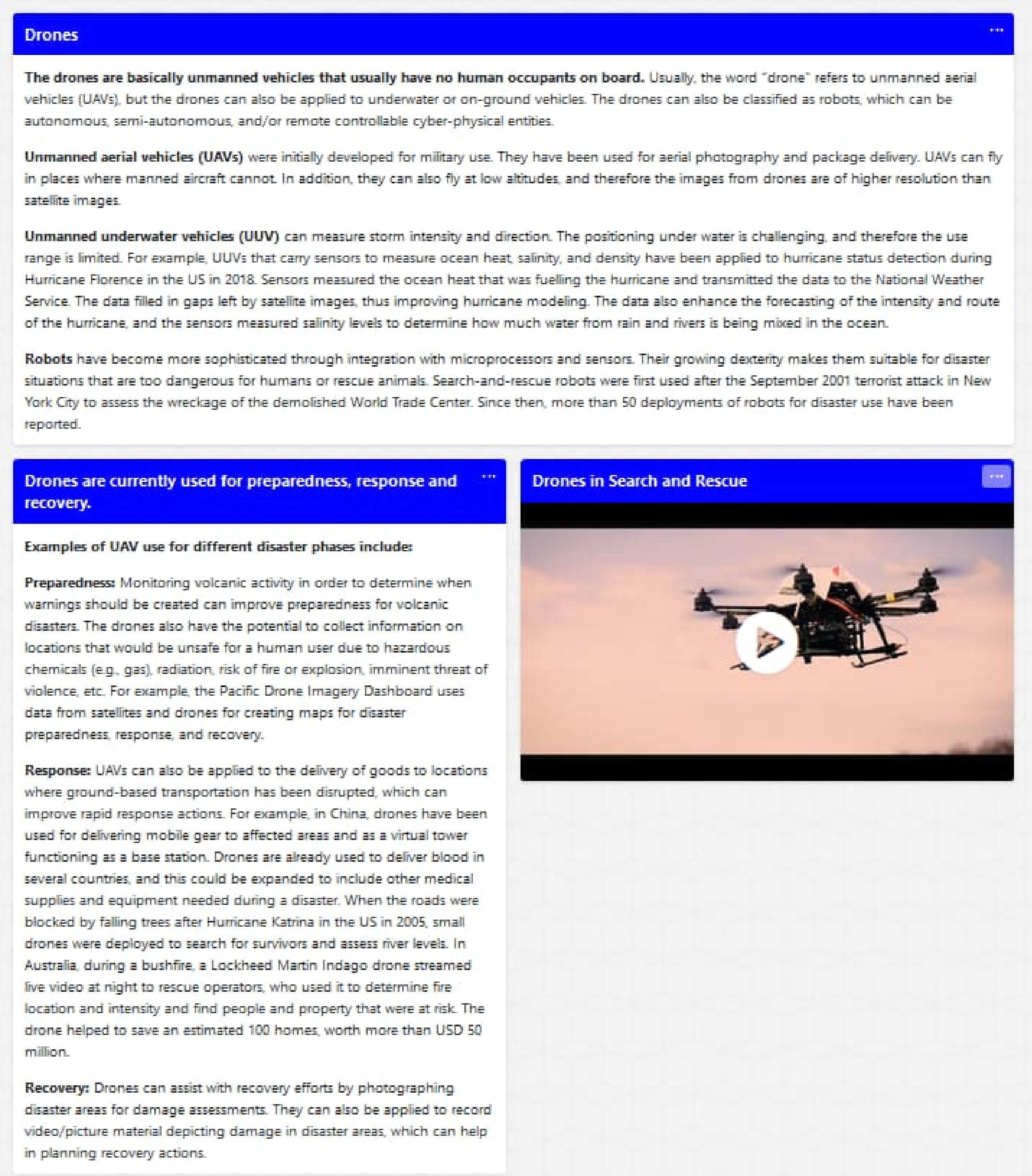

Figure 4. Presentation of drone technology.

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3.1.4. Artificial intelligence

Software algorithms are increasingly generating new insights about a variety of phenomena, which allows computers to imitate human intelligence, called Artificial Intelligence (AI). Examples of AI are already operational, such as voice and facial recognition, and commercialized products such as the IBM Watson computer system, which integrates AI into the analysis of Big Data. Watson has been applied to disaster scenarios by having it analyze weather and census data to help organizations prepare for a crisis and optimally allocate resources.

Research effort is currently being devoted to the use of AI for detecting and maybe one day predicting earthquakes to quicken recovery and response times. Humanitarian groups are hoping to speed up map creation by using machine learning in computer software to extract objects such as buildings and roads from aerial images. AI does not need to be costly, as shown in research by the Tanzania Meteorological Agency on weather and climate monitoring. The Agency used the PHP programming language to execute equations regarding meteorological observations, with the software refining its calculations to make better predictions. The cloud-based system features a user-friendly web-based interface and utilizes the free open-source MySQL database management software.

Artificial intelligence and machine learning have the potential to help in making predictions and in identification and classification. When it comes to processing information, AI is used for image recognition of satellite photos to identify damaged buildings, flooding, impassable roads, etc. Multiple data streams can be combined with the removal of unreliable data and the generation of heat maps. For example, DigitalGlobe (https: //www.digitalglobe.com) provides open-source software for disaster response that learns how to recognize buildings in satellite photos. Following the Nepal earthquakes in 2015, humanitarian and relief groups used pre- and post-disaster imagery and utilized crowdsourced data analysis and machine learning to identify locations affected by the quakes that had not yet been assessed or received aid.

- Emergency calls: During a crisis, call centers are often overwhelmed. In addition to voice calls, emergencies are increasingly reported by text messages and social media. AI and machine learning are being applied to cope with the volume and different types of calls. In the US, Watson (developed by IBM) is being used for speech-to-text recognition at emergency call centers. The text is input to analytical software that guides operators on how to respond to the call.
- Social media analysis: Real-time information from social media sources, such as Twitter and discussion boards, can be analyzed and validated by AI to filter and classify information and make predictive analyses. Artificial Intelligence for Disaster Response (AIDR) was created to process the large number of tweets generated during a crisis. AIDR uses machine learning to automatically process tweets in real-time. The software collects tweets based on hashtags and keywords and then uses AI to further classify them by topic. The open-source software is free for those who work in crisis response.
- Predictive analytics: AI is being used to analyze past data to predict what is likely to happen in the event of a disaster. Optima Predict software processes information from emergency response systems to optimize ambulance routes. The data can be integrated with online dashboards so that emergency personnel can respond in real-time.

AI provides the potential for advances in disaster management. However, there are challenges arising from ethical and privacy issues. In addition, AI can make mistakes just as humans can, so they should not be the only base for analysis, predictions, and emergency plans. Important areas that need to be considered include the importance of bringing more diversity in the field of data science to reduce bias, and racial and gender stereotyping; the appropriate use of AI in judicial systems to make them fairer as

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well as more efficient; and finding ways to ensure that the benefits of the technology are spread amongst as many people as possible.

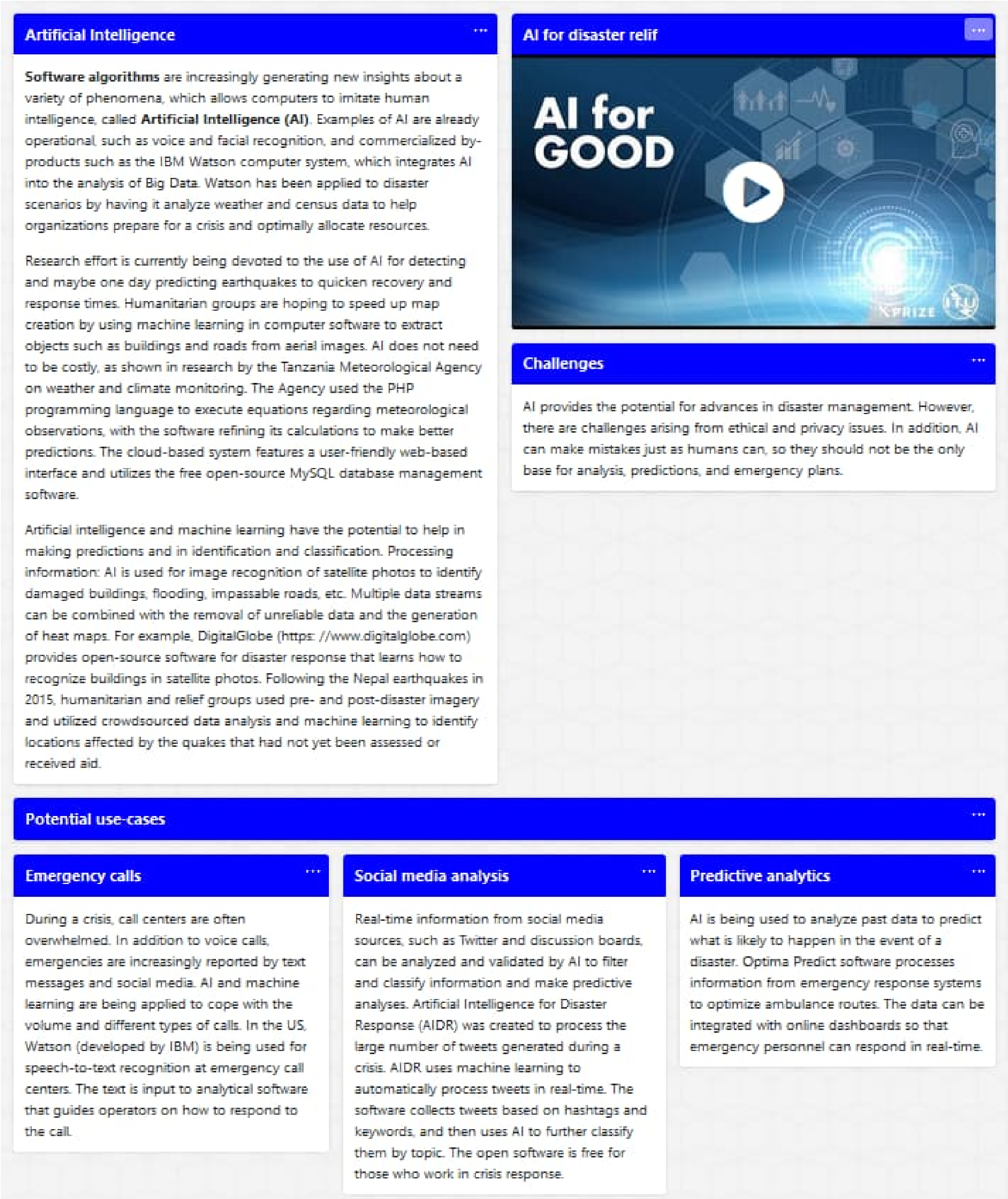

Figure 5. Presentation of Artificial Intelligence and its use opportunities.

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3.2. Location-based services

Location-based services consisted of three technology presentations. First, location-based terms and technologies were presented (Figure 6), then indoor and outdoor positioning technologies (Figures 7 and 8), and finally transferring positioning data between authorities and citizens in potential or actual danger (Figure 9). One set of evaluation questions was used to cover this whole area.

3.2.1. Location information transfer and use between authorities and citizens

Location-Based Services (LBS) are mobile applications that provide information depending on the location of the user. LBS applications differ from other geographic information systems (GIS) and web mapping applications because they "know" the context where their users are and therefore can adapt the contents and presentation accordingly (Steiniger et al., 2006). They are mainly used in a dynamic and mobile environment.

The two main types of location-based services are:

1. information is sent from disaster managers and responders to the people in need of help, or
2. information from people in a dangerous situation is sent to disaster managers.

To make LBS work, different system components are needed, i.e., mobile devices, positioning, communication networks, and service and content provider.

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Location-Based services, LBS

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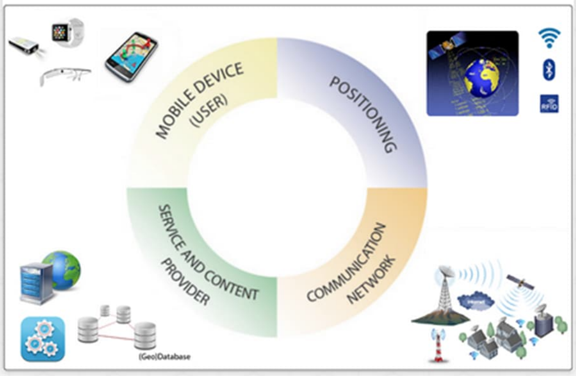
2. information from people in a dangerous situation is sent to disaster managers.

To make LBS work, different system components are needed, i.e., mobile devices, positioning, communication networks, and service and content provider. (Figure 1).

Figure 1. System components of LBS.

Figure 1 System components of LBS (adapted from Steiniger et al. (2006) at CartouCHe(link is external) under CC BY 2.0).



Using a **mobile device,** the user can request and receive the needed information according to his/her location in mobile environments. Possible devices include smartphones, wearable devices like smartwatches and digital glasses, haptic devices, public displays, built-in devices (e.g., built-in car navigation systems), and so on. The information can be received in graphical (e.g., mobile maps, augmented reality, and 3D), verbal (e.g., verbal instructions), haptic (e.g., vibration), and hybrid forms.

Positioning involves a variety of location sensor technologies and positioning methods that have been developed for both outdoor and indoor environments. The positioning component determines the current location of the user. For outdoor LBS applications, the global positioning system, GPS, is a general one together with map matching algorithms that improve on the poor GPS accuracy in urban environments. Most of the outdoor positioning technologies include global navigation satellite systems (GNSS), cellular networks, and wireless networks. Indoor LBS applications use technologies, such as the WiFI wireless connection standard, Bluetooth, and radio-frequency identification (RFID).

Communication network: The communication network (for example, cellular network or WiFi network) transfers the data and service request of the user from his/her mobile device to the service and content provider and sends the requested information back to the user's device.

Service and content provider: The service and content provider processes the user's requests, and returns the needed information. It might not store and maintain all the information, and very often needs to access and integrate other data sources (e.g., geographic boundaries, road network data, points of interest (POI) data, and event data) for processing service request. It is important to follow data protection practices in all activities (such as data storing time and access rights for data).

Some LBS applications (e.g., built-in car navigation systems) may already store all the information locally on the mobile device and process all service requests solely on the device. Therefore, there is no need to send the request over the communication network to the service and content provider.

Information in LBS applications can be communicated to users in graphical, verbal and haptic forms.

Mobile maps: Maps are the most general and most important presentation form when communicating geo-referenced information, as many of the questions LBS applications try to answer are geo-related.

Augmented Reality: AR is a novel technology that superimposes computer-generated information (e.g., images or texts) on a user's view of the real world and provides an 'augmented' view. As an example, a location-based game called "Pokemon Go" uses this technology to display virtual creatures on the camera display of smartphones. There are also AR-based LBS applications for navigation that superimpose route information on the real-world camera view (Huang et al., 2012).

Verbal descriptions: LBS information can be communicated to users orally via verbal descriptions. For example, car navigation systems communicate route instructions verbally to their users, and there are also applications for visually impaired pedestrians to find a proper route to their target.

Haptic feedback: Haptic or tactile feedback, such as vibrations on smartphones, is usually integrated into other communication forms to enhance users' experiences and performance with the LBS applications.

Figure 2 A screenshot of the AR-based interface for outdoor pedestrian navigation, with a real-world camera view, route overlay, street names and relevant landmarks. Source: Huang & Gao (2018).

Figure 6. Introduction to location based service technologies and terms.

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3.2.2. Outdoor and indoor positioning technologies

Global Navigation Satellite Systems (GNSS) provide the location and time information in all weather conditions anywhere on or near the Earth's surface with global positioning satellites. The European Union's Galileo system can provide high-precision positioning data. It can be used together with Copernicus, the EU Earth Observation (EO) program, which can provide information on crop health, soil moisture, forest growth and flooding areas.

Positium Ltd has developed and tested a tool that uses call data records during and after catastrophes to provide information regarding the districts with greater inflow of people, patterns of rapid movement, relative inflows of people during times of crisis compared to ordinary time, and information regarding the regions that receive more people because of a nearby emergency[10]. CDR data can be used to follow people's movements in floods, humanitarian crises, and even during disease outbreaks. (Võik et al. 2021a).

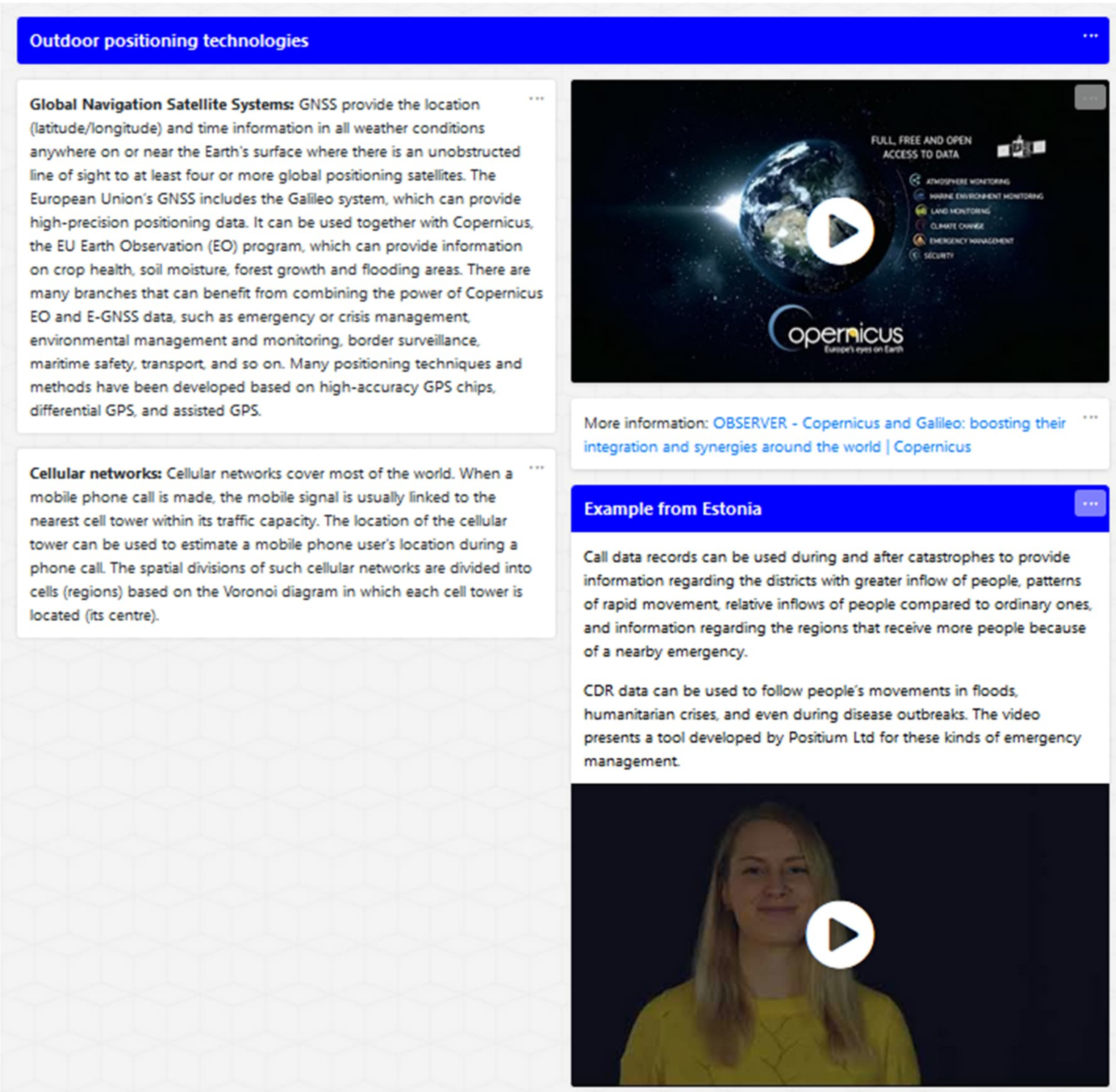

Figure 7. Presentation of outdoor positioning technology.

[10] Võik et al. 2021a BuildERS D4.3.

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Wi-Fi technology is widely used for Internet connection in hotels, business buildings, coffee shops, and many other fixed places. Therefore, it has become an attractive technology also for positioning purpose. The use of smartphone sensors can improve the positioning results, and, for instance, it might be possible to determine the floor level of a multi-storey building from which the signal is received.

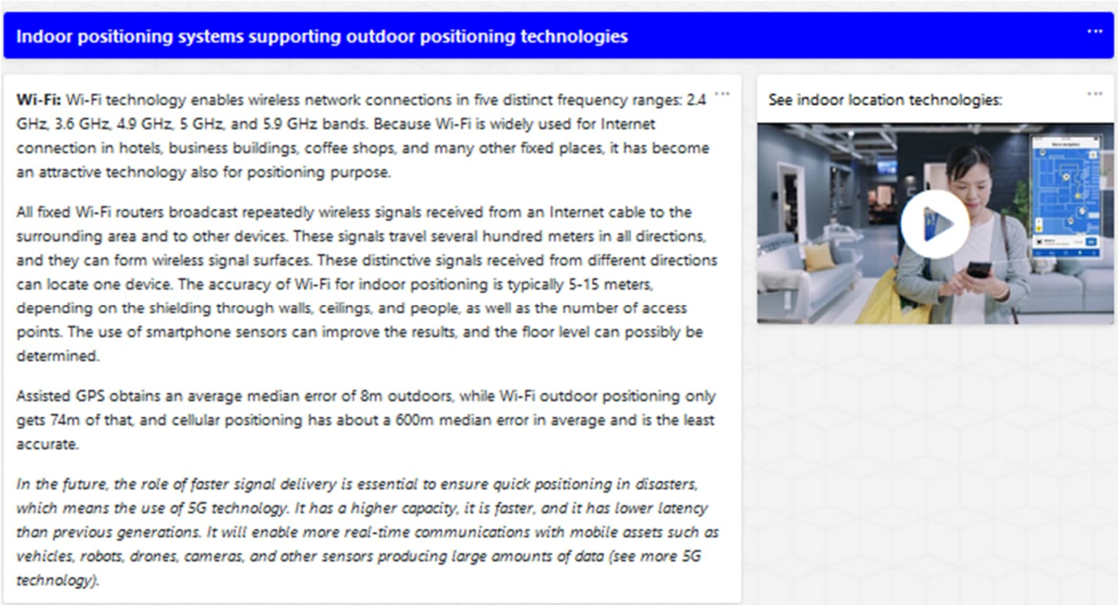

Figure 8. Presentation of indoor positioning technology.

3.2.3. Location information transfer and use between authorities and citizens

One of the simplest examples of this is a Location-Based Alert System used to send an SMS to alert people about an upcoming natural hazard in a specific area. Authorities can alert all mobile inbound and outbound subscribers in a specified area. One of the most significant ways to inform people in danger is to use location-based system applications to send information to people who are in a dangerous situation. These applications that send communicating information have the greatest impact in the early response cycle of disaster management giving people time to leave the dangerous place.

Some examples of applications were introduced. For example, the Finnish radiation safety centre STUK, provides citizens real-time information about external radiation in different parts of Finland. A flood warning system offers information on flooding situations both physically, by flood warning flashers, and online, by a map application where the situation can be checked and a usable route can be chosen before arriving in flood zone.

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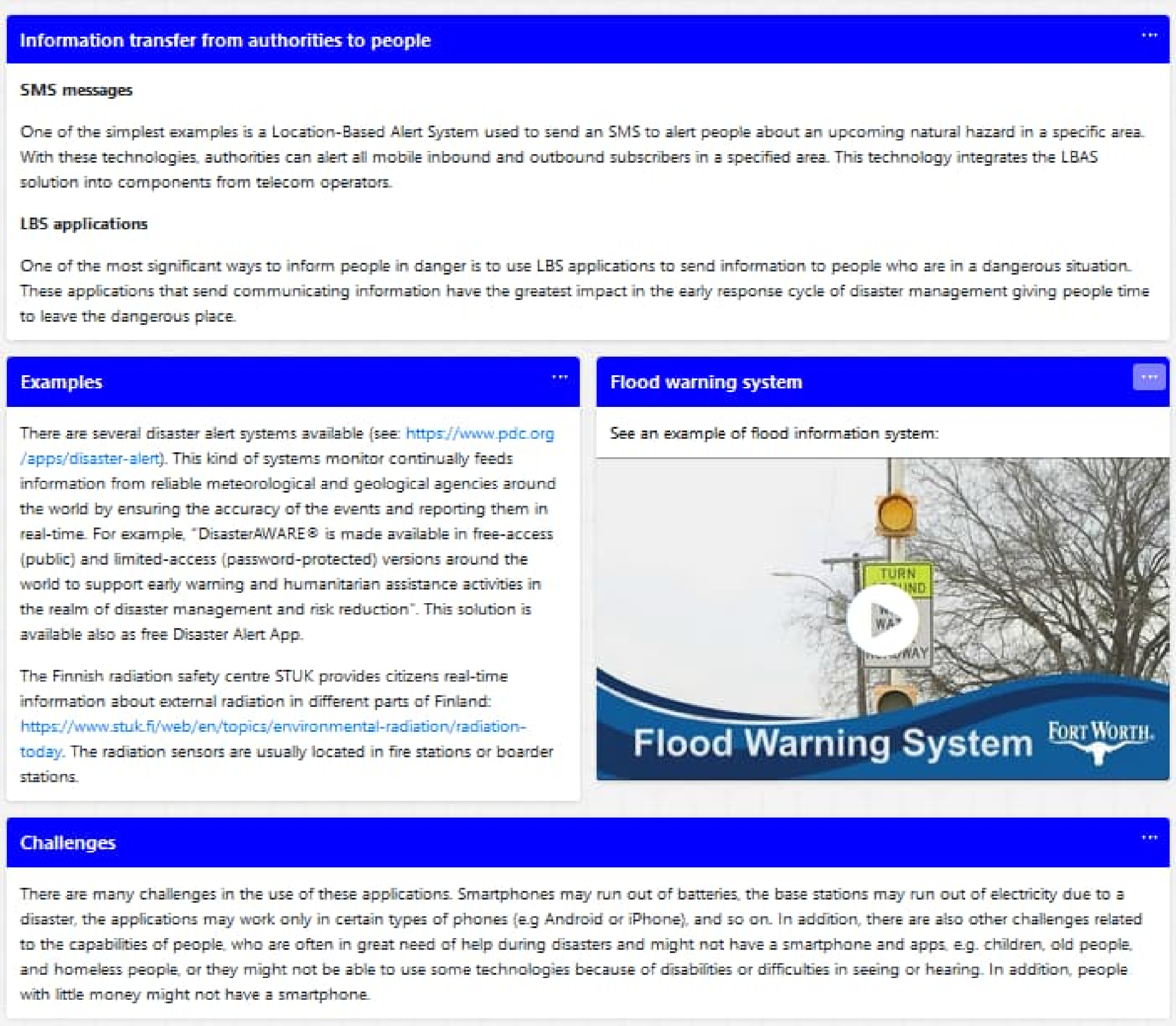

Information transfer from authorities to people

SMS messages

One of the simplest examples is a Location-Based Alert System used to send an SMS to alert people about an upcoming natural hazard in a specific area. With these technologies, authorities can alert all mobile inbound and outbound subscribers in a specified area. This technology integrates the LBAS solution into components from telecom operators.

LBS applications

One of the most significant ways to inform people in danger is to use LBS applications to send information to people who are in a dangerous situation. These applications that send communicating information have the greatest impact in the early response cycle of disaster management giving people time to leave the dangerous place.

Examples

There are several disaster alert systems available (see: https://www.pdc.org/apps/disaster-alert). This kind of systems monitor continually feeds information from reliable meteorological and geological agencies around the world by ensuring the accuracy of the events and reporting them in real-time. For example, "DisasterAWARE® is made available in free-access (public) and limited-access (password-protected) versions around the world to support early warning and humanitarian assistance activities in the realm of disaster management and risk reduction". This solution is available also as free Disaster Alert App.

The Finnish radiation safety centre STUK provides citizens real-time information about external radiation in different parts of Finland: https://www.stuk.fi/web/en/topics/environmental-radiation/radiation-today. The radiation sensors are usually located in fire stations or boarder stations.

Flood warning system

See an example of flood information system:

Challenges

There are many challenges in the use of these applications. Smartphones may run out of batteries, the base stations may run out of electricity due to a disaster, the applications may work only in certain types of phones (e.g Android or iPhone), and so on. In addition, there are also other challenges related to the capabilities of people, who are often in great need of help during disasters and might not have a smartphone and apps, e.g. children, old people, and homeless people, or they might not be able to use some technologies because of disabilities or difficulties in seeing or hearing. In addition, people with little money might not have a smartphone.

Figure 9. Location specific information alerts from authorities to people.

The second method to use LBS is to gather mobile positioning data and use it for decision-making. Mobile positioning data can be divided into 1) active positioning (the system operator tracks the phone at all times), and 2) passive positioning (the system operator tracks the phone only when it is used for calling, texting etc.).

In Indonesia, CSID of Universitas Indonesia has developed a mobile application named SaveMyLife to improve disaster response time and increase the victim survival rate by taking into account their level of vulnerability in order to optimize search and rescue prioritization. The application has two main features: preloaded content and the panic button. The preloaded content provides users with information related to the nearest safety points, the estimated time required to reach the safety points, and real-time information about disasters given by official authorities. When the victims tap the "Panic Button", the rescue team can accurately determine their location, enabling them to effectively prepare appropriate aid or treatment plans for the victims. (Võik et al. 2021b).

Active mobile positioning data can be gathered from the smartphone users if they want to share it. The most popular solutions are 112 applications, which are used to share one's location with emergency services from the accident site.

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Figure 10. Sending location information from citizens in need to help to authorities.

The evaluation questions regarding location-based services were posed after all three informative sections.

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3.3. Data sharing between authorities for crisis management

The Howspace area for data sharing between authorities for crisis management consisted of three main sections:

1. Solutions for data sharing,
1. Blockchain technology, and
2. Data fusion from public datasets.

3.3.1. Solutions for data sharing

The first section justified the importance of real-time data. When a crisis occurs, the responders should be able to quickly access real-time information about the situation in the disaster area. Precise knowledge of the location of the resources in real-time is an efficient part of emergency management. On-line information about the endangered area is created by using and combining available databases, such as mobile positioning, different kinds of sensors and cameras from the area, satellite pictures, drone pictures, crowdsourcing of social media, etc., is vital for both preparedness, response, and risk mitigation phases.

This Howspace section named various information sources that can be used for building situational picture. Information on population, territory, resources, results from security and safety inspections, risk analyses, emergencies, incidents, and system errors or failures of critical infrastructure could be scanned. Landscape analysis based on geographical information systems (GIS databases), such as geomorphology, hydrography, and digital elevation terrain model for a correct position of resources are also possible information sources.

Two examples of data sharing solutions were presented. One was Insta Blue Aware™ web based situational awareness solution[11] for optimizing decision-making and operations. It connects to multiple data sources and combines and presents a shared map-based situation picture in a web browser.

[11] https://www.insta.fi/en/services/c5isr-and-situational-awareness/insta-blue-aware

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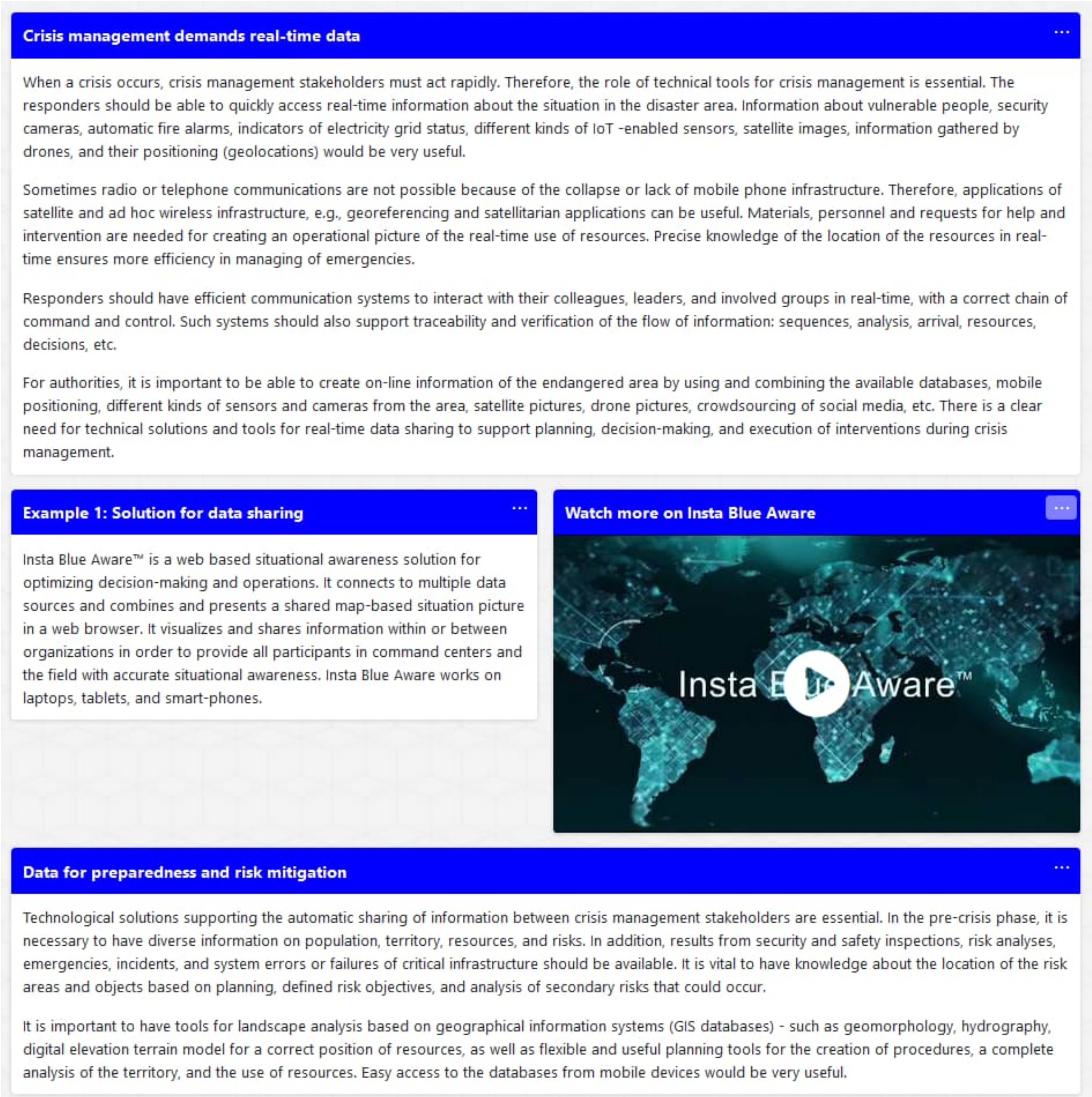

Figure 11. Presentation of a web-based situational awareness solution.

Another example was the BeAware platform[12], which helps authorities, first responders and citizens in extreme weather events by collecting information from weather sensors, social media, and photo and video detection for creating an operational picture. By processing weather and other multimodal data, the platform can generate early warnings and real-time alerts.

[12] https://beaware-project.eu/

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Figure 12. Presentation of beAWARE platform.

After the informative section, evaluation questions were followed.

3.3.2. Blockchain technology

The second section of the workshop presented blockchain technology for quick and reliable information-sharing between different stakeholders. The benefit of blockchain technology is that technology enables the maintenance of a shared distributed ledger which can be simultaneously read and modified by all involved parties, but is not owned by any party (Yli-Huumo et al. 2016). The crash of an individual computer or other device is not a problem, and the information cannot be accidentally or intentionally tampered with.

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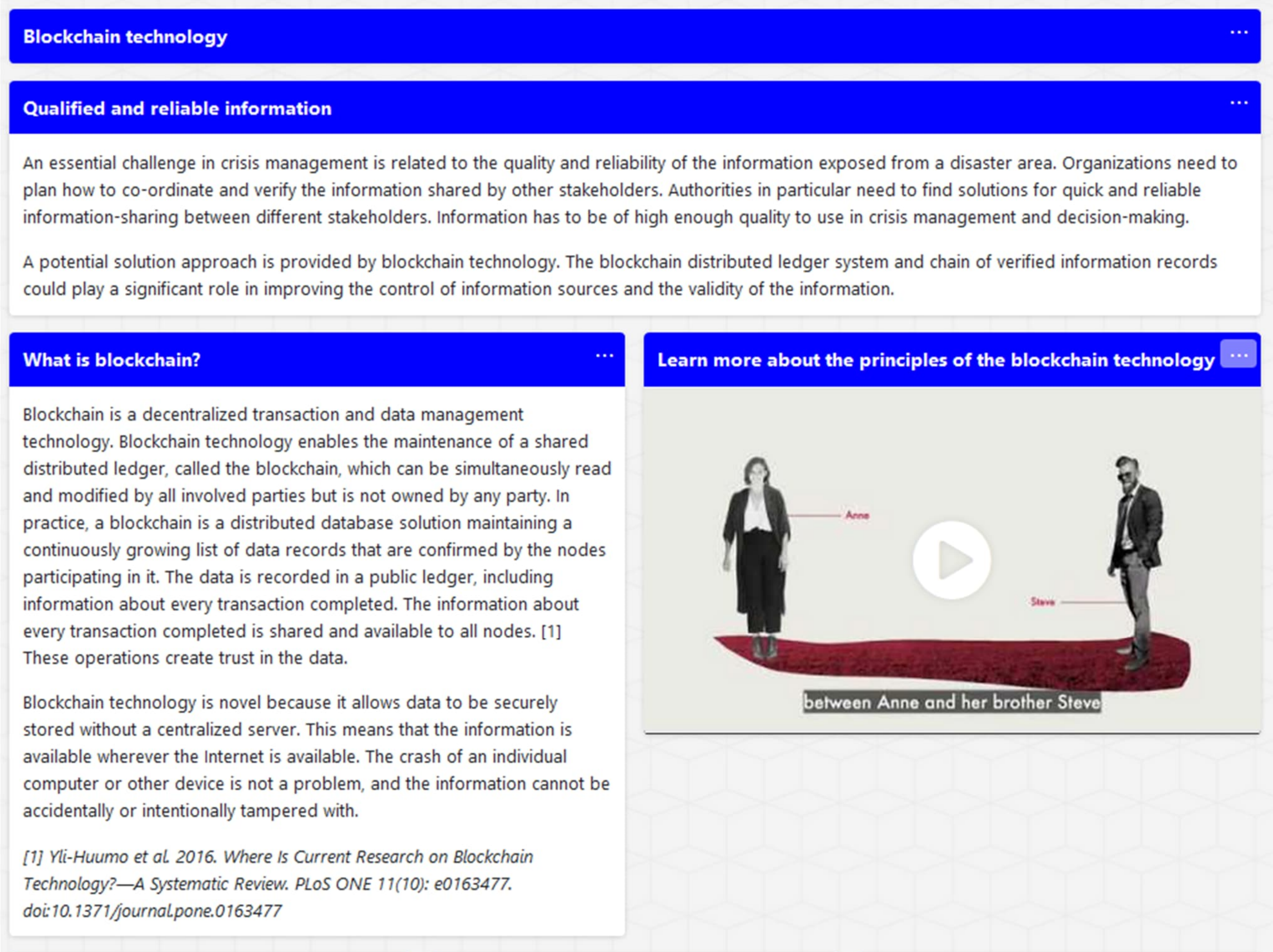

Blockchain technology

Qualified and reliable information

An essential challenge in crisis management is related to the quality and reliability of the information exposed from a disaster area. Organizations need to plan how to co-ordinate and verify the information shared by other stakeholders. Authorities in particular need to find solutions for quick and reliable information-sharing between different stakeholders. Information has to be of high enough quality to use in crisis management and decision-making.

A potential solution approach is provided by blockchain technology. The blockchain distributed ledger system and chain of verified information records could play a significant role in improving the control of information sources and the validity of the information.

What is blockchain?

Blockchain is a decentralized transaction and data management technology. Blockchain technology enables the maintenance of a shared distributed ledger, called the blockchain, which can be simultaneously read and modified by all involved parties but is not owned by any party. In practice, a blockchain is a distributed database solution maintaining a continuously growing list of data records that are confirmed by the nodes participating in it. The data is recorded in a public ledger, including information about every transaction completed. The information about every transaction completed is shared and available to all nodes. [1] These operations create trust in the data.

Blockchain technology is novel because it allows data to be securely stored without a centralized server. This means that the information is available wherever the Internet is available. The crash of an individual computer or other device is not a problem, and the information cannot be accidentally or intentionally tampered with.

[1] Yli-Huumo et al. 2016. Where Is Current Research on Blockchain Technology?—A Systematic Review. PLoS ONE 11(10): e0163477. doi:10.1371/journal.pone.0163477

Learn more about the principles of the blockchain technology

Figure 13. Presentation of blockchain technology.

Three examples of blockchain technology applications were presented. In the US, rapid and reliable data collection in diseases will be tested with government agencies, assistance agencies, telecommunication operators, food suppliers, transporters, and health workers. Collaboration in crisis situations with many actors needs trusted data sharing to offer relief effectively.

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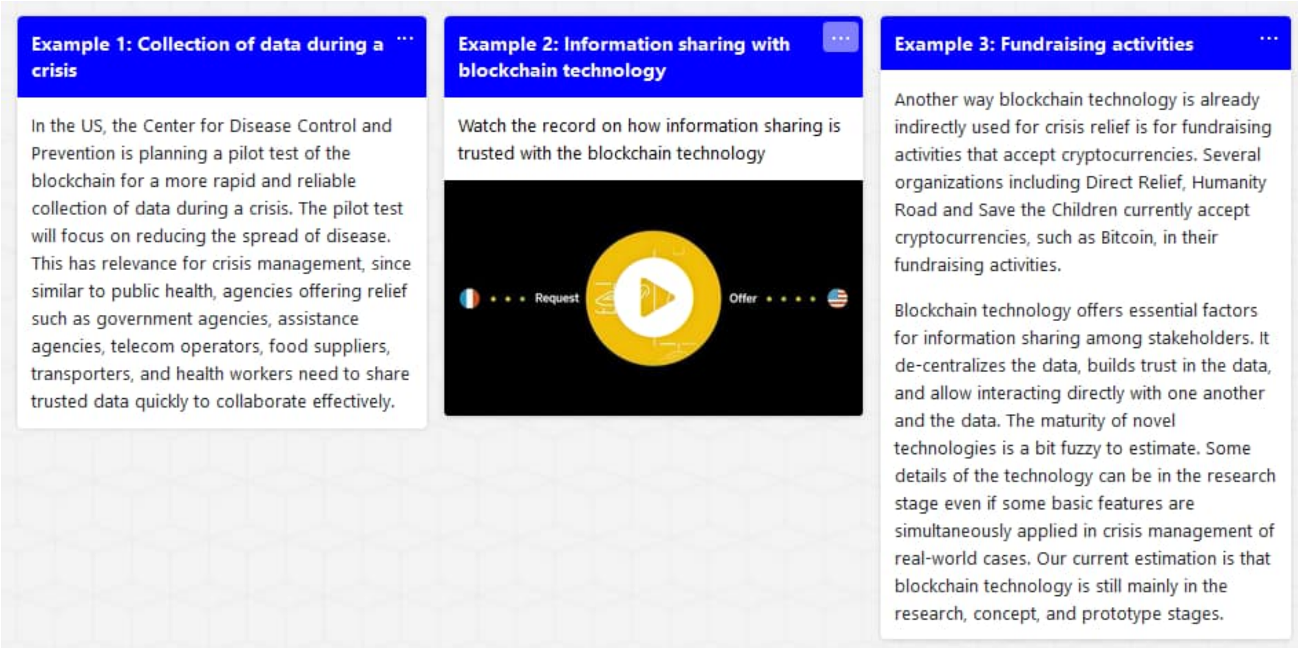

Figure 14. Presentation of the blockchain technology application opportunities.

The second example was the UN relief mission[13]. Unclear information from many disconnected sources like emails and social media, can hinder fast and efficient coordination of help in disaster and relief missions. Shared system of data record can significantly reduce complexity and streamline interactions with multiple parties. Blockchain allows users to connect several interdependent systems without having a single party controlling the system or data.

The third example revealed that some fundraising actors already accept cryptocurrencies, such as bitcoins, in their fundrasing activities for crisis relief. Therefore, organisatios such as Direct Relief, Humanity Road and Save the Children already indirectly use blockchain technology for crisis management.

Evaluation questions followed the informative section of technology.

3.3.3. Data fusion from public datasets

The third main section introduced a vulnerability assessment tool created in the BuildERS case study[14]. The tool brings together the varied factors of vulnerability and their representations in public datasets. It guides relevant stakeholders to systematically think through possible hazard scenarios, the related factors of vulnerability, and the sources of information about these vulnerabilities. The tool could serve as a useful addition to the risk analyses and emergency management planning that currently focus on the vulnerabilities of critical infrastructure.

The BuildERS vulnerability assessment tool integrates data managed by different state authorities and recognizes the need to complement registry-based data with assessments by representatives of the diverse society. It helps to understand factors influencing individuals' ability to cope and plan better prevention and response activities (Orru et al. 2021b)[15].

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[13] https://www.youtube.com/watch?v=DLkC6qt6a5I&t=4s
[14] Orru et al. 2021a. BuildERS D4.4. Reducing social vulnerability by innovative data fusion for more-informed rescue prioritisation
[15] Orru et al. 2021b. https://doi.org/10.1111/disa.12481

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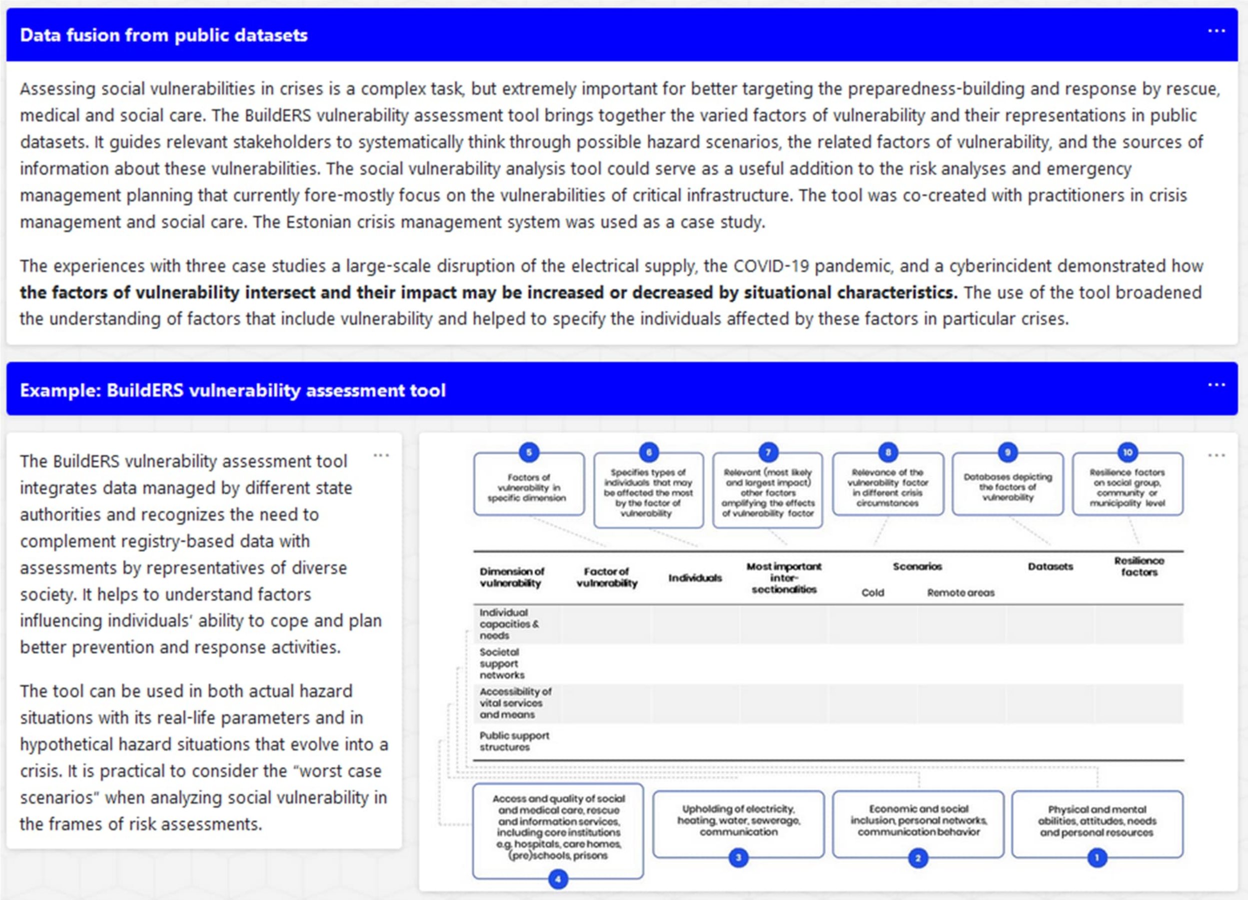

Figure 15. Presentation of using data from multiple sources for vulnerability assessment.

The tool can be used in both actual hazard situations with its real-life parameters and in hypothetical hazard situations that evolve into a crisis. It is practical to consider the "worst case scenarios" when analyzing social vulnerability in the frames of risk assessments.

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The tool guides users in distinguishing four dimensions of vulnerability factors (leftmost column): (1) individual capacities and needs, (2) societal support networks, (3) accessibility of vital services and means, and (4) public support structures. (For more information on the social vulnerability factors see Orru et al 2021 https://doi.org/10.1111/disa.12481).

The key analysis unit in the tool is the individuals affected by particular factors that influence vulnerability. **Each row in the tool describes one factor of vulnerability** and the individuals that are burdened with this vulnerability factor.

The vulnerability factors column (5) describes the factors of vulnerability distinguished among many factors in the broader vulnerability dimension in a particular crisis situation. The users of the tool are guided to estimate the relevance of these factors by the likelihood and magnitude of the factor's effect on individuals. The factors with the highest risk score should be involved as the vulnerability factor.

The factors of vulnerability concern anyone, but the degree to which each individual is affected by the vulnerability factor may differ to a large extent. The tool guides its users to consider which individuals (6) are burdened with specific factors arising from the circumstances where the individual lies.

The tool takes into consideration the factors that are assessed to be the most important intersecting factors that worsen the conditions created by the vulnerability factor in the case of certain individuals (7).

The relevance of the vulnerability factors may change if the base scenario changes and different crisis circumstances come into play (8). Therefore, the tool helps to assess the dynamics in vulnerability factors if certain contextual parameters are changed. The scenario conditions may be selected based on risk analyses ("the worst-case scenario") and/or the experiences of these conditions causing hazard exposures and exceeding coping capacities.

The tool guides connecting the factors of vulnerability, the affected individuals with specific databases, other information sources and their represented indicators depicting the factors of vulnerability (9). For example, the datasets and information sources used in the Estonian crisis management system were identified, and some sources that are currently under-utilized were pointed out.

For each individual at risk of falling into a vulnerable situation according to certain (intersected) parameters, resilience factors can be connected with a social group, a community, or a municipality (10). The information on crisis-preparedness in communities and municipalities indicates the community-level or administrative resilience, which may mitigate the effect of vulnerabilities in certain individuals.

Hear more on the vulnerability assessment tool

Ethical principles and legal bases

When processing personal data from different datasets, it is highly important to comply with ethical principles and legal bases. Merging different datasets requires a clear mandate and supporting institutional arrangements.

Safeguarding the rights and freedoms of the data subjects including clarification of the purposes of legitimate data use, access and sharing conditions, user accountability, and monitoring criteria must be carefully taken into account.

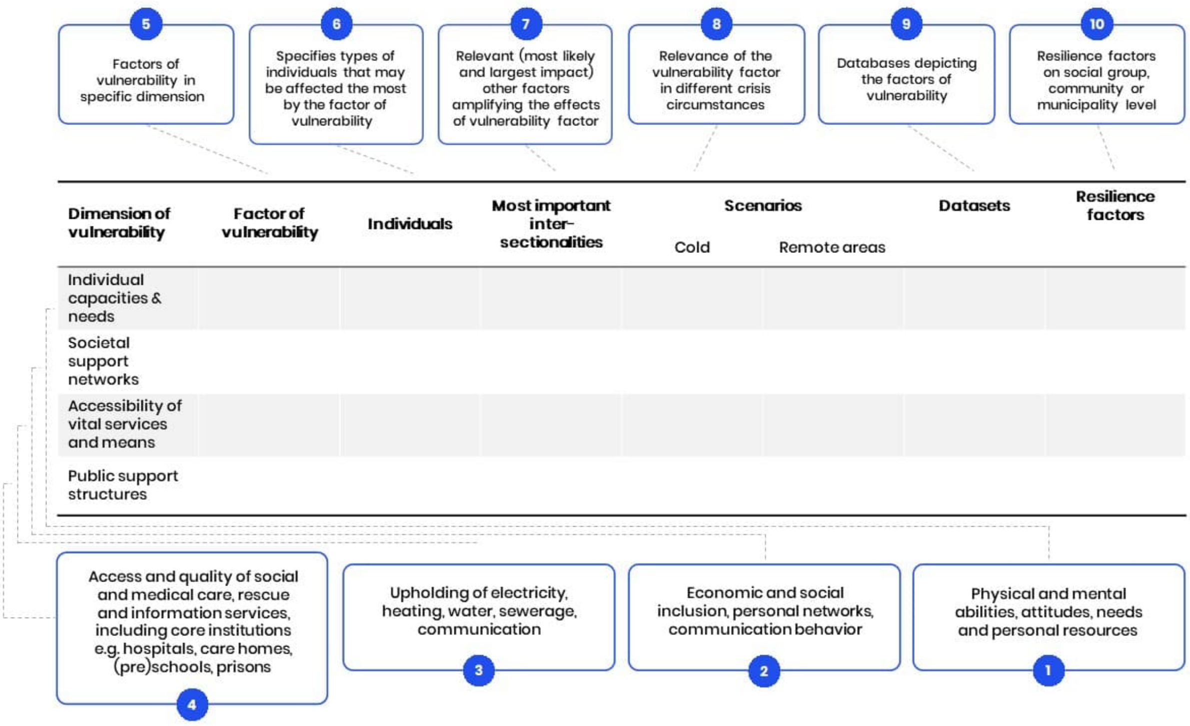

Figure 16. Visualisation of the BuildERS vulnerability assessment tool.

The processing of personal data from different datasets requires strict adherence to ethical principles and legal bases. Merging different datasets requires a clear mandate and supportive institutional arrangements. Safeguarding the rights and freedoms of the data subjects including privacy and data protection, clarification of the purposes of legitimate data use, access and sharing conditions, user accountability, opt-out options and monitoring criteria must be carefully taken into account.

Evaluation questions followed the presentation of the vulnerability assessment tool.

3.4. Crowdsourcing to improve preparedness

The Howspace area for Crowdsourcing consisted of three main sections:

1. Producing new data,
2. Enhancing existing data, and
3. Solving problems.

The introduction explained that the focus is on applications with active crowdsourcing. This means cases where users participate knowingly in the crowdsourcing activity and their participation requires special actions. This separates it from passive crowdsourcing where data that is generated as a by-product of another activity is utilised. The introduction also briefly listed factors that need to be addressed when creating a crowdsourcing application and what could motivate people to participate in crowdsourcing.

The **first section** (on producing new data) presented Ushahidi[16], a tool for gathering new data from people with knowledge of a specific issue (see Figure 17). Other given examples of applications were Sympton Radar[17] and Carchupa application[18]. These were followed by the evaluation questions.

Sympton Radar was launched at the beginning of the COVID-19 pandemic to gather data of both what kind of symptoms were related to the illness and location of the cases. The Carchupa application has been developed for gathering data about the condition of roads. It is a crowdsourcing app that allows anyone to participate if they are in the area where the roads of interest are located. The point is to take video footage of the road when driving on it, and later the video is analysed using artificial intelligence to identify the need for road repair work. The app motivates the users in two ways: there is a gaming aspect as the roads of interest contain virtual items that users can collect and, perhaps most importantly, users will also be paid for their contributions.

[16] https://www.ushahidi.com/
[17] https://www.oiretutka.fi/
[18] https://crowdchupa.com/

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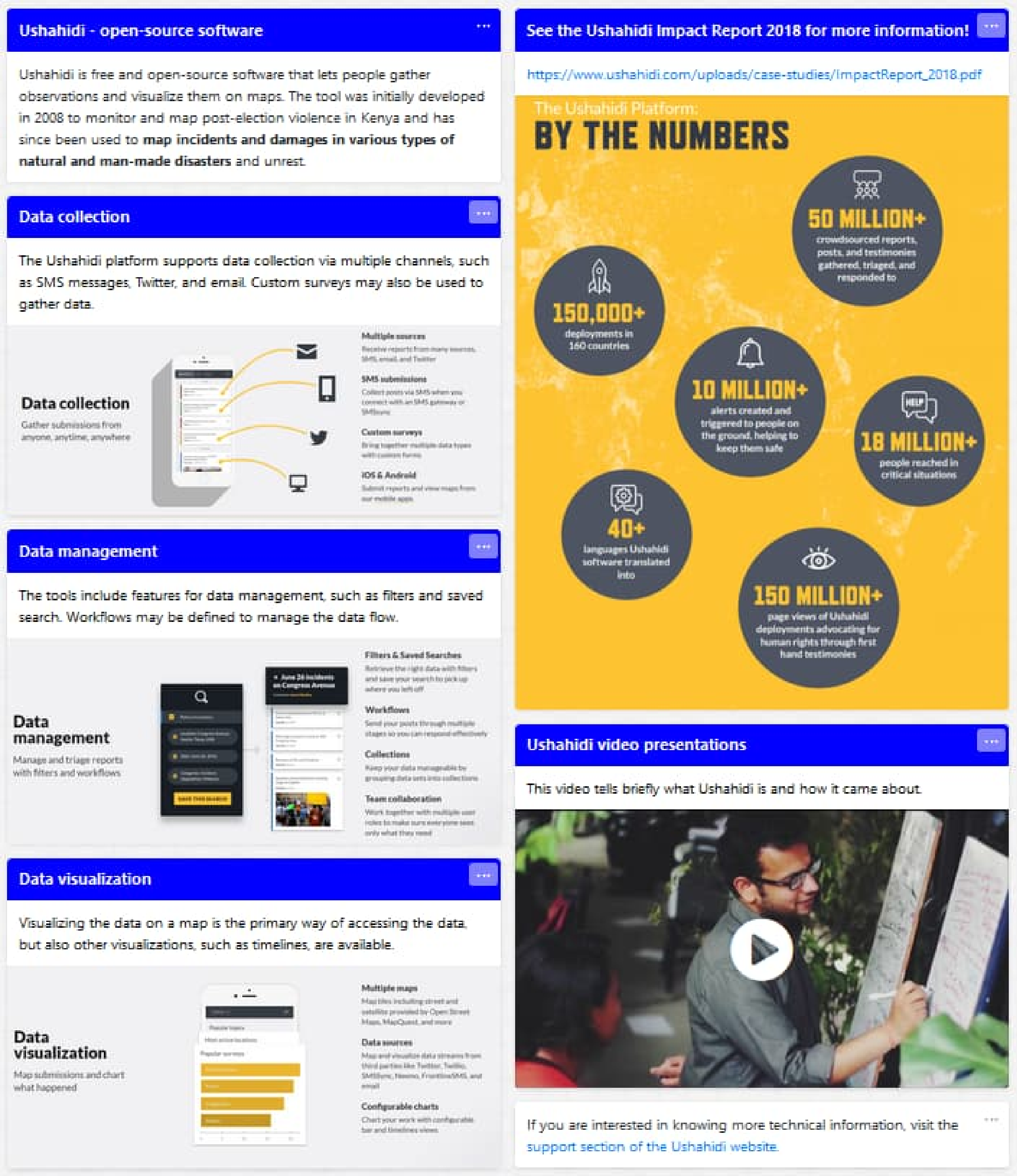

Figure 17. Presentation of Ushahidi software for gathering new data through crowdsourcing.

The second section (on enhancing existing data) presented map-based crowdsourcing examples and was followed by evaluation questions. OpenStreetMap offers free maps with multiple data points on streets and buildings. All this has been produced as a crowdsourced effort, and this platform and data can be used and further developed to support disaster preparedness and disaster management.

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MapSwipe app[19] was chosen as an example of data enhancement. The app can be used for various classification or identification tasks. Figure 18 (below) shows how crowds can participate in identifying places with damage by comparing satellite images before and after a disaster, an earthquake in the case.

The other example was Cochrane Crowd[20], a global community of volunteers who help to classify research results to support informed decision-making about healthcare.

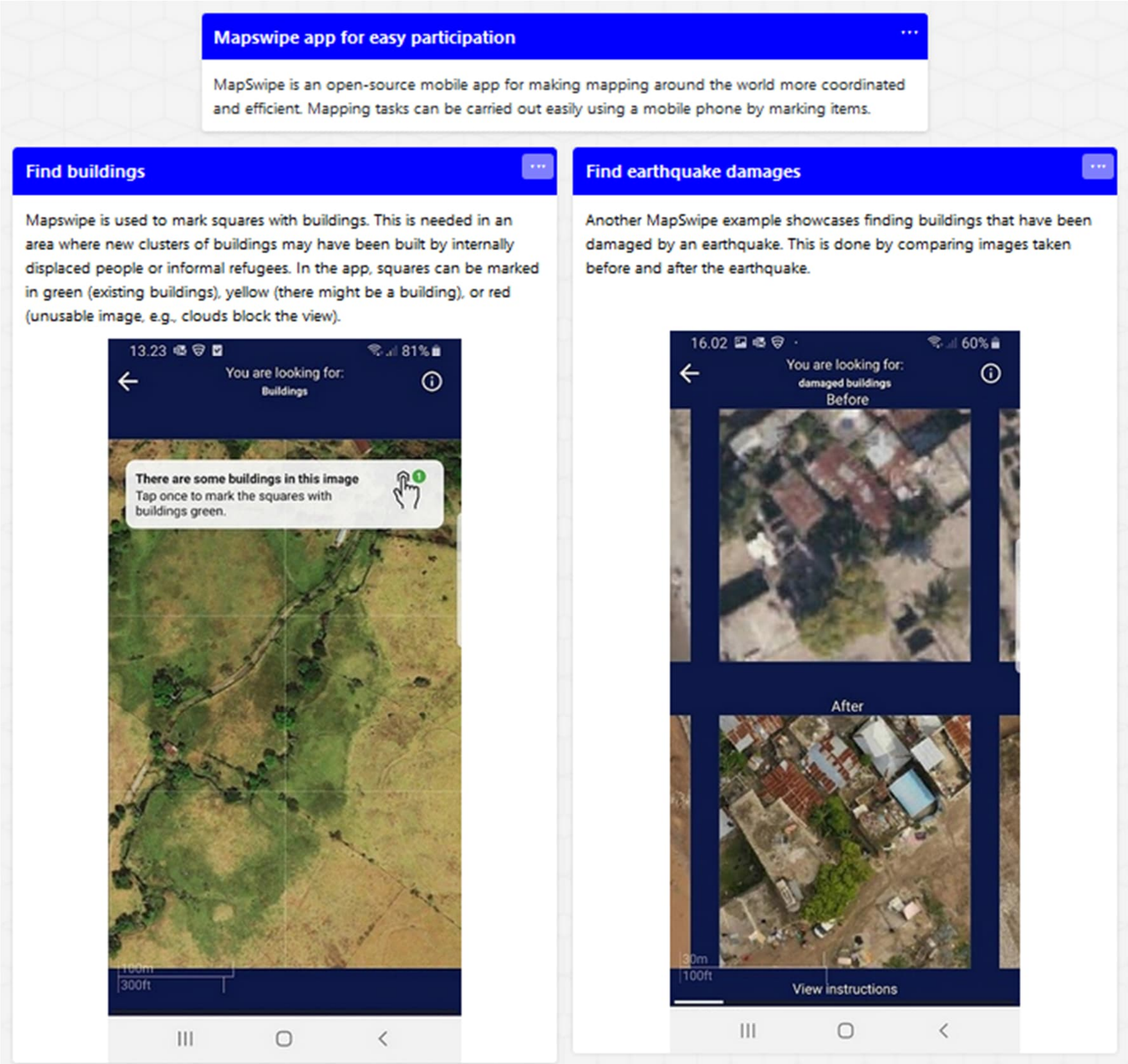

Figure 18. Presentation of the MapSwipe app for easy data enhancement.

The **third section** promoted the idea of involving crowds in more extensive participation than in the first two cases. The first two cases included very small and well defined tasks, but crowds could also participate with more demanding tasks. Crowdsourced ideation was given as the first example and projects with community participation as the second example (Figure 19 below). This last example mainly applies to local projects.

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[19] https://mapswipe.org/en/index.html
[20] https://crowd.cochrane.org/

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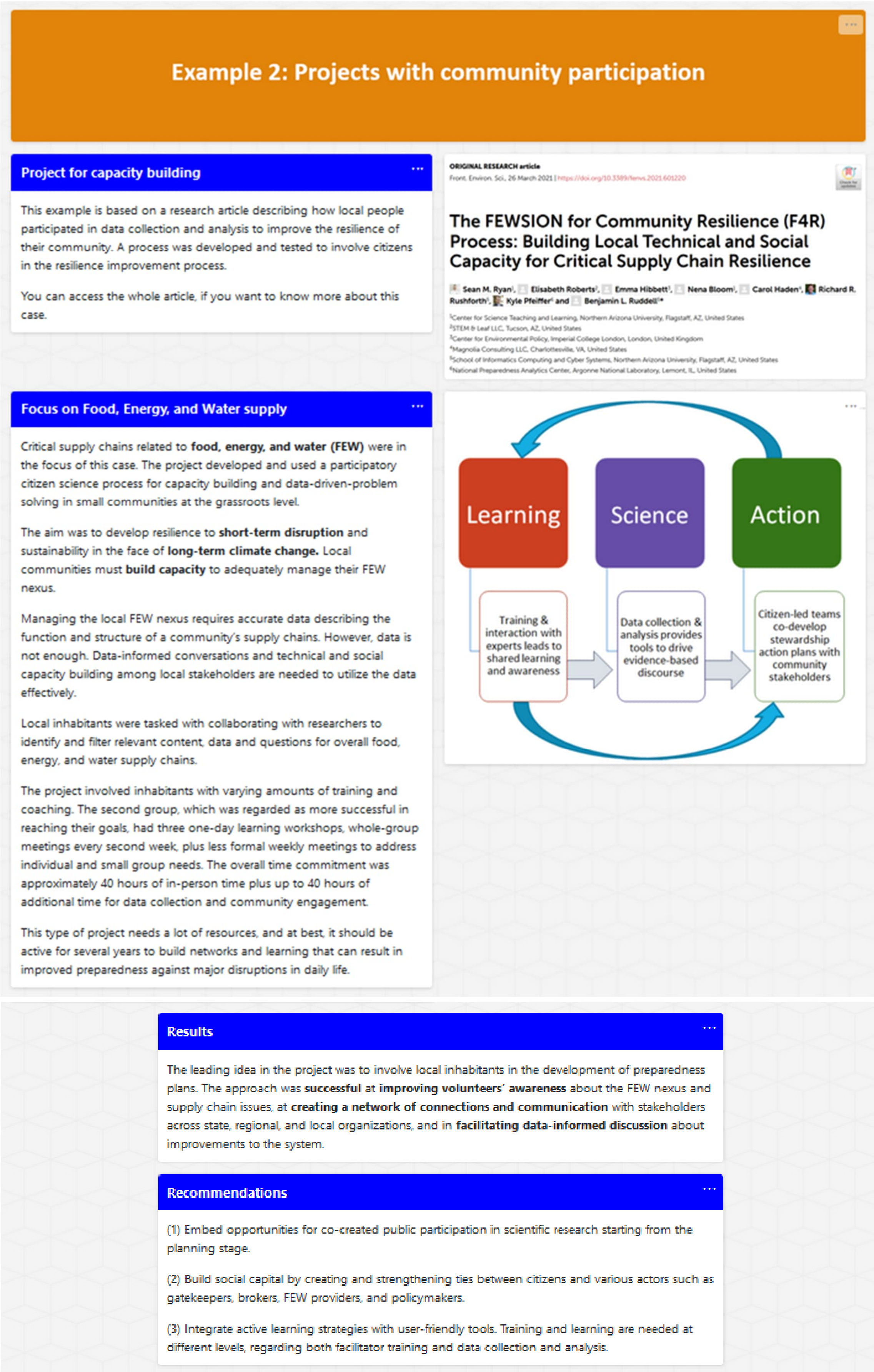

Figure 19. Presentation of involving locals to research.

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4. Results

4.1. Quantitative analysis of surveys conducted in three case studies

Chapter 4.1.1 presents the results of the surveys carried out in three BuildERS case studies (Estonia, Finland and Indonesia). For each of the case studies, main results on respondents' opinions of the tool or technology and results on perceived ethical risks are presented.

4.1.1. Results of dashboard based on MPD in Indonesia

Table 2 summarises the responses to the question on respondents' general opinions of the tool in the Indonesian case study (dashboard based on MPD).

Table 2. Dashboard based on MPD in Indonesia general opinions

Please indicate your opinions of the tool or technology, in regard to the following statements (from 1: strongly disagree to 5: strongly agree)									
	Distribution of responses [N]						Statistical figures		
	1: Strongly disagree	2	3	4	5: Strongly agree	Do not know	N (1-5)	Mean	Standard deviation
The tool or technology is effective in achieving its purpose		1	2	3	3		9	3,9	1,1
Regular use of the tool or technology would be efficient use of resources (such as money or working time)			2	3	4		9	4,2	0,8
The tool or technology should be adopted to regular use in my country			1	5	3		9	4,2	0,7
I would be willing to use the tool or technology again			2	4	3		9	4,1	0,8
The technology or tool is easy to use			2	3	4		9	4,2	0,8
There are clear instructions how to use the tool or technology			2	3	4		9	4,2	0,8
The tool or technology is suitable for civil protection				4	5		9	4,6	0,5
The tool or technology is suitable for crisis management				4	4	1	8	4,5	0,5
The tool or technology is suitable for Disaster Risk Reduction (DRR)			1	3	4	1	8	4,4	0,7
The technology or tool is accessible*		1	2	3	3		9	3,9	1,1

*Accessibility means that websites and mobile applications and their contents are such that anyone could use them and understand what is meant in them.

In general, respondents had positive perceptions of the tool. Except two individual responses, all responses to the 10 statements on the tool indicated neutral or positive opinions (responses 3-5 or do not know). The mean of responses was also close to 4 or 5 for all the statements presented to respondents. The number of responses was relatively small (N=9), and this has to be taken into account when interpreting the results.

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The results on perceived ethical risks are summarised in Tables 3 and 4.

Table 3. Dashboard based on MPD in Indonesia risk probability

Ethical acceptability of the tool or technology: How likely is it that the following risks will be realised when the tool or technology is used?									
Risk	Distribution of responses [N]						Statistical figures		
	1: Very unlikely	2: Unlikely	3: Likely	4: Very likely	5: Certain	Do not know	N (1-5)	Mean	Standard deviation
Discrimination of individuals	4	3	1	1			9	1,9	1,1
Deprivation of personal autonomy of an individual person	2	4	2	1			9	2,2	1,0
Infringement of privacy	2	1	5	1			9	2,6	1,0
Abuse of a relationship of trust	2	5	1	1			9	2,1	0,9
Causing personal disadvantage for an individual person	3	5		1			9	1,9	0,9
Stigmatisation of individuals	2	5	1	1			9	2,1	0,9
Inequality of individuals	2	5	1	1			9	2,1	0,9
Inequality of different groups of people	2	4	1	2			9	2,3	1,1
No freedom of choice to opt-out of the use of the tool or technology	3	3		3			9	2,3	1,3
Restriction of individual's life	2	6		1			9	2,0	0,9
Security of personal data is compromised	1	2	4	2			9	2,8	1,0
Collection of non-essential personal data	2	2	4	1			9	2,4	1,0
Automatic profiling	1	2	4	2			9	2,8	1,0
Accessibility requirements will not be met *		5		3		1	8	2,8	1,0

*Accessibility means that websites and mobile applications and their contents are such that anyone could use them and understand what is meant in them.

In general, most respondents considered most of the ethical risks unlikely or very unlikely to be realised. Exceptions to this include infringement of privacy, compromise of personal data, collection of non-essential personal data and automatic profiling. For these four risks, the mean of responses was also higher than for others. While this result provides an indication of the risks to be expected to be realised, it should be interpreted with caution, as the number of respondents was relatively small (N=9).

Respondents' assessments of risk severity in the Indonesian case study are presented in Table 5. In general, most respondents did not consider the studied ethical risks serious or very serious. For each risk, 8 or 9 responses were received with values 1–5. For all studied risks, only one or two of 8 or 9 respondents indicated any of the risks as serious or very serious (values 4 and 5). However, the number of responses was relatively low (N=9, responses with values 1–5: N=9 or N=8), and this should be taken into account when interpreting the results.

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Table 4. Dashboard based on MPD in Indonesia risk severity

Ethical acceptability of the tool or technology: How significant are the negative impacts to an individual or a group if the following risks related to the technology or tool are realised?									
Risk	Distribution of responses [N]							Statistical figures	
	1: Very minor	2: Minor	3: Moderate	4: Serious	5: Very serious	Do not know	N (1-5)	Mean	Standard deviation
Discrimination of individuals	4	2	2		1		9	2,1	1,4
Deprivation of personal autonomy of an individual person	2	3	3		1		9	2,4	1,2
Infringement of privacy	2		6		1		9	2,8	1,2
Abuse of a relationship of trust	3	2	3		1		9	2,3	1,3
Causing personal disadvantage for an individual person	2	3	3		1		9	2,4	1,2
Stigmatisation of individuals	3	1	4		1		9	2,4	1,3
Inequality of individuals	3	1	3	1	1		9	2,6	1,4
Inequality of different groups of people	2	2	3	1	1		9	2,7	1,3
No freedom of choice to opt-out of the use of the tool or technology	2	1	5	1			9	2,6	1,0
Restriction of individual's life	3	2	2	1	1		9	2,4	1,4
Security of personal data is compromised	1	3	3	1	1		9	2,8	1,2
Collection of non-essential personal data	2	3	2	1		1	8	2,3	1,0
Automatic profiling	3	1	3	2			9	2,4	1,2
Accessibility requirements will not be met *	1	1	6			1	8	2,6	0,7

*Accessibility means that websites and mobile applications and their contents are such that anyone could use them and understand what is meant in them.

4.1.2. Results of Trasim training platform

A summary of respondents' opinions regarding the Trasim training platform is presented in Table 6. Most of the respondents had neutral or positive perceptions on the tool, regarding its effectiveness in achieving its purpose, efficiency in terms of use of resources, willingness to take to tool to regular use, perceived ease of use and clarity of instructions, accessibility of the tool and its suitability for civil protection, crisis management and disaster risk reduction. Of 18 respondents, there were only few (1 or 2) responses in category 2 of a five-step Likert scale (1: Strongly disagree, 2, 3, 4, 5: Strongly agree) and no responses in category 1 to any of the statements.

The share of responses in category "Do not know" was substantial for some of the statements (Table 6). This applies to statements regarding the suitability of the tool for civil protection, crisis management and disaster risk reduction as well as the accessibility of the tool. The characteristics of the respondents have probably contributed to the share of responses in the category "Do not know". Most of the respondents who answered the questionnaire regarding Trasim were working for the police. It is possible, that some of the respondents did not perceive themselves as competent to assess the accessibility of the tool or its suitability for civil protection and disaster risk reduction while answering the questionnaire.

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Table 5.Trasim training platform general opinions

Please indicate your opinions of the tool or technology, in regard to the following statements (from 1: strongly disagree to 5: strongly agree)									
	Distribution of responses [N]						Statistical figures		
	1: Strongly disagree	2	3	4	5: Strongly agree	Do not know	N (1-5)	Mean	Standard deviation
The tool or technology is effective in achieving its purpose			1	14	3		18	4,1	0,5
Regular use of the tool or technology would be efficient use of resources (such as money or working time)		2	4	7	3	2	16	3,7	0,9
The tool or technology should be adopted to regular use in my country		2	6	5	3	2	16	3,6	1,0
I would be willing to use the tool or technology again			3	9	6		18	4,2	0,7
The technology or tool is easy to use			1	9	8		18	4,4	0,6
There are clear instructions how to use the tool or technology		2	4	6	4	2	16	3,8	1,0
The tool or technology is suitable for civil protection		1	3	6	2	6	12	3,8	0,9
The tool or technology is suitable for crisis management			5	8	1	4	14	3,7	0,6
The tool or technology is suitable for Disaster Risk Reduction (DRR)		2	6	5		5	13	3,2	0,7
The technology or tool is accessible*			7	3	2	6	12	3,6	0,8

*Accessibility means that websites and mobile applications and their contents are such that anyone could use them and understand what is meant in them.

Summary of respondents' opinions on the ethical risks related to the Trasim tool is presented in Tables 7 and 8. In general, most of the respondents considered the realisation of ethical risks unlikely in case of Trasim. For all of the ethical risks presented to the respondents, a clear majority of the responses was in categories 1 (very unlikely) and 2 (unlikely). The only exception for this is the risk that accessibility requirements will not be met. For this risk, most responses were in category "Do not know".

Table 6. Trasim training platform risk probability

Ethical acceptability of the tool or technology: How likely is it that the following risks will be realised when the tool or technology is used?									
Risk	Distribution of responses [N]						Statistical figures		
	1: Very unlikely	2: Unlikely	3: Likely	4: Very likely	5: Certain	Do not know	N (1-5)	Mean	Standard deviation
Discrimination of individuals	5	6	1			3	12	1,7	0,7
Deprivation of personal autonomy of an individual person	5	6	1			3	12	1,7	0,7
Infringement of privacy	4	6	2			3	12	1,8	0,7
Abuse of a relationship of trust	4	7	1			2	12	1,8	0,6
Causing personal disadvantage for an individual person	5	6	1			2	12	1,7	0,7
Stigmatisation of individuals	4	6	2			2	12	1,8	0,7
Inequality of individuals	4	6	1			3	11	1,7	0,6
Inequality of different groups of people	4	6	1			3	11	1,7	0,6
No freedom of choice to opt-out of the use of the tool or technology	4	4	3			3	11	1,9	0,8
Restriction of individual's life	5	5	1			3	11	1,6	0,7
Security of personal data is compromised	4	5	1			4	10	1,7	0,7
Collection of non-essential personal data	4	6	2			2	12	1,8	0,7
Automatic profiling	4	6	1			3	11	1,7	0,6
Accessibility requirements will not be met *	4		1	2		7	7	2,1	1,5

*Accessibility means that websites and mobile applications and their contents are such that anyone could use them and understand what is meant in them.

Respondents' opinions on the severity of ethical risks related to the use of the Trasim tool are summarised in Table 8. The severity of Analysis text heremost of the risks was perceived to be very minor, minor or at most moderate. Most responses were in categories 1–3 for all the ethical risks covered by the study. The only exception to this was the risk that accessibility requirements will not be met. For this risk, most responses were in category "do not know".

The number of responses received to questions on the severity of ethical risks and their probability of being realised (from 12 to 15 responses to each individual risk) was lower than the number of responses received to the question on general opinions of Trasim (18 responses to each individual statement). The most likely reason for this is that some respondents have filled in the questionnaire only partially and not answered all the questions.

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Table 7.Trasim training platform risk severity

Ethical acceptability of the tool or technology: How significant are the negative impacts to an individual or a group if the following risks related to the technology or tool are realised?									
Risk	Distribution of responses [N]						Statistical figures		
	1: Very minor	2: Minor	3: Moderate	4: Serious	5: Very serious	Do not know	N (1-5)	Mean	Standard deviation
Discrimination of individuals	4	3	1	2		2	10	2,1	1,2
Deprivation of personal autonomy of an individual person	4	3	1	1	1	2	10	2,2	1,4
Infringement of privacy	3	3	2	2		2	10	2,3	1,2
Abuse of a relationship of trust	3	4	2		1	2	10	2,2	1,2
Causing personal disadvantage for an individual person	3	3	3		1	2	10	2,3	1,3
Stigmatisation of individuals	3	4	2	1		2	10	2,1	1,0
Inequality of individuals	3	4	1	2		2	10	2,2	1,1
Inequality of different groups of people	3	4	1	1	1	2	10	2,3	1,3
No freedom of choice to opt-out of the use of the tool or technology	3	4	2			3	9	1,9	0,8
Restriction of individual's life	3	3	2	1		3	9	2,1	1,1
Security of personal data is compromised	3	3	1	2	1	2	10	2,5	1,4
Collection of non-essential personal data	4	3	2	1		2	10	2,0	1,1
Automatic profiling	3	4	2	1		2	10	2,1	1,0
Accessibility requirements will not be met *	2	1	3	1		5	7	2,4	1,1

*Accessibility means that websites and mobile applications and their contents are such that anyone could use them and understand what is meant in them.

4.1.3. Results of dashboard based on MPD in Estonia

Respondents' opinions of the dashboard based on MPD are summarised in Table 9. In general, respondents agreed with the statements presented in the questionnaire on the effectiveness and efficiency of the tool, willingness to use the tool in future, ease of use and clarity of instructions, suitability of the tool for civil protection, crisis management and disaster risk reduction and accessibility of the tool. Responses in the neutral category (3) or indicating disagreement with the statement (values 1 and 2) were a clear minority in case of all the statements. No analysis on statistical significance of this result was performed, as the number of responses from 1 to 5 was relatively low (N=10 or N=11).

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Table 8. Dashboard based on MPD in Estonia general opinions

Please indicate your opinions of the tool or technology, in regard to the following statements (from 1: strongly disagree to 5: strongly agree)									
	Distribution of responses [N]						Statistical figures		
	1: Strongly disagree	2	3	4	5: Strongly agree	Do not know	N (1-5)	Mean	Standard deviation
The tool or technology is effective in achieving its purpose				7	4		11	4,4	0,5
Regular use of the tool or technology would be efficient use of resources (such as money or working time)			1	7	3		11	4,2	0,6
The tool or technology should be adopted to regular use in my country			1	6	4		11	4,3	0,6
I would be willing to use the tool or technology again				3	8		11	4,7	0,5
The technology or tool is easy to use			2	5	4		11	4,2	0,8
There are clear instructions how to use the tool or technology			1	6	3	1	10	4,2	0,6
The tool or technology is suitable for civil protection			2	6	3		11	4,1	0,7
The tool or technology is suitable for crisis management		2	2	5	2		11	3,6	1,0
The tool or technology is suitable for Disaster Risk Reduction (DRR)				7	4		11	4,4	0,5
The technology or tool is accessible*		1	3	4	2		10	3,7	0,9

*Accessibility means that websites and mobile applications and their contents are such that anyone could use them and understand what is meant in them.

Respondents' perceptions on the ethical risks related to the tool are presented in Tables 10 and 11. For most of the studied ethical risks, the respondents considered unlikely that the risk will be realised (at most one or two responses in categories 3, 4 or 5 out of 10 or 11 responses with numeric values) (Table 10). With regard to probability of the risk being realised, the overall picture is more mixed in case of some of the studied risks (no freedom of choice to opt out, automatic profiling and accessibility requirements not being met by the tool). For these risks, both the mean of the responses and standard deviation of the responses are larger than other studied risks. However, it was not analysed whether these differences are statistically significant or not, as the number of responses was relatively small (responses with values from 1-5: N≤11).

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Table 9. Dashboard based on MPD in Estonia risk probability

Ethical acceptability of the tool or technology: How likely is it that the following risks will be realised when the tool or technology is used?									
Risk	Distribution of responses [N]						Statistical figures		
	1: Very unlikely	2: Unlikely	3: Likely	4: Very likely	5: Certain	Do not know	N (1-5)	Mean	Standard deviation
Discrimination of individuals	7	4					11	1,4	0,5
Deprivation of personal autonomy of an individual person	7	4					11	1,4	0,5
Infringement of privacy	6	4	1				11	1,5	0,7
Abuse of a relationship of trust	5	6					11	1,5	0,5
Causing personal disadvantage for an individual person	6	5					11	1,5	0,5
Stigmatisation of individuals	8	3					11	1,3	0,5
Inequality of individuals	6	5					11	1,5	0,5
Inequality of different groups of people	4	5	2				11	1,8	0,8
No freedom of choice to opt-out of the use of the tool or technology	4	4	1	1	1		11	2,2	1,3
Restriction of individual's life	6	4	1				11	1,5	0,7
Security of personal data is compromised	4	5		1		1	10	1,8	0,9
Collection of non-essential personal data	4	5		1		1	10	1,8	0,9
Automatic profiling	3	2	3	1		2	9	2,2	1,1
Accessibility requirements will not be met *	1	3	2	1		4	7	2,4	1,0

*Accessibility means that websites and mobile applications and their contents are such that anyone could use them and understand what is meant in them.

Respondents' assessments of the severity of the risks related to the use of the tool are presented in Table 11. In general, respondents considered the significance of the ethical risks to be from very minor to moderate. For all the risks presented to respondents, a clear majority of the responses was in categories 1 (very minor), 2 (minor) and 3 (moderate) (Table 11). Differences between the means of the responses were also relatively small (largest mean: 2.5, smallest mean: 1.7).

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Table 10. Dashboard based on MPD in Estonia risk severity

Ethical acceptability of the tool or technology: How significant are the negative impacts to an individual or a group if the following risks related to the technology or tool are realised?									
Risk	Distribution of responses [N]						Statistical figures		
	1: Very minor	2: Minor	3: Moderate	4: Serious	5: Very serious	Do not know	N (1-5)	Mean	Standard deviation
Discrimination of individuals	5	4	2				11	1,7	0,8
Deprivation of personal autonomy of an individual person	5	4	2				11	1,7	0,8
Infringement of privacy	5	3	3				11	1,8	0,9
Abuse of a relationship of trust	5	3	2	1			11	1,9	1,0
Causing personal disadvantage for an individual person	4	4	3				11	1,9	0,8
Stigmatisation of individuals	5	4	2				11	1,7	0,8
Inequality of individuals	5	5	1				11	1,6	0,7
Inequality of different groups of people	3	4	2	2			11	2,3	1,1
No freedom of choice to opt-out of the use of the tool or technology	3	4	4	1			11	2,2	1,0
Restriction of individual's life	4	4	3				11	1,9	0,8
Security of personal data is compromised	3	4	3		1		11	2,3	1,2
Collection of non-essential personal data	4	4	2		1		11	2,1	1,2
Automatic profiling	2	3	4		1	1	10	2,5	1,2
Accessibility requirements will not be met *	1	3	4			3	8	2,4	0,7

*Accessibility means that websites and mobile applications and their contents are such that anyone could use them and understand what is meant in them.

4.2. Howspace and interview results

4.2.1. General results

A total of 76 responses were received to the Howspace workshops. The first theme Emerging technologies for risk and vulnerability assessments got the highest number of responses, with a total of 37 responses (49%). Theme Location-based services got 10 responses (13%). Of the responses, 13 (17%) were received for the theme Data sharing between authorities for crisis management. The last theme Crowdsourcing for improving preparedness got 16 responses (21%).

The technology-specific number of responses are shown in Table 12. Most of the responses were focused on satellite-based solutions, connectivity (5G and IoT solutions), and location-based services. The least responses were received for the blockchain technology.

Table 11. Number of responses received for different technologies.

Technology theme	Technology	Number of responses
Emerging technologies for risk and vulnerability assessments	Satellite-based solutions	11

Emerging technologies for risk and vulnerability assessments	Connectivity	10
Location-Based Services	Location-Based Services	10
Emerging technologies for risk and vulnerability assessments	Drones	8
Emerging technologies for risk and vulnerability assessments	Artificial Intelligence	8
Crowdsourcing for improving preparedness	Solving problems	7
Data sharing between authorities for crisis management	Solutions for data sharing	6
Crowdsourcing for improving preparedness	Producing new data	5
Data sharing between authorities for crisis management	Data fusion from public datasets	4
Crowdsourcing for improving preparedness	Enhancing data	4
Data sharing between authorities for crisis management	Blockchain technology	3
	responses in total	76

The majority of responses (30 responses, 39%) came from public sector (e.g. governments and other authorities). Almost as many responses (26 responses, 34%) came from not-for-profit sector (e.g. NGOs, faith-based organisations). 17 responses (22%) were from private sector (e.g. most businesses and self-employed). Three responses (4%) focused on 'other' option.

Most of the responses came from national level (36 responses, 47%) or global/EU level (23 responses, 30%). Of the responses, 11 (14%) were from regional level, and six responses (8%) were from local level.

Most of the responses were from Finland (45 responses, 59%). Responses were received from Belgium (10 responses, 13%), Italy (8 responses, 11%), Germany (7 responses, 9%), Estonia (3 responses, 4%), United Kingdom (2 responses, 3%), and Hungary (1 response, 1%).

4.2.2. Statement results

The results to the statements in the Howspace workshops and the same statements presented in the interviews are presented in tables 11 and 12. Table 11 includes the results regarding the first two technology themes that are emerging technologies for risk and vulnerability assessment and location-based services. Table 12 includes the results regarding the two latter themes which are data sharing between authorities for crisis management and crowdsourcing for improving preparedness. The answers were asked on a Likert scale, where correspondences were: 1 = strongly disagree, 2 = disagree, 3 = not agree or disagree, 4 = agree, and 5= strongly agree. The values in tables 11 and 12 are averages of respondents' responses.

The correspondences of the technology themes coded in tables 11 and 12 are as follows:

1-1 Satellite-based solutions
1-2 Connectivity
1-3 Drones
1-4 Artificial intelligence
2-5 Location-based services
3-6 Data sharing
3-7 Blockchain technology
3-8 Data fusion from public datasets

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4-9 Crowdsourcing to produce new data
4-10 Crowdsourcing to enhance data
4-11 Crowdsourcing to solve problems.

The number of responses varied between technology themes and their sub-themes (N=1-11). Those values that are presented in parentheses included less than five responses. These values are not included in the following comparison since the number or responses was low.

Table 12. Results of the Howspace workshops and interviews regarding emerging technologies and location-based services.

Argument	**1-1**	**1-2**	**1-3**	**1-4**	**2-5**
This technology is very useful	4,1	3,9	4,5	**3,8***	**4,9**
This technology has great innovation potential	4,3	3,9	**4,4**	**3,2**	**4,4**
This technology contains major ethical issues	**1,8**	3,3	2,8	3,6	**3,8**
This technology can increase or create risks for vulnerable people	**2,1**	2,6	2,4	3,0	2,9
This technology has great benefits with regards to its costs	3,9	3,5	**4,3**	**3,1**	4,0
This technology should be adopted to regular use in my country	4,0	**3,1**	**4,4**	3,3	4,3
This technology will be used widely in crisis management in 5-10 years	3,7	**3,1**	**4,7**	3,3	4,4

*The highest and the lowest averages of responses are bolded.

Table 13. Results of the Howspace workshops and interviews regarding data sharing between authorities and crowdsourcing.

Argument	**3-6**	**3-7**	**3-8**	**4-9**	**4-10**	**4-11**
This technology is very useful	4,5	(3,7)**	(4,3)	4,0	(4,0)	4,6
This technology has great innovation potential	(4,3)	(3,5)	(3,7)	(3,7)	(4,0)	4,0
This technology contains major ethical issues	(2,5)	(1,0)	(1,7)	(3,0)	(3,0)	3,4
This technology can increase or create risks for vulnerable people	(3,0)	(2,0)	(1,3)	(4,0)	(3,0)	**3,2***
This technology has great benefits with regards to its costs	(3,8)	(2,5)	(3,7)	(2,7)	(3,0)	4,0
This technology should be adopted to regular use in my country	4,2	(2,5)	(3,7)	(2,7)	(3,0)	3,6
This technology will be used widely in crisis management in 5-10 years	(4,0)	(2,0)	(3,7)	(4,3)	(3,8)	4,0

*The highest and the lowest averages of responses are bolded.
** Those values included less than five responses are presented in parentheses.

The biggest difference between responses occurred when evaluating major ethical issues of technologies. The technology deemed to have the fewest ethical issues was the satellite-based solutions (average 1,8) while the technologies thought to have the most ethical issues were location-based solutions and artificial intelligence (average 3,8 and 3,6, respectively). However, there was not a huge gap between the lowest

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and highest ranked technologies in terms of ethical issues, and none of the average values did not rise to agree or strongly agree (average equal or more than 4) that technologies contains major ethical issues.

Responses to the use of technology in crisis management in the near future was also associated with greater variation. Drones (average 4,7), location-based services (average 4,4) and crowdsourcing (average 4,0) were assessed to be used widely in crisis management in 5-10 years whereas connectivity opportunities through 5G and Internet of Things technologies (average 3,1) were evaluated as the least utilised technology.

The most useful technology based on the results was location-based services (average 4,9). Crowdsourcing for improving preparedness (average 4,6), data sharing solutions between authorities for crisis management (average 4,5), drones (average 4,5), and satellite-based solutions (average 4,1) were also assessed to be very useful technologies. Artificial intelligence (average 3,8) was evaluated to be the least useful technology in disaster management.

Drones (average 4,4), location-based services (average 4,4,) satellite-based solutions (average 4,3), and crowdsourcing (average 4,0) were mentioned to have great innovation potential whereas artificial intelligence (average 3,2) was evaluated to have the least innovation potential.

Crowdsourcing (average 3,2) and Artificial intelligence (average 3,0) were estimated to be able to increase or create risks for vulnerable people more than other technologies. Satellite-based solutions (average 2,1) were estimated to increase or create risks for vulnerable less than other technologies under evaluation. The differences between values when evaluating possible risks for vulnerable people were quite moderate. It should be also noticed that none of the technologies were not estimated to create risks to a great extent (average less than 4 or 5).

Drones (average 4,3), location-based services (average 4,0) and crowdsourcing (average 4,0) were estimated to have great benefits with regard to their costs. Artificial intelligence (average 3,1) was assessed to offer the least amount of benefits concerning costs.

Drones (average 4,4), location-based services (average 4,3) and data sharing between authorities (average 4,2) were technologies to be adopted for regular use, whereas connectivity opportunities through 5G and Internet of Things technologies (average 3,1) were assessed to be less important to adopt for regular use.

4.2.3. Usability and benefits of technologies in crisis management

This section presents the results regarding questions “What kind of benefits would this technology offer for crisis management?” and “How would you use this technology in crisis management?”.

Satellite-based solutions

According to the workshop participants, satellite-based solutions can benefit crisis management in several ways. These solutions can provide new visual and cartographic data and reliable knowledge/information on the spatial extent of disasters and local crisis conditions. Furthermore, this data and information can be used in early warnings, prediction and monitoring of crises. Information could also be used to coordinate with different stakeholders of the crisis. It was also said that, at the moment, satellite-based solutions are more useful for prevention activities than for crisis management, but another participant also pointed out

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that satellites can provide a real-time overview of how the crisis is spreading: *"Prediction and monitoring of crises, having a real-time overview of how the crisis is spreading, e.g. with forest fires."*[21] However, the problem with the current situation is that most of the users cannot use satellites directly but only upon request.

Connectivity opportunities through 5G and Internet of Things technologies

Benefits of 5G and Internet of Things focused on the use of sensors to gather real-time data from multiple sources. Respondents said that connectivity technologies could provide real-time updates on the current situation on the ground and real-time data to identify potential risks and to notify people of the risk and faster response to the crisis:

- *"Readily available real time data from multiple sources to get notification about developing threats and updates on the current situation "on the ground"."*
- *"Alerting of a danger before it hits and by doing this, more people have the ability to go to a safer area before the crisis. Monitoring the crisis through the help of the sensors"*
- *"I like the idea of the use of sensors to identify potential flood risks. This would have been very useful in Belgium prior to the flooding that occurred this past summer."*
- *"Sensors can be used in various types of crises. This enables to identify risks, notify people of the risk and faster the response to a crisis."*

Respondents also pointed out that these technologies could provide smoother and more flexible access to data sources, so that situation specific data needs could be covered more easily.

Drones

Drones can provide quick, close and high-resolution inspections of areas affected by disasters. Furthermore, respondents felt that drones extend the reach of visual observation, while keeping a safe distance to the crisis. Drones could provide benefits to many different users in different use cases and for example, to transport help when other transport options are excluded for different reasons: *"Observing crisis from safe distance; transporting help when other transport options are excluded for different reasons; locating vulnerable people".*

Artificial intelligence

Artificial Intelligence can be used to quickly analyse of large amounts of data and to find correlations in the data to get a better overview of the crisis situation. Furthermore, AI could be used to predict future crises based on the data. Responders also proposed that AI could monitor social media to gain knowledge of misinformation floating around in order to combat against the misinformation: *"--using AI to analyze tweets in a disaster situation. This might be a good way to gain a better understanding of what type of misinformation is floating around in order to communicate with the necessary stakeholders to create a strategy to combat this misinformation."*

Location-based services

Location-based services offer many possibilities in crisis management. Regarding the benefits of the location-based services, respondents said that these services offer a great deal of information for decision-making in operational and management level, for example to justify needs of resources without visiting the site. *"Information will be used for decision-making in different phases of disasters."* Furthermore,

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[21] Texts in italics are quotations from the responses.

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respondents pointed out that cooperation with different organizations can be improved with location-based services. These services thus improve preparedness and capabilities in disasters. Respondents also identified many possibilities, where location-based services could be utilized: *"Collecting situational awareness, disseminating situational awareness, allocating resources, planning and practicing the use of resources, gathering data using existing sources, both static and more dynamic sources in the future. Gathering information from citizens by crowdsourcing methods, collecting data by AI analysis seeking out a variety of issues, supporting decision making by visualization and management support. AI assisted decision making."*

Data sharing between authorities for crisis management

Workshop participants pointed out that data sharing between authorities would provide a great opportunity to streamline communications in a crisis situation and that it would enable foresight in all levels of disaster management. This would enable sharing situational awareness, which would provide the ability to have a more targeted response to the crisis: *"Data sharing enables foresight in all levels of disaster management, support choosing right activities at the right time, enables good crisis management."* Effective and working data sharing would improve evidence-based management of the crises.

Crowdsourcing for improving preparedness

Crowdsourcing was seen to be a good way to collect data easily from acute crisis situations. The data can be usually collected from individuals by smart phones, so it was seen to be a flexible method and that it is possible to reach people and information that are otherwise unseen by authorities (e.g. rural areas where authorities are not present all the time). It was also pointed out that crowdsourcing offers two-way communication, so communities can feed necessary information to authorities and authorities can use the information in crisis management and communication. However, there was also a comment that crowdsourcing is not useful in crisis situations, as it requires too much time, but most of the respondents said that the technology provides a better understanding of people and area in crisis situations. Also, it was highlighted that crowdsourcing can provide unbiased information (*"--avoid the politicization which sometimes determines which crises receive attention from the media"*) of the crisis, but there is also a risk of collecting misinformation: "*It could be a good way to collect data from the places were there is no authorities available. However; does it also provide a chance for a collect misunderstanding or even for lies?*"

4.2.4. Identifying, finding and assessing vulnerabilities

This section presents the results regarding questions "How could this technology be used in identifying vulnerabilities that are not currently addressed?", "How could this technology be used to find vulnerable people in crisis situations?", and "What kind of data could be gathered using this technology to make vulnerability assessment?".

Satellite-based solutions

It was mentioned that due to the warming of the climate, new areas are becoming at risk of disasters they have never faced before. In some areas where crises have been rather minor, crises now and in the future may be much larger and have more of an impact on society. Crisis and their impacts could be examined more thoroughly by satellite-based solutions. "*I think this technology does not allow do identify individuals, it is more about estimating the total of people being threatened by the crisis or to estimate the crisis area. But this information is important as well!"* On the other hand, it was mentioned that it might be possible to

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identify people who are threatened by ongoing disasters and are cut off from possible evacuation routes on satellite images. Another suggestion was that satellite data could be implemented with population data to enable to assess vulnerabilities.

Connectivity opportunities through 5G and Internet of Things technologies

There was seen potential of utilising technology to identify the locations of individuals in a flood or earthquake by rescue personnel scanning the disaster site from above. With a 5G connection, with GPS turned on, drones monitoring, and other sensors monitoring, it might be possible to find the people more easily. For vulnerable people, it is easier to reach out for help by phones and emergency applications. "*I like that this technology enables to notify individuals e.g. by phone. It is more personal, faster and more seriously taken this way than, for example, writing on the news portal that there is a storm coming up. People get the information faster and this is essential during a crisis. I would say that without this technology, people who read or listen to news maybe once-twice a week or don't consume social media that much are vulnerable as they might not get the information fast enough. This technology would enable them to be less vulnerable."*

Responders said that vulnerability may be mapped, received and analysed by devices and applications carried by people. With a pre-downloaded application, it is possible to write down personal health problems or conditions that may make an individual vulnerable in different crises. One solution mentioned was SaveMyLife application created by University of Indonesia. Information could be transferred during a crisis to organisations providing help through IoT connections.

Drones

Drones may be able to go to locations where no other access exists and find people in danger. They can be used to look for people still caught in affected disasters and to locate people who need special assistance. They can be used to map areas affected by natural disasters and destroyed traffic infrastructure. They can be used to collect visual information, also with infra-red cameras to identify heat sources like people who can't be seen in the normal visual spectrum, for example, at night. "*Mostly visual information that can be combined with different other technologies, e.g. body heat detectors, night vision possibilities, transporting possibilities etc*."

Artificial intelligence

In disasters, AI may analyse calls for help on Social Media and forward requests of help and identified special needs to help rescue organisations and other actors response effectively.

Location-based services

It was suggested that if location-based solutions, such as mobile apps, contact all people in a certain area or place, they can also contact people who may be vulnerable. This is, of course, possible if people have mobile phones and they use service-enabling applications. Technology could identify impacts of accidents or disasters in a certain area and help to plan evacuation activities. Data could show which people and where these people are who need special support.

In a crisis, people can inform through technological applications what kind of help they need by choosing from pre-defined options. Technology could assess an individual's proximity or ability to access an evacuation route and/or their proximity to a centre that could provide assistance in crisis (i.e., earthquake or flood). Technology could also enable multilingual communication in crisis and send emergency warnings and evacuation guidance to phones located in a specific area/ base station.

The challenge is that when using personal data such as health records, there are always GDPR issues to be considered. However, data could illuminate special needs of individuals: "*By integrating data on place of residence and data from health and social records, it is possible to combine new useful data. Data may reveal vulnerabilities, such as patient recovering from a surgery or a user of respirator living alone, and definitely needing assistance in disaster situations.*" "*Chips in garment or under skin would provide location-based information of dementia patients, but acceptability is not achieved yet."*

Data sharing between authorities for crisis management

Technological solutions could be used to identify calls for help on social media platforms and to bring them to the attention of disaster responders. Technology could be used for indicating abnormal events and identifying weak signals of phenomenon, so called "red flags" of spatial or temporal frequency potentially indicating gradually evolving pattern.

It was said that there is already much data and a lot of information available. The challenge is to cross-check existing data from the viewpoint of different actors. The most impressive new functionalities may be found from the interfaces between actors who have not cooperated before. Data could be examined from the point of view of individual well-being, which could create new perspectives. It was also highlighted that vulnerability should be identified before crisis situations happen and in so-called "everyday life". That could enable to identify abnormal situations/issues, enhance preparedness planning, enable fast response, and comprehensive crisis management.

There was a suggestion for individual level technology assistant. "*I particularly like the facial recognition aspect of the technology, especially in regard to the ability to translate messages from different languages in order to reach crisis management personnel. This is a great way to tackle communication-related barriers in a crisis for populations like tourists who may not have the same situational awareness as a local, or a migrant or refugee, who may not yet speak the language of the host country."*

Blockchain technology

Rescue services, for example, could use this technology to reduce overlapping when searching in a particular area for affected individuals. If one area has already been searched, another block could be created, that will give a signal to other rescue groups that they can start searching in another area. *"This technology could be useful in identifying gaps in current strategies to provide humanitarian aid in a crisis situation. For example, the UN cluster system sometimes results in redundancy of services which overlap and do not always address the multitude of needs of a population during a crisis."*

Vulnerability assessment tool

It was pointed out that the vulnerability assessment tool shifts the focus from vulnerability emanating from an individual's capacities to their connections in society and their ability to access social support structures. This reveals vulnerabilities that may not have been previously considered in crisis management strategies.

Crowdsourcing for improving preparedness

One perception was that technology could bring to light new vulnerabilities that may not be self-identifiable for certain populations, and give crisis management personnel or NGOs new insight into the realities of

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the populations they serve during crises. Another suggestion was that technology could utilise information from the grass-root level that could be disseminated through collaborative networks. In this way, new vulnerabilities that had not previously been focused on could be illuminated.

The ability of this technology to find vulnerable people in a crisis situation may be limited, but if it would be used in a similar manner to the mapping of Covid-19 symptoms, authorities might have a general idea, where certain populations are that might require assistance. However, this is limited to individuals who have access to mobile devices. Disaster management is carried out by multiple agencies who often do not have a common interphase. Crowdsourcing technology could act as the 'interpreter'.

Crowdsourcing was seen the most useful in cases where large population is concerned. In a situation where danger is gradually evolving and may become serious, predictive data analysis would help to find vulnerable people.

4.2.5. Risks, challenges and gaps in the use of technologies

This section presents the results regarding questions "What risks do you see in using this technology?", "What challenges do you see in adopting this technology?", and "What kind of gaps do you see related to applying this technology?".

Satellite-based solutions

Responders assessed that freely available pictures of private property pose a risk of misuse of information by criminal parties. There might also rise risks for violation of privacy. The high costs regarding launching and operating satellites may pose challenges. "*Given the constant budget challenges faced by disaster relief forces, it could be challenging for them to get access to satellite imagery*." Problems may occur if frequency and timeliness of satellite imagery is too low for real-time disaster detection and monitoring. Fleets of satellites like Iceye system were seen to improve the situation. On the other hand, the information relies quite heavily on a multilevel coordination plan. If such a plan is not implemented, the high cost of operations may not be justified.

Potential human rights violations against migrants and refugee populations were mentioned: "*If this information is used and weaponized by agencies like Frontex, for example, it could lead to increased pushbacks (particularly in the Mediterranean), increased interference with NGO rescue ships, and an overall increase of EU member states shirking their responsibilities of welcoming refugees*."

Connectivity opportunities through 5G and Internet of Things technologies

Private issues concerned responders: "*If every aspect of day-to-day live is monitored through the IoT it could cause tremendous privacy issues."* People should also understand all the functions of the IoT devices they use so that they can decide what kind of information devices are collecting. *"-- and not all people want or can buy them - as there is a risk of personal data going out everywhere, people may not want to use this*." Lack of non-internet based backup systems could cause problems: "--*Furthermore, too much reliance on digital communication networks can become problematic if it fails due to a disaster.*"

Drones

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Many risks were seen regarding drones. They can intrude into private spaces, they can threaten normal air traffic and can also be easily weaponized. Drones may cause accidents and collisions with manned aircrafts. They can be hacked and therefore lead by someone else whose intentions may be hostile. Existing regulation were seen unclear. There is a need for: "-- *clear laws stating who and when is allowed to fly drones and on which conditions + which security conditions must be met to get that permit to fly and use UAV for rescue operations*." General public acceptance was also seen as an issue that has to be taken into account when using drones and legislate new regulations.

Artificial intelligence

Artificial intelligence often has unknown or unrecognized biases based on the data used to train it. AI technology may be applied without fully understanding of what it actually does. There might also be expectations that AI works in any case or case at hand, if it has worked in the previous case. "*I think AI itself is not risky as it is an analysing tool that helps to create fast insights and conclusions from large amounts of data. I see the risks in the data that is being given to the AI tool. If we give the AI weather data that is being collected, I think it does not have so many risks or privacy concerns. If we give AI social media or more personal data, it raises issues. So, for me, it is very database dependent.*"

Location-based services

It was seen that applications should be very easy to use. It should be also very carefully defined who can use the information gathered from people. Most vulnerable people may have not possibilities to use mobile phones, or they do not get information on possible applications they could use to get help. It should be ensured that applications are inclusive, allowing for individuals who might face communication-related barriers to also use them.

Reliability of data or lack of it might cause problems. If data is collected via smart phones, it should be known what is the percentage of population in an area having smart phones. It might be difficult to get data from the most vulnerable people, as they do not have smart phones or any other kinds of equipment for data collection.

Data security is a big concern. Who manage data, who can reach data, where data is stored, and what kind of data is gathered? It should be ensured that data collected to a certain intention is not used for any other purpose such as commercial solutions if not beforehand notified. Data availability must be strict defined and protected only for real users.

Basic technological solutions already exist, but there might be lack of understanding on how technology is possible to utilise/applicate in different domains. Data integration is a hot topic, and the question is more like how to invent new ways of integration. "*During the Covid-19 situation, location of mobile phones were followed by a certain applications (e.g. in Finland) if user had approved to use the application. Basically, the idea was a very good, an alarm will come, if the phone is near to a person infected. Same kind of idea could be used for other needs. Data did not include personal data, it was pseudonymized*."

Responders saw personal data issues as challenging and GDPR issues maybe a reason not to take technology into use. Trust in authorities may also become a threshold for using technological services.

Data sharing between authorities for crisis management

One challenge is that quite often security sector act as a silo. There is no broader view than one sector at time. Because resource problems and high costs can be a big challenge for some public organisations,

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there is no broader view of costs. There may exist resistance to change ways of working. Some organisations may want to continue as before and may not want to start using new technological solutions.

If e-platform “collapses”, information is not available anymore or it could be damaged. There should always be a backup system to enable the use of tool off-line, and technology should operate in serious damages of critical infrastructure. It is challenging to ensure functionality of extensive long-term communication system against power disruptions. “*The more sensitive technology, the more susceptible for technical problems, and dependence on electricity increase all the time*”.

Blockchain technology

The strength of blockchain is that experts are the ones that can update and add new information. In terms of humanitarian aid or crisis management, although this technology provides opportunities to act more efficiently, it may miss the perspectives of vulnerable populations themselves. In this way, certain needs may be missed and go unmet. “*I am not entirely convinced that a database using blockchain is really necessary for the coordination of disaster relief efforts. Couldn't a central database which is run by a trustworthy actor (for example the UN) and is regularly backed up achieve the same results with a less complicated and resource intensive infrastructure?”*

Crowdsourcing for improving preparedness

People might deliver false information due to their own misunderstandings, they might have hostile intentions, or they might even make jokes. Crowdsourcing technologies could be more useful as a supplement to crisis management rather than being used directly by crisis management. Guidelines for collaboration will need to be put in place in order to ensure effectiveness and aligned activities. It is also necessary to find and offer value to the end user. Readiness to change the traditional way of working might be low in some organisations, and challenges may rise when planning new activities.

Crowdsourcing could be most helpful in total catastrophes, floods, earthquakes etc. However, in these situations the mobile network does not always work. On the other hand, technology could be used in preparedness. “*Since this technology is mostly useful in the preparedness phase, it is important that if any new vulnerabilities are identified they are not viewed as 'static'.”*

4.2.6. Ethical challenges and risks for vulnerable people

This section presents insights into major ethical issues regarding technology and the potential of technology to increase or create risks for vulnerable people.

Satellite-based solutions

The very high-resolution imagery, which shows targets as small as decimetres, can lead to security risk of terrorism. It could also provide criminals with information about valuable targets for armed robberies or locate areas of chaos to exploit chaos. State actors or private stalkers can use technology for spying on people. Aside from potential GDPR issues and the potential weaponization of such information against migrant and refugee populations, homeless populations may also be at risk. This could increase the precarity of their situations. “*Another example: if a migrant encampment was identified it could result in increased police presence, brutality, or increased deportations. This is detrimental for social care organisations who sometimes rely on these populations coming forward to seek help in order to provide*

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services. With increased distrust in authorities, vulnerabilities may be increased as some populations may be too fearful to seek out services."

Connectivity opportunities through 5G and Internet of Things technologies

Aside from potential violations of privacy, this technology could further marginalize individuals who already face communication-related barriers. Populations like homeless, refugees and migrants may not have updated devices enabling connectivity technologies and may not be able to benefit from this technology. Privacy issues also concerned: "*Violations of privacy when people carrying IoT devices do not completely understand all of their functions*".

Drones

It was highlighted that intrusion into privacy by very clear images of personal spaces and potential use of weapons are ethical problems. There are some general privacy concerns that are not concerning only e.g. vulnerable people but everybody. The opposite viewpoint, on the other hand, pointed out: "*If a person is vulnerable during a crisis situation, I see more help of this solution than harm for them*".

Artificial intelligence

AI is quite novel technology and it is very difficult to completely avoid mistakes. This might lead to ethical problems when data associated with people is processed. Even worse situations may happen: "*AI-induced mistakes in connection with disaster relief can be literally fatal*". AI-systems are often biased against already discriminated population groups due to the data used to train it. Therefore, certain populations who do not have access to a computer or a phone may be left out of the AI's analysis, thus perpetuating normative conceptions.

Location-based services

Careful definitions will be needed, in which situations authorities or other organisations can send "mass" messages to people. Processes and protocols should be managed properly. Risks occur if located-based information is available or easily accessed to other actors than intended. Data can be, for instance, utilised commercially, as commercial utilisation can be a requirement for technology availability. Authority may use data for invoicing services etc., or data can be used for criminal investigation. "*By integrating location-based data, taxation data, and data from health and social care services it might be possible to identify vulnerable persons. There are many ethical challenges associated with such data integration, although the purpose could be good and improve help provided to vulnerable people*".

In some cases, vulnerable populations may not be as mobile as others. For example, a homeless community may congregate in one particular area if they know that it is safe. If the positioning data was matched to their community, there is a potential for this information to be weaponized against them i.e. police pushing them out of those areas at a later time. *"In future dystopia some actor might want to use data against population groups, data security must be in high level to prevent data misuse"*.

Very practical concern also raised: "*Individuals should not rely too much on mobile phones. If disasters happen, they might need to survive themselves. Mobile networks might collapse, or phones will be out of power. Technology may always fail.*"

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Data sharing between authorities for crisis management

Technology as a technical platform was not seen as a problem. Ethical problems will be related to the content and data itself, since information security and GDPR issues may cause ethical problems. "*Witnessing or finding yourself in the middle of a disaster is very traumatizing. The use of the facial recognition tool as well as the ability of the users of the application to provide pictures of the disaster in real time will have to be strictly regulated in order to ensure that these images are not circulated further post disaster."* On the other hand, if technology and the number of remote services increase, personal contacts between vulnerable people and others will decrease. This is also problematic.

Blockchain technology

This technology may be inaccessible to some individuals who are considered vulnerable or as a part of a vulnerable population. This may exacerbate pre-existing communication barriers or further marginalize some individuals who already find themselves left out of crisis management or response strategies.

Data fusion from public datasets

Although the tool offers several useful features, its use is limited by the quality of available data. If vulnerable people are not covered by the data sources already collected, vulnerability will be not identified when using this kind of tools.

Crowdsourcing for improving preparedness

This technology relies on the use of mobile phones, which have the capacity to utilize newer apps. Certain individuals who may be a part of populations that are considered vulnerable may not have access to novel mobile phones. This may lead to them being excluded from the assessment when using this technology. The involvement of citizens greatly depends on their capacity to participate. Language barriers or distrust in authorities, for example, could prevent some individuals from participating. If this happens, some populations will be left out of the co-creation problem-solving process.

If the information is not used, it can also be a problem: *"My data -way of thinking exist in Europe. How ethical it is not to use available information in serious crisis even though the use of information has not been allowed in advance? It would be more ethical to use the data, so permissibility must be agreed carefully beforehand."*

Information can also be jeopardised if it is shared freely: *"There are potential privacy implications for technologies such as mapswipe. It would be valuable in identifying encampments of internal migrants for humanitarian aid personnel who might not otherwise have known where to look. However, it can also pose some serious issues, i.e., identifying homeless encampments or informal refugee camps. This sort of information, if in the wrong hands, could be weaponized against them and lead to their expulsion or worse."*

4.2.7. Future prospects for technologies in crisis management

This section presents the results regarding question "How do you see the future of this technology?" and provides insights into how it might be put to regular use in crisis management in the near future.

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Satellite-based solutions

Responders saw that satellite-based solutions will increase knowledge on disasters spatial extent, both in real-time and in statistical purposes. In order to make better use of statistics, easy-to-understand explanations should be provided so that first responders, government agencies and other actors using the data have a clear and uniform understanding of the results. Data can then be used more efficiently for evidence-based management.

Drones

Drones will soon be in routine use in crisis management. They can replace costly manned aircrafts and have access to places with some level of obstacles as compared to manned aircraft. There is potential of using drones especially for remote positioning in areas at risk. Current flight regulations still need changes regarding remote flight.

Artificial intelligence

AI will probably become much more widespread and an integral part of both everyday live and disaster response efforts. However, it will be a subject to enormous discussions and controversies.

Location-based services

It was seen that various actors are working to promote and improve the use of location-based data in various sectors. However, there will be big challenges in locating persons, since ethical problems will exist. Significant added-value from location-based services would be needed to accept extensive use of location-based applications. Technology is developing fast. "*New drones were tested in a drill, where fictional chemical leak happened. The software calculated requirements needed in the rescue operation very detailed*." New applications will be used e.g. for monitoring: "*Previously, electricity pole was equipped with electric cable, now with optical fibre that enables using of sensors. They can be used to detect deviant behaviour, analyse sound, or guidance of crowd control.*"

Solutions for data sharing

Service platforms and communication systems will evolve further and they are used in everyday life, not only disasters. They can facilitate administration to identify what kind of data society can produce. Systems and technological solutions will likely to become more complex and maybe more susceptibility to technical problems. Electrical dependence will increase, which will be a big concern for the resilience of society.

Data fusion from public datasets

Data fusion from public datasets will provide a great basis for understanding vulnerability as a dynamic phenomenon rather than a static one. That understanding could lead to the development of other tools or strategies to prepare crisis management.

Crowdsourcing for improving preparedness

If crowdsourcing technology is misused, it will enable abuse of power and trampling of human rights. Technology will change society. E-platforms will enable individuals to start business easily and with low threshold. Sensor technology may monitor, e.g., health issues, and personal sensors may transmit a wide range of data to other parties. Changing society will require public debate and agreement of rules. Some

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kind of training will be needed for volunteers but committed fourth sector is a good resource pool in disasters. Authorities could call help when needed by technological applications and utilise volunteers' large areas of expertise. Crowdsourcing will increase because of the increasing use of mobile phones also in developing countries.

"Should be used already in everyday life (not only in disasters), will facilitate administration to identify what kind of data society can produce".

4.3. Discussion

The analysis presented the results of end-user evaluations of the new technologies identified in the Catalogue of tools and technologies for disaster management (Task 2.5). Technological tools tested in three BuildERS case studies were also included in the evaluation. The end-user evaluation and assessment were carried out through questionnaire-based surveys and in co-creative workshops with technology partners, first responders and service providers, officials of cities and local communities, supportive NGOs, and other stakeholders.

A total of 76 responses were received in the Howspace workshops. Our experience was that it was very difficult to get people participate in the evaluation. A part of people registered in the online platform did not respond to any questions or leave any comments. We did not receive feedback on the issue so we can just assume possible reasons for incompleteness. Participants might have found it laborious to focus on the questions, or they might have just wanted to see what kind of tool the online platform was. In any case, the Covid-19 situation has led to considerable increase of online surveys, so the BuildERS workshops contended for attention and time of contacted end-users.

The majority of the responses (over 70%) came from public sector or from not-for-profit sector. This means that the views of public authorities and organisations providing help in crisis are emphasised in the responses. A fifth of the responses came from private sector, where occupations such as technology development, research, education, and training were mentioned. Thus, the responses also reflect the views of technology developers. Views of national and global/EU level dominated in the responses, since almost 80% of responses came from those levels. Thus, responses reflect less local or regional level expertise.

Most of the responses focused on satellite-based solutions, connectivity (5G and IoT), and location-based services. Blockchain technology received the fewest responses. The distribution of responses may be due to the fact that some technologies such as satellite-based solutions, connectivity, and location-based services are well known and already in use and thus, respondents might see them as suitable solutions and offering many possibilities to support crisis management. On the other hand, blockchain technology may be quite unfamiliar and not so obvious choice for supporting crisis management as the respondents do not understand the technology and its possibilities very well.

When looking at the results, it seems that drones, location-based services, and crowdsourcing are the most preferable technological solutions in crisis management. They were assessed to be the most useful technologies, having great innovation potential, they had more benefits in comparison to their costs, and they were estimated to be used widely in crisis management in the near future. On the other hand, technological solutions containing most ethical issues were estimated to be location-based services and Artificial Intelligence. However, there was not a huge gap between the lowest and highest ranked technologies in terms of ethical issues. AI solutions and crowdsourcing were estimated to increase or create risks for vulnerable people more than other technologies. Therefore, technological solutions may

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offer great opportunities to support crisis management, but at the same time, potential risks and ethical concerns must be carefully considered not to cause any additional problems for people or society.

Data security was seen as a big concern related to all technologies. It should be ensured that data collected to a certain purpose is not used for any other purposes if not beforehand notified. It should be also very carefully defined who can use the information gathered from the people. Data management procedures must be strictly defined: what kind of data is allowed to gather, who manages data, who can reach data, and where data is stored. One challenge is that quite often different actors such as authorities act as separate silos. There is no broader view than one sector at time. Silos complicate active data sharing and may slow down evidence-based management in crisis. There are solutions such as platforms for data sharing, but the problem seems to be they are not yet utilised widely and efficiently enough. Authorities also need to consider availability of resources, and lack of funding might be a big problem in the utilization of new technologies.

Reliability and lack of data might cause risks. If ordinary people (i.e. not crisis management experts) participate in data production, risks may occur. People might deliver false information due to their own misunderstandings, they might have hostile intentions, or they might even make jokes. Guidelines for wide collaboration with volunteer actors will need to put in place in order to ensure data reliability. If data is collected by using smart phones, it should be known what is the amount of population having smart phones. Certain individuals who may be a part of populations that are considered vulnerable may not have possibilities to use smart phones, or they do not get information on possible applications they could use to produce data or get help. This may lead to them being excluded when using technology. The involvement of people greatly depends on their capacity to participate. Language barriers or distrust in authorities, for example, could prevent some individuals from participating. It should be ensured that applications are easy to use and inclusive, allowing for individuals who might face communication-related barriers to also use them.

People should understand the functions of technological devices or services they use so that they can decide what kind of information devices and solutions can collect. For instance, devices with IoT solutions and AI technology may be used without fully understanding what they actually do. Technological solutions such as location-based services are already widely used, but there might be lack of understanding on how novel technological solutions can be utilised or exploited in different domains. People might share data for the purposes they are not willing to do just because they do not understand which actors will use data, how data is used and, and where data is used. This may be due to insufficient or unclear terms of use (or similar documents), or just because people do not understand the technological capabilities well enough. On the other hand, some people might not share the needed data as they cannot be sure (or do not trust) that authorities or companies handle their data securely and in accordance with their promise (e.g., terms of use, privacy notice).

With the fast development of technology and innovative utilisation of technological solutions for new domains challenge to keep legislation up to date. Technology offers great opportunities for crisis management, such as the use of drones in disaster areas where rescue personnel have no access to all areas or places. However, use of technology may violate privacy of individuals if regulation does not set appropriate code of actions. In addition to regulation, general public acceptance was seen as an issue that has to be taken into account when using technological solutions and services in new ways.

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5. Conclusions

Based on the results of end-user evaluation, following recommendations should be taken into account in the implementation of technological solutions in crisis management.

- It should be ensured that technological solutions and applications are easy to use and inclusive, allowing for individuals who might face communication-related barriers to also use them.
    - Apply people/user-focused design in early stages of development.

- It should be ensured that data collected to a certain purpose is not used for any other purpose. It should be also very carefully defined who can use the information gathered from the people. Data management procedures must be strictly defined, and practices outlined.
    - Regarding personal data: enforce GDPR and educate/guide on the possibilities GDPR offers.
    - Regarding other data: enforce related regulation and educate/guide on the data management practices.

- To streamline communication in a crisis and enable foresight in all levels of disaster management, data sharing between authorities should be secured. Effective and smooth data sharing is essential for situational awareness and evidence-based management in crises.
    - Dismantle silos between different organisations.
    - Enable data sharing with GDPR, related regulation and standards.

- Technological solutions do not reach all people. To improve information sharing, there should be developed and implemented solutions that are widely available and usable (e.g. cost-efficient, easy to use, and suitable for different devices). Non-technological tools and methods are still needed to support crisis management. These tools and methods should be used along with emerging technologies and to improve technological solutions continuously.
    - Acknowledge and identify people that cannot be reached with technological solutions.
    - Design tools and methods to reach them in crisis situations.
    - Develop and implement technological solutions that reach wider population.

The last recommendation should be seen in a wide context. Actors might be authorities, organisations offering help, NGOs and volunteers, or ordinary citizens.

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6. Annexes

Annex 1. Questionnaire of the survey.

Section	Question	Response option
Background information Background information is used to evaluate if the tool or technology is seen differently by different type of users. In addition, purpose is to find out, what tool or technology was used and whether the tool or technology was used or only demonstrated to respondent.	Do you represent:	Citizen / individual user Non-governmental organisation (NGO) Municipality Local authority Government Rescue organisation Police or border control Industry University / research organisation Education, shools Other (specify)
	Which of the technologies or tools you are evaluating? Select the option that represents the tool or technology that you are evaluating. All questions will be related to the selected technology.	Finland: Interactive exercise platform (Trasim) Estonia: Indonesia: Other, please name or describe the tool or technology
	Have you used the technology or tool in question?	Yes No
Questions on the Trasim tool This section includes a few questions related to the Trasim tool. **This section was only shown if Finland was selected in the background information.**	**Please indicate your opinions of the Trasim tool in regard to the following statements, from 1 (Strongly disagree) to 5 (Strongly agree)**	**Likert scale from 1 to 5**
	Trasim operated in a reliable manner during the exercise.	
	Trasim presented the communication scenarios in a realistic way.	
	Collaboration with other public authorities worked in a realistic way in the exercise carried out with Trasim	
	The exercise carried out with Trasim improved my skills to protect vulnerable groups against hate speech and online shaming.	
	The exercise carried out with Trasim improved my skills to interact with vulnerable groups	

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Section	Question	Response option
	The exercise carried out with Trasim improved my abilities to answer needs for information by media and the general public	
Usability of the tool or technology Purpose of the following questions is to evaluate user experience and usability of the tool and thus, the technology readiness level, too.	**Please indicate your opinions of the tool or technology, in regard to the following statements (from 1: strongly disagree to 5: strongly agree)**	**Likert scale from 1 to 5**
	The tool or technology is effective in achieving its purpose	
	Regular use of the tool or technology would be efficient use of resources (such as money or working time)	
	The tool or technology should be adopted to regular use in my country	
	I would be willing to use the tool or technology again	
	The technology or tool is easy to use	
	There are clear instructions how to use the tool or technology	
	The tool or technology is suitable for civil protection	
	The tool or technology is suitable for crisis management	
	The tool or technology is suitable for Disaster Risk Reduction (DRR)	
*Accessible means that websites and mobile applications and their contents are such that anyone could use them and understand what is meant in them.	The technology or tool is accessible*	
Perceived risks or challenges of the tool or technology Following questions are used to evaluate potential risks and challenges related to implementation of the tool or technology.	**Please indicate your opinions on the risks and challenges potentially related to the tool or technology, in regard to the following statements (from 1: strongly disagree to 5: strongly agree)**	**Likert scale from 1 to 5**
	The benefits of the tool or technology are unclear	
	The costs of the tool or technology are unclear	
	The costs of implementation are too high compared to the benefits	
	The operating costs are too high compared to the benefits	

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Section	Question	Response option
	Technological maturity of the tool or technology is not sufficient for practical use	
	Implementation of the tool or use of the technology is prevented by regulatory barriers	
	Vulnerable groups may be affected in an adverse way	
	Acceptance of the tool or technology by the general public is unclear	
	Acceptance of the tool or technology by the general public is not likely	
*Accessible means that websites and mobile applications and their contents are such that anyone could use them and understand what is meant in them.	The tool or technology violates privacy or otherwise does not meet applicable data protection requirements	
Ethical acceptability of the tool or technology Following questions are used to evaluate ethical aspects regarding the tool or technology. Purpose is to find out if the usage of the tool or technology might have negative impact on lives of individuals.	**How likely is it that the following risks will be realised when the tool or technology is used? Please state your opinion on following risks (on the scale from 1: Very unlikely to 5: Certain)**	**Likert scale from 1 to 5**
	Discrimination of individuals	
	Deprivation of personal autonomy of an individual person	
	Infringement of privacy	
	Abuse of a relationship of trust	
	Causing personal disadvantage for an individual person	
	Stigmatisation of individuals	
	Inequality of individuals	
	Inequality of different groups of people	
	No freedom of choice to opt-out of the use of the tool or technology	
	Restriction of individual's life	
	Security of personal data is compromised	
	Collection of non-essential personal data	
	Automatic profiling	
*Accessibility means that websites and mobile applications and their contents are such that anyone could use them and understand what is meant in them.	Accessibility* requirements will not be met	
	How significant are the negative impacts to an	**Likert scale from 1 to 5**

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Section	Question	Response option
	individual or a group if the following risks related to the technology or tool are realised? Please state your opinion on the following risks (on the scale from 1: Very minor to 5: Very serious)	
	Discrimination of individuals	
	Deprivation of personal autonomy of an individual person	
	Infringement of privacy	
	Abuse of a relationship of trust	
	Causing personal disadvantage for an individual person	
	Stigmatisation of individuals	
	Inequality of individuals	
	Inequality of different groups of people	
	No freedom of choice to opt-out of the use of the tool or technology	
	Restriction of individual's life	
	Security of personal data is compromised	
	Collection of non-essential personal data	
	Automatic profiling	
*Accessibility means that websites and mobile applications and their contents are such that anyone could use them and understand what is meant in them.	Accessibility* requirements will not be met	
BuildERS model The section includes questions regarding the tool or technology in the context of the BuildERS model. The BuildERS model is described below. [FIGURE] Before crisis (prevention, preparedness), acute crisis (response), after the crisis (recovery, learning). Reslience impacts more before risk and during the risk. Vulnerability increases during the crisis and is highest immediately after the crisis. Risk awareness and social capital affect fundamentally to reslience and vulnerability of individuals, groups and society. By learning from crisises and preparing to them, it is possible to increase risk awareness and social capital.	**In which phases of the crisis management or emergency management circle (BuildERS-model) is the technology or tool relevant? Please, express your opinion with a number from 1 (Not relevant at all) to 5 (Highly relevant).**	**Likert scale from 1 to 5**

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Section	Question	Response option
This section includes special terminology of BuildERS project. The terminology is described below. Resilience: Processes of proactive and/or reactive patterned adjustment and adaptation and change enacted in everyday life, but, in particular, in the face of risks, crises and disasters. (BuildERS definition) Risk awareness: Collective (groups and communities) acknowledgment about a risk and potential risk preventing and mitigating actions, fostered by risk communication. (BuildERS definition) Social capital: Networks, norms, values and trust that entities (individuals, groups, society) have available and which may offer resources for mutual advantage and support and for facilitating coordination and cooperation in case of crisis and disasters. (BuildERS definition) Vulnerability: Dynamic characteristic of entities (individuals, groups, society) of being susceptible to harm or loss, which manifests as situational inability (or weakness) to access adequate resources and means of protection to anticipate, cope with, recover and learn from the impact of natural or man-made hazards. (BuildERS definition)		
	In the Pre-crisis (prevention / mitigation and preparation)	
	In the Acute crisis (response)	
	In the Post-crisis (recovery / learning)	
	Other possibilities? (please specify)	
	Please indicate your opinion on the scope of the technology or tool. Please, state your agreement with the statements, from 1 (strongly	**Likert scale from 1 to 5**

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Section	Question	Response option
	disagree) to 5 (strongly agree).	
	The technology can be used to improve the protection of Individual citizen in crisis	
	The technology can be used to improve the protection of Specific groups in crisis	
	The technology can be used to improve the protection of the Whole society in crisis	
	How does the technology or tool contribute to resilience building in a crisis?	**Please indicate whether you agree with the following statements, from 1 (Strongly disagree) to 5 (Strongly agree).**
	The use of the technology / tool can improve risk perception of an individual citizen	
	The use of the technology / tool can improve risk awareness of specific groups	
	The use of technology / tool is beneficial for the society at large in terms of improved risk awareness and social capital	
	The use of the technology / tool can improve social capital of individual citizen	
	The use of the technology / tool can improve social capital of specific groups	
Technical readiness of the tool or technology These questions are used to evaluate the Technology Readiness Level (TRL) of the tool. TRL is a method for estimating the maturity of technologies. The purpose is to determine the level of development to guide authorities and others in selection of suitable tools for Disaster Risk Reduction (DRR).		**Please indicate your opinions of the tool or technology, in regard to the following statements, from 1 (Strongly disagree) to 5 (Strongly agree)**
	The technology or tool provides the functionality you expect	
	The technology or tool operates in a reliable manner	
	The technology or tool requires further development to be relevant for practical use	
	A prototype of the technology or tool has been implemented and validated in relevant environment	

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Section	Question	Response option
	Technical feasibility of the tool or technology has been fully demonstrated	
	The tool or technology has been demonstrated in real operational environment	
	The tool or technology has been accepted for practical use (by at least one intended user)	
	The technology or tool has been utilised in real operating environment for its intended purpose	
	The technology or tool is available on the market for large-scale deployment	
*Accessibility means that websites and mobile applications and their contents are such that anyone could use them and understand what is meant in them.	The technology or tool meets applicable accessibility* requirements	
Free word	**Here you can state e.g. how you would develop or improve technology or tool in question.**	**Open ended question**

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Annex 2. The agenda of the kick-off event of end-user evaluation

End-user evaluation of new tools and technologies for disaster management - Online kick-off event

Tuesday 5th October at 9-11 CET via Teams

Each presentation will include time for a short discussion and questions.

Programme:

9 – 9:10	**Short presentation of the BuildERS project and target of the workshop** Juhani Latvakoski, VTT
9:10 – 9:30	**People in the middle of disaster - Elbe flooding disasters** Peter Windsheimer, German Red Gross
9:30 - 10:10	**Authorities' viewpoints for disaster management** **Overview of authorities' perspective on new tools in crisis management** Margo Klaos, Estonian Rescue Board **Emerging technologies** Alessandro Galvagni, Provincia autonoma di Trento
10:10 - 11:30	**Examples of available new tools** **Data sharing between authorities for crisis management** Ville Somppi, Insta **Using historical mobile positioning data for crisis management,** Eva-Johanna Võik, Positium **Crowdsourcing for disaster management and preparedness** Asta Bäck, VTT **Opportunities from Copernicus services and Earth Observation** Mikko Strahlendorff, Finnish Meteorological Institute
11:30 - 11:40	**Short introduction to the Howspace platform and co-creation activities** Jaana Keränen, VTT
	Closing the event

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