LODE PROJECT

Report of the Final Workshop of the Project

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Loss Data Enhancement for DRR & CCA management

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1. Purpose and objectives of the workshop

The final workshop for the LODE project was hosted by the Greek partner OASP and was held in Athens, Greece in 1-2 July 2021. Due to the COVID 19 pandemic restrictions the workshop took place in an hybrid form so that both in person and online participants could participate and exchange final feedback on the project's results.

The purpose of the workshop was to present the overall results of the work that took place over the duration of the project and discuss insights for further research. Selected parts of the work that were carried out by the project's partners were grouped so that a structure into thematic approach was followed.

Following the central question of the project, how to collect and gain knowledge out of disaster loss data, different approaches were presented and discussed.

At the second part, the developed database tool was presented and tested during the workshop and feedback on its function was exchanged between the partners and stakeholders.

The final LODE workshop was attended by an extended number of participants and stakeholders in person and remotely (Annex1, Annex2).

Figure 1: The venue of the Final LODE Workshop

2. Structure of the Hybrid Workshop

In the beginning of the first day the hosts (Greek partner OASP) welcomed the participants. The coordinator of the project, Prof. Scira Menoni presented the LODE project, its background, its results and the structure of the two-day workshop.

Figure 2: Day 1 of the Final Workshop

The first day stakeholders and partners of the project presented applications of post disaster damage data from different showcases and topics (critical infrastructure, residential, ecosystems, cultural heritage, etc.).

The second day was focused on presentations on the use of data as well as the presentation and demo of the developed database. It was followed by three breakout sessions where partners could discuss the strong points of the project and further feedback on future direction of research. The program of the workshop is attached in the report (Annex 3).

More explicitly, on the first day of the workshop, the welcoming and introduction speeches of the project were followed by a presentation of the activities of the DRMK and the work that is being developed at the JRC concerning the Disaster Science Report 2020.

Following the stakeholder's presentations from JRC, showcases of applications of post disaster damage data were presented focusing on critical infrastructure. The power system showcase from Finland and the telecommunication showcase from Italy were presented. After a short break, another stakeholder presentation was held from the Enel Foundation and Lombardia Region, followed by a presentation on the Safety4Rails project from Milan.

Then another showcase of application of post disaster damage data was presented focusing on the residential sector from Greece. The Italian case of seismic damage data collection was then presented and followed by the use of data to evaluate their impact on natural assets in Serbia.

After the lunchbreak, the parameter of cultural heritage data was presented and followed by the showcase of the Lorca earthquake in Spain and its impact on cultural heritage. For the final part of this section a perspective from an Interreg project from Polimi was presented.

The presentation of the different showcases and selected examples was followed by an introduction and a demo of the information system.

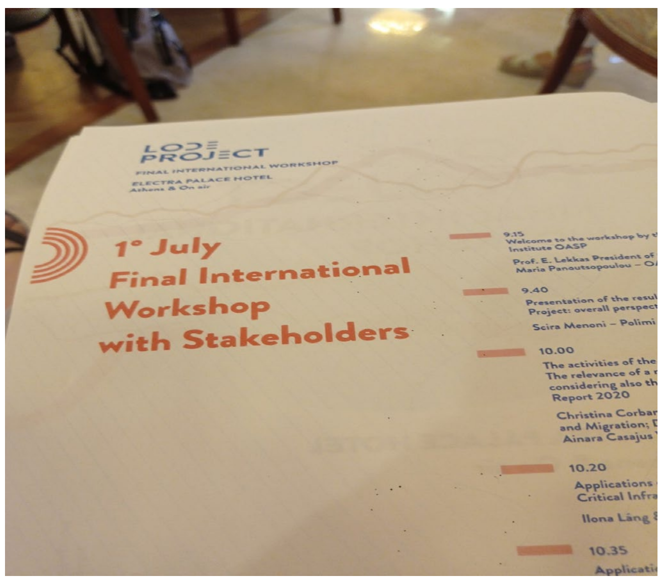

Figure 3: Agenda of the Workshop

The second day, the presentations of the selected showcases continued with applications from the agricultural and the business sectors as well as multi-sectors analysis. Moreover, the stakeholder’s perspectives from the insurance sector were presented. Applications of post disaster damage data for multi sector analysis were presented from different partners. The added value of the information system for emergency management and recovery was presented as well as take away lessons on the use of post disaster damage data. The last presentation was from European Central Bank about the indirect financial impacts of disasters.

There were also three breakout sessions on two main topics. The outcomes of the breakout sessions are described in detail in paragraph 3.

Furthermore, there was a collective test of the information system and a collective plenary in order to write the index of the White Paper as described in paragraph 5.

3. Breakout sessions

Two breakout sessions groups were created in presence and one via web.

The main subjects discussed were the evaluation of the potential uses of the information system and further improvements.

The questions for discussion were:

- Are there technical obstacles to the adoption of the Lode information system in your organisation or in the organisations with which you work?
- What do you see as challenges (if any) in the organisational culture of your organisation in developing a more coordinated data collection and management?
- What do you see as main aspects favouring the adoption of the Lode system at the level of your organisation? In your country?
- What do you see as main obstacles in the adoption of the Lode system at the level of your organisation? In your country?
- How can the system (if in case) can be improved/complemented to be adopted/used by your organisation?

As it concerns the first breakout session the following opportunities, challenges and suggestions for improvements are summarized as follows.

<u>Positive aspects/opportunities in LODE System adoption:</u>

- Importance of having a centralized “place” to collect the damage information from different point of views. Referred to cultural Heritage management, public, but also for insurance companies (stakeholders), to have information also on the not insured assets.

- Importance of the standards present in the system. The availability of this tool can encourage the people to collaborate more.
- Importance of the system that permit to change the way of data collection, to pass from the actual damage descriptions (very heavy text) to a standardized one. The best would be at municipal level.
- Acceleration of the researches on risks due to the availability of data. Possibility to share data in Europe. Possibility, then, to share data and knowledge also related to risks not so studied and considered in all the countries (depending on how the country is prone to different risks), but that can be in any case present in the territories.
- Importance of application at regional level. In fact in the online breakout session it was commented by several stakeholders that the regional level is the key link between the very local municipal level where data are produced especially as regards physical damage and the national and higher levels.
- Importance to overcome the actual fragmentation of the data among different institutions and companies for the various sectors (e.g. Heritage and lifelines).
- Many directives are now existent in Europe and in the different countries, to use data for different purposes, but scattered. The use of this system could be an opportunity to re-organize the topic directives.
- Interesting the connection of the system with the Sendai indicators.
- Thinking to obtain funds (European, national, etc.) for the reconstruction project, or research on risks, more in general, it could be easier having available and organized data as the ones in this system.
- Positive aspect, thanks also to the data standardisation, related to make the data collection more reliable and less dependent on the subjectivity of the involved people

<u>Challenges and obstacles in LODE System adoption</u>

- Difficulties to persuade the possible involved offices/administrations of the usefulness of this system.
- Decision about who will be in charge of inserting data in the system, considering the already assigned work assignment (it's difficult that without being mandatory an additional work is accepted).
- Requirement of some mandatory directives/laws for the definition of the offices/entities who has to fill and use the system, considering the actual fragmentation of the collection
- Question about the time to have a sufficiently robust system to be efficacy consulted.
- Could be a possible idea to ask universities to insert data having then the data for the researches? Objection: but who has the data are not the universities, then an additional step would be required.
- Possible connections with other existent DB or Information systems (e.g. potential pollution activities/industries).
- This system could be useful to improve the collaboration of the different entities/administrations involved in the civil protection system, or, more in general, in the emergency and recovery organization/management.
- What may be the role of citizens and private stakeholders, some or many of whom actually self pay for the losses without asking for compensation.
- As for insurance data there are challenges in collecting data from multiple companies intervening in the post disaster. They must be also sensitized on the importance of a standardized data collection. Or at least on a harmonizing such data collection. The regulator of insurance (Eiopa for example has an important role) should provide guidelines and perhaps also issue compelling regulations on data disclosure, still maintaining the privacy and security aspects. Common agreements at least at the EU level are welcome in terms of benchmarking and also on common aspects to be guaranteed by different databases. In the case of New Zealand after the Canterbury

seismic swarm 2010-2011, even after 5 years the insurance industry did not know how many payouts still had to be reimbursed.

- Banks are generally reluctant to lend following disasters. Insurance is certainly a way to decrease the protection gap, nevertheless we are seeing reduction in insurance penetration in some high risk areas such as California for example. The European Central Bank is carrying out stress tests of economy under scenarios of climate change. However the data on which such effort grounds is not consistent among different areas and across different sectors. Issues such as geolocation of items and assets is a new topic for Central Banks, yet of extreme importance to assess exposed systems and objects.
- Importance of having a user manual
- Add help, "i", near the cells where the parameters have to be inserted, to support the filling and avoid misunderstanding (e.g. some terms/measures could be understood in different ways).
- Make the interface more user-friendly, perhaps reducing the number of menus.
- Importance to guide the filling, evidencing the filled parts and the ones to be completed. In this way, it would be easier not to forget some parts.
- Think about an interface with two levels: one with the more general information and one with the more detailed data.
- Characterize better the damage levels (not only high, low, etc.).
- Provide for the insertion of the names of who input the data.
- There is a redundancy control? As for events that could be inserted with similar, but not equal denominations (e.g. Central Italy seismic event, Earthquake Norcia 2016, etc.).
- It's difficult to give a cost amount for each asset, usually are more aggregated.
- Possibility to connect with existent DB, to insert the pre-existent data.

Figure 4: Breakout session 1

The second breakout session group highlighted the following points:

- The bureaucracy of institutions and organizations doesn't allow to move forward, it makes the procedures more complex and longer, therefore the adoption of the system could be hampered by these dynamics
- An important characteristic is related to the access to the system, one of the questions was "is it free of charge"? An this was accompanied by the question "who is going to maintain it?"
- Adopting a new system -> organizations are overwhelmed by tools and new systems, this could lead to resistance in adopting a new one, moreover, every group will notice pro and cons related to their interest/activities so it could be hard to make clear the completeness of the developed system -> this led to another question "should the system be tailored according to every organization need?" according to the conceptual development of the DBMS and the specifi characteristic of relating data this could be possible, every organization could have a specific interface with specific fields to fill but the inserted data would be stored in apposite spaces with specific relationships that allow to join the different "pieces". However, when organizations will get familiar with the see the DBMS then they will be able to grasp its potential, but allowing the change would be the hardest step to accomplish.

Currently in many organizations data are stored in excel files and it would be hard to make them change their way of working – could be possible to introduce the data in the LODE system through an excel file?

- Observation | the LODE's product is a digital tool therefore it is important to take into account its dependency with the telecom and power system (considering that one of the aim is to support the data collection in the aftermath of an event)
- PRIVACY ISSUES in order to be able to implement the tool a legal framework needs to be established | currently it is possible to access the system without authorization, however appropriate use case diagrams should be designed so that different accounts can be created and according to each profile accessing the interface, everyone will have access to a different function
- BASELINE DATA | collecting all those information could be very demanding for an organization, in addition some data (i.e. cadastral ones) are complex and got modified along time. Whom should insert these data? And how?
- GEOREFERENTATION and REFERENCE SYSTEM | every group uses coordinates according to their internal organization, therefore there could be some problems. However the possibility of automatically insert data with the georeferentiation would allow conversions -> METADATA should be clearly specified
- The possibility to add pictures and docs and at different times it is very powerful feature
- The tool should be tested but organizations should be trained. The tool is freely accessible, but the testing and training takes time and money, the system should be enhanced to facilitate the communication with the potential users
- TAXONOMY we need to have the same words for all countries, every single word needs to be defined. A clear definition for each filed should be provided
- Qualitative attributes should be reduced as much as possible or even eliminated

Figure 5: Breakout session 2

4. Results of the project

In overall during the final workshop, it was collectively agreed that the LODE project succeeded to develop a tool to collect and manage different damage and loss data in a coherent way. The database tool was found to be easily navigated by the participants. The strong points of the database tool are that it incorporated data from different sources and sectors. The importance of further incorporation of indirect and non-tangible impacts was stressed during the sessions. Therefore, LODE resulted to a first attempt of developing an important tool for damage and loss data incorporation in DRR. Moreover, a strong network of stakeholders across countries and at the EU level, interested in disaster loss data collection and management was developed during the 30month period of the LODE project.

5. White Paper

The final workshop concluded with the collective plenary for the draft outline of a white paper that will describe the future needs to be developed in research and practice for the successful integration of disaster data in disaster risk reduction.

The outline of the paper was developed collectively during the closing of the workshop and participants who were interested in, contributed to its writing.

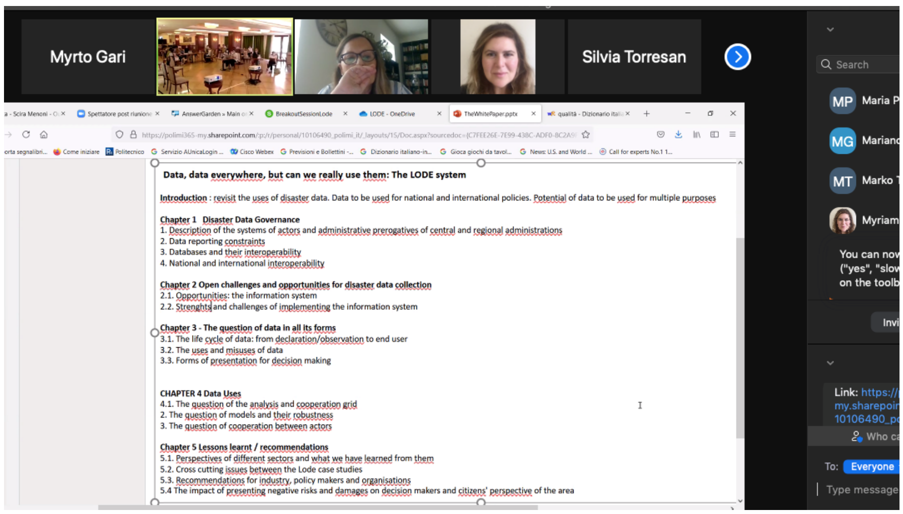

Figure 6: Collective White Paper contents draft

DATA, DATA EVERYWHERE, BUT CAN WE REALLY USE AND REUSE THEM?

THE "WHITE PAPER" RESULTING FROM THE LODE PROJECT IN USING POST DISASTER DAMAGE DATA AND DEVELOPING AN ENHANCED INFORMATION SYSTEM FOR MANAGING AND QUERYING SUCH DATA.

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1. Introduction

Data are everywhere, every day we are overwhelmed by a deluge of data that freely circulate across the web. Yet finding good data, the data one need for a specific task or on which to ground effective action is neither trivial nor easy. The realm of disaster management is no exception. After severe events we get from new and traditional media figures of estimated total damage and losses that look exact and precise and are sometime included in official databases, national as well as global. Yet our experience as stakeholders, practitioners and researchers in the field of disaster risk reduction and climate change adaptation is that those numbers are rarely reliable as they cannot be grounded on the detailed and laborious collection that is required and takes actually place in most countries after a severe disaster and constitutes the basis for the estimation of needs, financial and material, for recovery and reconstruction. Those data, though, will not get the front page in the media, as their production takes time and they will then come out when the interest on the event has been overshadowed by more recent news. Unfortunately the management of such data is also rather fragmented among different authorities and organisations in charge of different tasks and sectors so that a comprehensive and coordinated assessment, including a comparative analysis across sectors and at appropriate spatial and temporal scales is missing. This rather frustrating state of affairs is not specific to our times, it was already highlighted as a problem by Gilbert White, the pioneer of modern disaster studies, in his PhD dissertation in 1945. Since then a number of scholars in different countries have pointed at the need to improve our knowledge on past disasters' damage in order to learn lessons, improve our risk modelling capacity, better mitigate and prepare for the future.

In the Analytical Report 15 produced by the EU Commission in July 2020, High Value Datasets are defined as those "associated with important benefits for society, the environment and the economy, in particular, because of their suitability for the creation of value-added services, applications and new, high-quality and decent jobs, and of the number of potential beneficiaries of the value-added services and applications based on those datasets". Whilst the list of datasets that will be considered as of high value has still to be approved, ongoing discussions suggest that perhaps disaster loss data albeit considered of extreme relevance are not yet gaining this status, mainly because of their unavailability, restricted accessibility and the many limitations that the scientific community has highlighted in Lode as well as in past projects. Loss and damage data certainly have a large potential of being used and reused for a number of applications and services as will be described in section 4 in particular but their management needs to be substantially improved to allow them to be widely usable and shared as required by the Open Data Directive (EU) 2019/1024.

Experiences during the LODE project and other similar activities have demonstrated that although building a system for disaster impact data collection, processing and archiving may be laborious and require wide co-operation, ultimately, the availability of good quality data and information services built on data offer large potential to reduce societal impacts and improve the preparedness and the resilience of the society. The general dilemma is that various sectors and end users are requiring more accurate impact forecasts and preparedness tools, but the high-resolution impact data required for the development of forecasts and tools are not collected or shared. It would be beneficial for several sectors to make their data available openly or at minimum, for research purposes. To our consideration, there is an increasing demand for policies and guidelines to promote data collection in many sectors and expand the data availability for research and development. Although the scientific community already acknowledges the importance of easily accessible, high-quality impact data, in many sectors, the potential benefits of the data collection and sharing is not yet fully understood.

The present White Paper has been initially conceived at the final Workshop of the Lode project, it then grounds on the discussions that were held in the various sessions, on the presentations provided with insightful material by partners and stakeholders but is also the outcome of two and a half years of work devoted to develop an enhanced information system to better manage disaster loss data and to use data collected in showcases for a number of applications (the use and reuse of data).

This paper is organised in five sections, beyond this introduction. The second reports some facts regarding the current situation in terms of disaster loss data governance and reporting in Europe; the third relates to the features and the lifecycle of the data, the type of damage that they more often represent. The fourth and the fifth sections discuss the uses of damage data, the former in a more conceptual and general way, the latter evidencing the cross cutting lessons learnt in all the showcases of the Lode project. The sixth illustrates the information system that has been developed, from the requirements to the conceptual and physical modelling down to its implementation and the development of the user interface. The seventh then discusses further challenges to be considered for making the information system usable by public administration as an ordinary tool and the challenges that are still ahead and which could not be fully satisfied by the Lode system or that have emerged as a result of the project itself.

2. Current Disaster Data Governance

Existing practices on damage data collection and archive involve different public and private stakeholders using their own tools and approaches, which respond to their specific needs and commitments under the national/regional/local laws and regulations in force, if any.

Usually, the data collection is specifically tailored to the specific applications needed to specifically fulfil their tasks in different phases. The work only goes on until the task is over with very little critical reviews further on and/or no updates of the data.

In most countries, most stakeholders maintain an archive of collected damage and impact data in the form of a database with different levels of detail in its contents and structure, albeit they are usually not interconnected, and sometimes not even shared. That makes it difficult when it comes to handling the data in a more or less homogeneous and systematic way. Having the same data evaluated in a different way by different stakeholders might well often lead to data duplication and misinterpretations.

Having different interests and needs and no legal obligation for collecting data hinders the implementation of homogeneous and systematic collecting tools and the search for a common IT systems. In fact, even when working together and coordinated during emergency situations, some public stakeholders maintain their own in-house data collection and archive systems producing their own internal reports based on their own data. Quite often the data is not shared for reasons other than personal data protection regulations.

In some cases, stakeholders seem to be reluctant on having a link to any common database (e.g., at European scale) unless it could represent a clear benefit for their institution or if compulsory under national or European regulations. One of the main arguments against developing and using common and better organised tools relates to perception that this may constitute an extra burden to existing obligations challenged by the very limited dedicated staff. An additional issue regards the data protection laws (e.g., the European GDPR) that prevents public, and especially private stakeholders, data sharing at single asset scale under a comprehensive and homogeneous database.

At present, overcoming these difficulties clearly apparent in most showcases would need special attention to account for specific institutional national/regional contexts. Furthermore, the situation is made even more complex due to the fragmentation of data among many different stakeholders (e.g insurance companies in some countries), so that even in case a common information system were available, it would be very difficult to populate it.

In general, Civil Protection emergency procedures do not incorporate the need for performing more precise evaluations of collected data once the emergency is over. While improving the quality and completion of damage/loss data is beneficial to develop financially efficient future planning and allocation of resources, this is in most cases overlooked. There is a need for developing strategies to emphasize the benefits of the implementation of shared, compatible and quality databases. Whether recommendations at EU level or national/regional regulations, specific funding, advising and resources should be made available.

Based on the information collected and the contributions from the partners, an analysis and comparison has been carried out, specifically regarding the dataset which cover European countries or regions (Table 1).

GLOBAL	EM-DAT	NatCAT	SIGMA Explorer	NOAA	GLC	DFO	COPERNICUS EMS	DAILY MAPS

EUROPEAN	HANZE	eMARS	EFFIS	EFAS	EDO					
NATIONAL	DISASTER	CDTE	CNIH	CCS	GDAEFK'S DATABASE	GDAEFK BUILDING DAMAGE and COST ASSESSMENT	FloodCat	D.a.Do	AVI	WSL
	PRONTO	ARIA	ONRN	Flood Loss Statistics database for Finland	Forest use notifications	Electricity distribution fault data	DesInventar Serbia	DamaGIS	AJDA	Finnish Traffic Accident Database
LOCAL	GENCAT DB	2014 Secchia River Flooding	MEFF	RASDA						

Table 1. Subset of analysis

The main findings indicate that:

- 19 datasets are public, 4 are partially public (i.e. raw data are not available, only statistical analysis are available), 7 store data that can be acquired on request, 1 is unfinished/unavailable and 4 have reserved access;
- 20 out of the 31 datasets related to European countries or regions are still updated and maintained;
- 14 of the datasets analyzed allow to retrieve data in tabular format, while 8 give graphics on number statistics, loss amount diagrams, percentage distributions, tables and a maps with aggregated values as output; alongside 8 dataset present an interactive interface with Web map viewer and platforms; both static maps and tables are the output of 4 datasets considered;

In order to have a clearer overview regarding the typology of hazards considered and the time span covered, Figure 1 qualitatively illustrates the different characteristics of the datasets considered in this work.

Data are collected with different approaches and for different objectives in the analysed countries, making it difficult to compare them. Main challenges to overcome are not only related to the use of an appropriate data collection methodology, but also to aspects such as the definition of the event and its time of occurrence/duration, the classification of the disaster (i.e. in the case of floods and landslides), the spatial extent and the exact location of an event.

Moreover, the actual situation is characterized not only by the fragmentation of data but also and especially by the fragmentation of responsibilities in which lies the strongest influence for data quality.

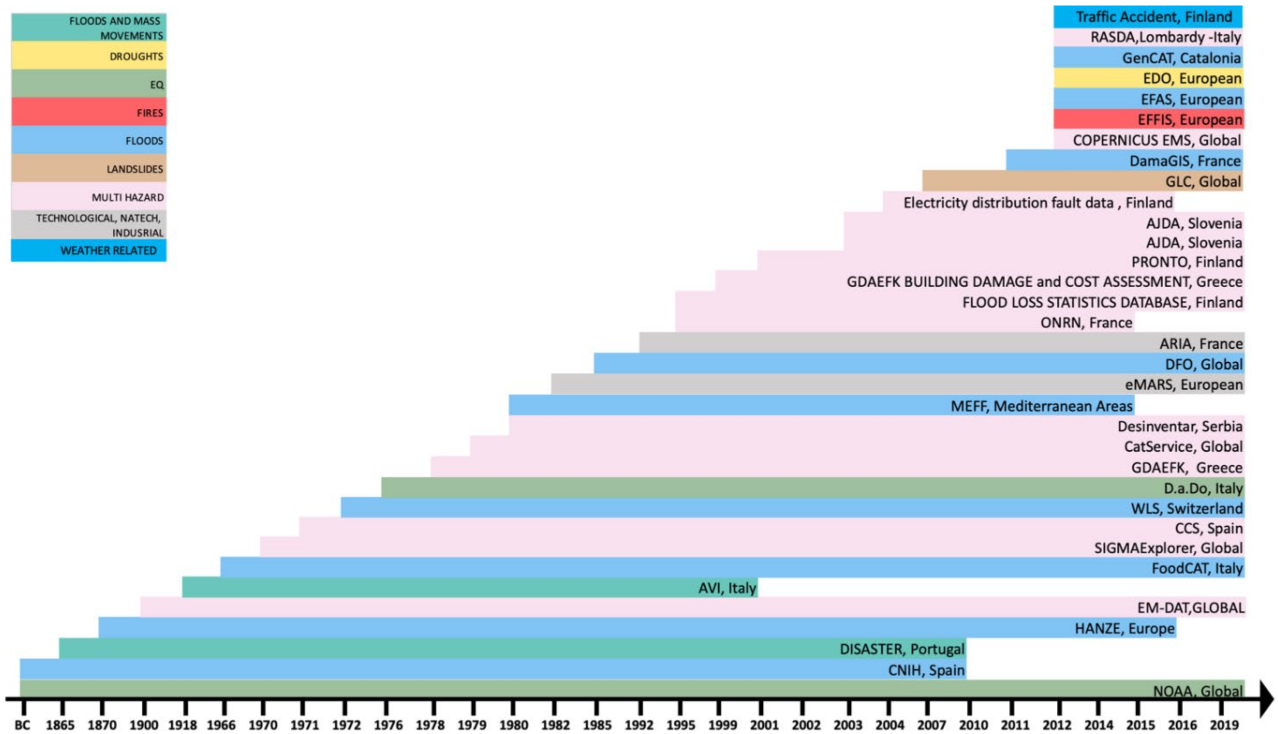

Figure 1. Characteristics of the datasets (time and spatial coverage, type of hazards) (NB: time frame not in scale, qualitative representation).

3. Type of post disaster damage and loss data

3.1. Post disaster damage data production

Disaster data reporting varies in Europe and by sector. These data are part of an administrative, cultural and sectoral tradition specific to the States. They also depend on the prerogatives devolved to the public and private sectors.

In their declarative forms, these data can be presented in three structures.

- *The first is the result of declarations and post-disaster surveys*. These data, declared by third parties, depend on elements fixed upstream by the managers of these data. Established at the level of the exposed stake (e.g. building, transport infrastructure, industrial site, ...), it allows to account for the nature of the damage as well as its estimated amount. Thus, it is difficult to postulate an exhaustiveness of the latter.
- *The second is based on remote-sensing data*. These data, collected at the scale of the observed territorial grid (e.g. pixel, so-called homogeneous zone) or administrative grid (e.g. district, municipality, ...) reports the various observations on interpreted images. The cost of the needed devices makes it difficult to obtain, for the moment, an exhaustive coverage of the largest territorial grid exposed to the damaging phenomenon. Also getting an asset level representation requires the most expensive satellite images, whilst with the less refined ones, validation at the ground level is necessary. The Copernicus service in this regard is a relevant resource that is useful

especially in the first stages to get an overview of the most damaged areas and sectors. In the future it would be important to connect such level of information with the first type derived from direct surveys. The use of satellite images and remote sensing data in particular can be helpful to capture multiple environmental changes and their drivers within the same technique (Chen et al., 2020), giving a sounder picture of the disaster event in question.

- *The third and last data structure is the result of damage simulation from observations of past disasters and projections and constrained with the empirical observation that becomes available from the occurred event*. These data are used and generated by models and often too strong assumptions are made on the possibility to transpose them from one event to another, revealing recurrent shortcomings in the induction and deduction processes that they mobilize.

3.2. The life cycle of data: from declaration/observation to end user and reuse

In the quest for more accurate information on disaster impacts the life cycle of damage and loss data is central. From how data are observed, gathered and reported after a disaster, how they are recorded and introduced in different databases to how they are shared and archived and re-visited for further use, data management brings to the surface complex questions of how data can be used within their lifecycle.

- The life cycle of damage data begins with *research and planning* of which types of data will be useful after the occurrence of a catastrophic event. The questions that arise during this phase of the data life cycle concern the preparation needed to identify data to be collected and ways to collect them.
- During the *collection* phase of the data, detailed guidelines on collection methods and timing must be provided. The collection of data in multi hazard, cascading and/or interconnected events complicates the procedure. Further questions arise on who collects the data, targeted training on data collection methods and procedures, the possibility of citizen's contribution and the issues that arise around self-reporting of damage and loss data.
- The following phase, data *processing and analysis* calls for questions around data homogenization and data aggregation in order to understand the direct, indirect, tangible and intangible disaster impacts.

Questions of privacy and ethical issues arise in the following phases of *publishing, sharing and preserving* data for future use.

3.3. Type of losses addressed by damage and loss data

Damage and loss data constitute the foundational elements of disaster information and knowledge building processes (Walia & Menoni et al. 2020); as such they also establish the ground for evidence-based disaster risk reduction policies and post-disaster recovery, stipulating a safe and sustainable development. Be that as it may, the path from damage and loss data to evidence-based policies is not evident nor straightforward. It requires pro-active thinking, distinct analytical-methodological considerations and strategic planning.

Undeniably, damage data are essential for better understanding hazard impacts, manifested under adverse conditions of vulnerability and exposure, and causing distinct disaster effects. These are impacts that unfold both in a direct and in an indirect way, evolving differently and in varying time-spans. Hence, each path of this two-fold impact evolution inhibits highly differentiated trajectories from damage-loss to recovery-reconstruction. In this respect in disaster studies and policy, emergency response to damage and loss, gather the outmost attention and mobilizing all dynamics (human and technical resources) towards immediate relief and recovery, they soon (in most cases) fade away and as (socio-economic and policy) attention shifts towards the normal, undermining visions and objectives associated to recovery and change.

It is not uncommon that an overwhelming expertise, resource mobilization financial aid mobilization, are concentrating during the first post-disaster phase; and hence damage-direct losses, are often considered as a good proxy to impacts and potential needs. And here is where a direct (conventional) policy link is structured between damage-loss information and humanitarian aid-shelter. Aid is unilaterally allocated to households based on building damage data.

Furthermore, the phases following emergency response and up to reconstruction remain largely under-documented, under-researched and even under-funded. In addition, a far more evident information void is identifiable in relation to long-term and social and economic post-disaster impacts (DuPont & Noy, 2015). While institutions and local communities rapidly (and in many respects adequately) address the first post disaster phase (involving physical-damage documentations, financial cost estimates and addressing immediate relief and organizing reconstruction) little attention is given to the social and economic impacts that are directly linked to disaster, but continue evolving long after the event. These impacts are often disclosed once the normal life has been reconstituted and the community's interest is absorbed by the everyday tensions and complexities of the post-disaster society.

Moreover, when everyday life is disrupted in such an intense way the damages that occur are both tangible and intangible. While the tangible damages and losses are easier to estimate and address, the intangible ones often pose challenges to researchers and practitioners. The social and economic impacts of disastrous events belong largely to the intangible damages; not having a concrete physical status, but they are also drastically affecting the post-disaster community. Intangible or non-quantifiable impacts are the vast hidden part of the iceberg that tests post-disaster policies.

4. Use, reuse and misuses of post disaster damage data and losses estimation

The effort of data collection must be somehow "rewarded" and recognized by stakeholders as bringing key advantages. The latter are associated to the many potential fields of applications in which such data can be used and reused several times for different purposes and by different stakeholders, thus maximizing their value.

Based on existing literature, on reports (see De Groeve et al., 2013; Walia and Menoni et al., 2020) and on the practical experience of the consortium and the network of involved stakeholders, the following uses have been identified and explored:

a. The first is to *compensate damaged parties* proportionately to the extent of their losses, discriminating between insured and uninsured ones.
b. The second is to allow *designers of structures to better size them* in view of the intensity and frequency of the damaging events to which they may be exposed and in general planners and regional and city managers identify through the so called *"forensic investigation"* the drivers and root causes of damage (Oliver-Smith et al., 2016).
c. The third is the *design of policies and strategies* for governance and preventive management of disaster risks both before the occurrence of an event and in its aftermath. In the latter case, accounting and analyzing damage and loss data can be used to monitor the response and direct it towards more resilient outcomes.
d. The fourth is *to increase knowledge* about disasters and risks, including a better understanding of the comprehensive impact on communities, the total economic loss and the comparative overview of loss of profit among different sectors also in the view of *improving disaster risk modelling* and development of pre-event scenarios.
e. Finally, the fifth is the *scaling of warning and preparedness* in emergency and crisis situations.

These five uses listed highlight the need for a better understanding of the actors and decision-makers who use them. Thus, beyond the regulatory or normative need for disaster data reporting, a description of the ecosystem of actors and users of disaster data is needed. Table 2 provides a synthetic overview of such uses, illustrating the objective that is pursued in the second column, the stakeholders interested or involved in the third as well as the main challenges and requirements in terms of data quality, granularity, etc. in the fourth.

Type of Use	**Objective**	**Stakeholders involved**	**Challenges & Requirements**
Compensation & Needs	Identify the needed financial resources for recovery and reconstruction	Agencies and organisations in charge of recovery and reconstruction including international and domestic donors; insurance	Privacy issues to be overcome with appropriate access to different levels of existing databases

Forensic	Identify lessons learnt	researchers; public administrations in charge of risk prevention and adaptation; insurance modelers	Get data at different scales, including asset level; get the description of damage not only monetary figures of losses; often linked with an idea of guilt
	Identify root causes and drivers of damage		
	Highlight the role of vulnerability in forming damage		
Design of policies & strategies including accounting	Identify trends overtime	Governments; decision makers at different levels; international agencies; researchers	Multisectors data needed; methods and metadata should be harmonised for comparison among regions/countries that must be compared
	Program needed resources for the future		
	Respond to policy obligations (Sendai)		
Enhanced knowledge and Risk modelling	Improve current models	Researchers	Willingness to share data across sectors; data as assets especially for "closed" models
	Cover more aspects (temporal and spatial scales as well as sectors) in risk assessments and scenarios	Agencies in charge of risk prevention in the long and short term; insurance	
Improved early warnings & preparedness	Identify correlations between occurred damage and certain features of the triggering event (meteorological) so as to make evidence based forecasts and alerts	Agencies in charge of early warnings; local communities; insurance	A large number of empirical data are needed regarding the same type of damage (for example to the power network and service) in order to be able issuing an alert that is based on prioritization of avoided damage

Table 2. Synthesis of uses

In the context of the first, third and fifth use, the ultimate decision-makers may be insurers or public decision-makers respectively. For the latter two, the information provided by the disaster data alone is not sufficient. It will thus be necessary to provide in addition to information related to the history of disasters and incidents and accidents on the exposed territory, the respect of the recommended regulatory measures as well as the envelope of annual public and private aid amounts. In this context, multi-criteria and multi-actor approaches such as single criterion synthesis (e.g. cost-benefit approaches) or synthetic outranking can be very useful because they provide both monetized and non-monetized information in order to seize recovery and reconstruction management.

In the context of the second, fourth and fifth uses, the decision-makers are also design engineers or planners of urbanization control in the territories. As such, information distinguishing the nature of the exposed stake, the nature and the history of damages on this stake, the details of dimensioning and the age of the structure, its geographical location and these territorial constraints are precious. Numerical or analytical methods favouring information of the type of risk levels (heat maps), probabilities of rupture of the integrity of the stake as well as an appreciation of the current and potential damage should be favoured. The same is true for information that can lead to projections on the occurrence and projected intensity of feared extreme events.

One major challenge in the matrix (Figure 2) regards the need to coordinate damage and loss data across various units, agencies and organisations within public administrations and in private and semiprivate organisations such as insurance and lifelines managing companies. Both the latter can be fully private, partly private or be based on a private public partnership. Virtually, such data could be then used by all and reinforce each stakeholder's capacity to better manage its task in reducing, facing, managing and adapting to risks and events. Certainly after long decades of separation of tasks and specialization of different agencies and offices within the same administration competing for resources and power it is hard to imagine a future of sharing and collaborative efforts. Yet this is exactly what is required to face contemporary complex challenges involving global as well as more local based risks but with potentially very large scale consequences in an increasingly small and interconnected world. Therefore the shift towards enhanced cooperation and extended opening of different types of data and datasets is a priority of various policies in different fields, including disaster risk and climate change adaptation. This will perhaps become more likely should the different stakeholders not only convene to debate about those issues but also experience practically systems such as the Lode one getting as a rewarding the possibility to use and reuse the data for different tasks and policies the hold the responsibility for.

4.1 Misuses and constraints in using post disaster damage data

Considering the uses listed above, we were able to identify five categories of data misuse presented below:

a. *The aggregation of data of different nature*, unit and declarative size.
b. *The inference of a probability of occurrence on the basis of a very weak or even incomplete sampling of events*, as well as the misuse of the territorial anchoring of these events.
c. The characterization of an estimated amount of the cost of a disaster *neglecting the cost of living in the countries*, the nature of the declarative system of the listed

damages as well as the distribution of the declarations of data between the public and the private sector.

d. The *erasure of the specificities of the damaging phenomenon and of the evolution of urbanization* in the declaration of the monetary magnitude of the disaster.
e. The hypertrophy of data declarations vocalizing mainly on *accidental and acute effects* to the detriment of chronic and diffuse effects of disasters.

Putting these recurrent misuses into perspective allows us to move towards a responsible and reasoned approach to enhanced systems and procedures of damage and loss data management.

The distinction of uses highlights that although it is possible to conceive a unique disaster database, the interoperability of this database with contextual and conjunctural databases will have to be imagined from the conception and in the respect of the administrative and cultural specificities of the states and their management of the distinctions between the public and private sectors. Issues that must be carefully addressed arise around every phase of the data life cycle. In combination with the development of a common database where data are recorded and stored for common usage, clear guidelines should be developed for the collection of structured and integrated data and a data coordination system.

<u>BOX 1 The interplay between forensic investigation and risk modelling</u>

The increasing availability of sophisticated models and computer calculation power must be met by equally well performing datasets both in quantity and quality that are needed to feed such models. (Casajus Valles et al., 2020; GFDRR, 2018). In this respect forensic analysis and risk modelling are closely linked. Through the former, we acquire enhanced understanding of the hazard, exposure, and vulnerability components of risk in any given disaster situation to comprehend risk in its totality. When considering scenarios where multiple interacting risks and their drivers might appear, the full picture of the risk, as built with the available data, is vitally important to understand the spatio-temporal disaster dynamics (Poljanšek et al., 2019).

High quality, detailed data gives rise to the possibility to select powerful and sophisticated models that are more able to capitalise on the information contained within the dataset. This could make use of either deterministic models that rely on qualitative expert judgement, or a probabilistic approach that exploits quantitative data to consider multiple risk scenarios (Dottori et al., 2016). The reliability of the probabilistic impacts or losses that are derived from the model output are directly linked to the input data used for training, and the validation of the model using data from existing disaster loss databases.

In general, where more data is available, a more sophisticated model can be chosen (Poljanšek et al., 2019). For example, flooding models have traditionally been performed using stage-damage curves that estimate damages through water depth alone, whereas enhancements of these mainstream measures can be made through the integration of other hazard variables such as flood velocity or duration (Wagenaar et al., 2019).

BOX 2. Data sharing between private and public stakeholders for enhancing the resilience of critical infrastructures

Private sector (e.g. distribution system operators (DSOs), insurance companies and agriculture) as well as the authorities of the public sector rely strongly on different weather-related information in their preparedness regarding natural hazards. High-quality weather forecasts, precise early warning systems and rapid communication between the authorities, weather specialists and private companies are in the key role in successful preparedness of the society. Weather information is needed especially when weather-related events are the hazard and cause negative impacts but also when hazard is not weather-related, but weather has an impact on response and recovery operations.

In the recent decades the skill of the numerical weather prediction (NWP) models has increased continuously (Bauer et al., 2015), however the forecasts still contain uncertainties that for instance the employees of the DSOs need to cope with. In addition, the traditional weather forecasts do not indicate the impact of the weather hazards for the sectors. The responsibility of the decision making, including uncertainty estimation of weather impacts is laid on different actors, e.g. DSO or emergency service, and the decision depends on the personal expertise of the involved personnel. To reduce the subjective components in the response, it is important to understand more deeply the relations between the natural hazards and their societal impacts and further develop tools to improve quality and promptness of decision making. With *impact forecasting* the traditional weather (hazard) forecasts and tools can be extended by including information on exposure and vulnerability and using models (statistical, physically-based) to translate the weather-related hazard into socioeconomic consequences (Mertz et al., 2020). However, this introduces additional uncertainties that arise for example from the complex relations between vulnerability, exposure and hazard information and the quality of the impact data used in model development (Aznar-Siguan and Bresch, 2019). Alongside the traditional meteorological data sources, high quality socio-economic impact data can be used to reduce the uncertainties of *impact forecasts* and through research, increase the understanding of the processes that lead to severe consequences of natural hazards as well as utilized in reporting and monitoring related to disaster risk reduction and climate change adaptation

There is a growing interest towards the impact forecasts in DSOs and civil protection, since new tools can help them to prepare for the weather events with sufficient human resources and other precautionary measures. In Finland a long-lasting co-operation between the Finnish Meteorological Institute (FMI), civil protection and individual DSOs has led to open sharing of impact data. For example, the emergency call data is running in real-time on the workstations of the duty forecasters of FMI and based on the emergency call density, the forecasters can issue higher level of warnings with short notice (e.g. during a rapidly propagating convective storm). Through fruitful co-operation and data sharing, the civil protection acknowledges that timely warnings save lives. The emergency call data is additionally being archived in FMI's database, which makes it easily accessible also for research purposes e.g. to discover the dependencies between monthly emergency call rates and occurrence of high wind speeds.

FMI also receives local power cut data from the operating area of individual DSOs (covers spatially often either a municipality or a region) and national data from the energy authorities. For the Finnish energy sector, the long lasting power cuts mean economical losses, for example, in price reductions and compensations for the customers under conditions defined in the Finnish Electricity Market Act. Thus, the DSOs are generally motivated to advance their preparedness procedures, invest in impact tool development and share their impact data. Several years of co-operation with the stakeholders have resulted a sufficient availability of power cut data, however, some challenges remain to be solved.

Regarding the individual DSOs, the coverage of spatially and temporally high-resolution data is available only at a regional level, which is restricting the data usage. The national power cut data on the other hand covers the entire country, however, the data is aggregated spatially in very large areas (larger than the regional level) which prevents spatially detailed analysis. In some cases and countries, it might be even more challenging to access power cut data because of the scattered data or lack of resources in DSOs. During the LODE project, we also discovered that DSOs and local emergency management are in close co-operation in Finland during a weather hazard since many of their procedures are overlapping – before, during and after the hazard. Developing impact forecasting tools which would indicate the most effective utilization of common resources would be highly beneficial for the society.

4.2. The issue of interoperability between Databases needed to produce post disaster damage data and to use them for different purposes

The term "interoperability" refers "*to the basic ability of different computerized products or systems to readily connect and exchange information with one another, in either implementation or access, without restriction…".* In other words, interoperability is the ability to join-up and merge data without losing meaning (JUDS 2016).

Interoperability has been increasingly required especially between public database. The term indicates the ability of information systems to exchange and migrate data and to enable sharing of information. Better said, it is understood as information systems 'speaking to each other' and as an evolutionary tool that will enable further uses through the aggregation of data from different sources (link).

Significant effort has been made to enhance the databases interoperability at different spatial scales, including the European Directive inspire; nevertheless, the goal is far from being reached.
Each existing system has been created for a specific purpose in alignment with the data protection principles and elaborated and complex legal frameworks, therefore the access and re-use of data procedures are still limited by the specific features of every system.
Currently, even though systems allow a fairly easy connection through specific access paths, it still remains hard to really create a flow of information from one dataset to another.

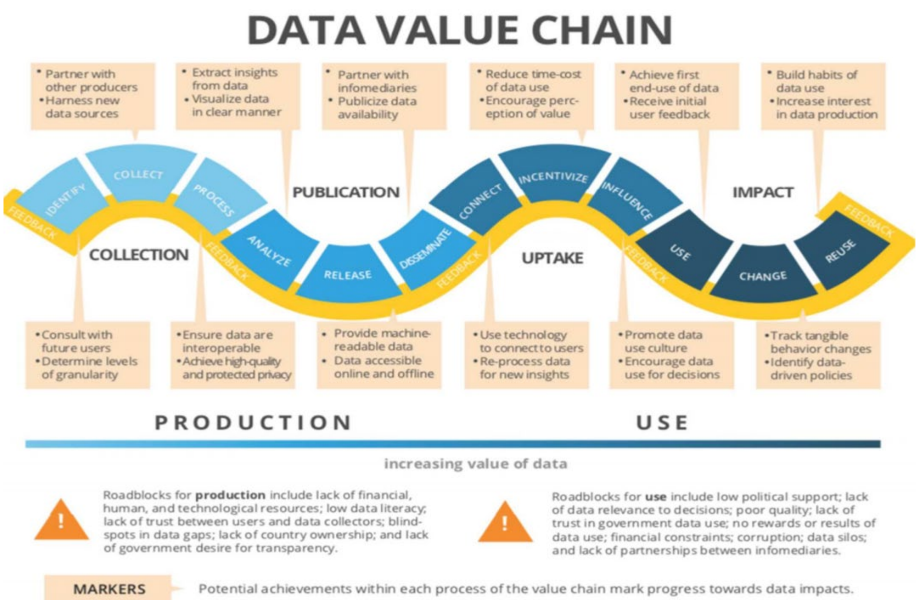

Figure 2: The Data Value Chain (Source: OpendataWatch)

Making such procedure possible would bring numerous advantages in terms of time saving but also in terms of reducing the possibility to commit errors in the recording phase and reducing redundancy of saved data. For instance, usually when a survey is carried out after a disastrous event the surveyor has to collect primary data regarding the damaged assets or company such as owner, location, VAT etc., or even cadastral data as forthe residential damage assessment in Italy. Having an automatic connection to the official source of those information would speed the operation and would enhance the results.
In practice, data is said to be interoperable when it can be easily re-used and processed in different applications, allowing different information systems to work together, enabling every development sector to become more data driven.
The main concept of interoperability follows the idea of Data Value Chain model (Open Data Watch 2018) (figure 2). This chain model implies that interoperability should be linked both to data collection and use within all programmatic cycles of relevant information systems.
Interoperability concept can be divided in four main levels (Morales&Orrell, 2018):

- *Technology layer:* This represents the most basic level of data interoperability and is by the requirement that data can be published and can be accessible through standardized interfaces on the web.
- *Data and format layers:* These capture the need to structure data and metadata according to agreed models and schemas and to codify data using standard classifications and vocabularies.
- *Human layer:* This refers to the need for a common understanding among users and producers of data, regarding the meaning of the terms used to describe its contents and its proper use (there is an overlap here with the technology and data layers, in that the development and use of common classifications, taxonomies, and ontologies to understand the semantic relationships between different data elements are crucial to machine-to-machine data interoperability).
- *Institutional and organizational layers:* These are about the effective allocation of responsibility (and accountability) for data collection, processing, analysis, and dissemination both within and across organizations. They cover aspects such as data sharing agreements, licenses, and memoranda of understanding.

It can be held that the Lode project information system aligns to most of the definitions and understandings of interoperability discussed above, as far as it has been designed to manage heterogeneous data and to provide a single point of information open to link with external databases and systems, such as the Risk Data Hub of the European Commission.

5. Cross cutting lessons learnt from using available post disaster damage and loss data in the Lode project's showcases

The showcases of damage and data loss management applied across the case studies of the LODE project, can give a first-hand insight into the issues that are faced in terms of post disaster damage data collection across sectors, locations, and scales.

Issues could be found from the offset of the applications, with the initial data collection proving to be more difficult than anticipated. With a variety of data types coming from different authorities and stakeholders, either local, regional, or national, there was an unexpected delay in the beginning phases of the project for a large number of the showcases, further exacerbated by the negative effects of the Covid-19 pandemic.

For the applications of damage data across the showcases, the quality of data was paramount, particularly where advanced techniques were applied (e.g. the Tapani storm in Finland and the Secchia river flooding). Unfortunately, it was also found that significant proportions of the data were of a low quality. Mistakes and subjective components of the data could also be found, as in the collection of data for Finnish power outages, to the point where the data may lose all value for the selected application.

Following these initial issues, there was often significant effort needed to transform the collected data into a format that was usable for the various applications. As a consensus, it was found that data was provided in largely unstructured formats, requiring additional time to make them usable. In particular, significant time resources were spent on the geolocalisation of data points for several of the showcases. While for some showcases (such as the Secchia river flooding and the Kefalonia earthquake) this process could be automated to an extent, there were shared limitations in carrying this out, with data points that were incomplete, contained errors, or were incompatible with the chosen mapping or GIS software, meaning that many points had to be manually and individually geolocated.

Even after the extra effort required for these transformations, the available data was also largely inconsistent across the different showcases, having access to damage data for different sectors, or at disparate granularities. This was highlighted in the consideration of damages to cultural heritage, where different systems for classification of conservations status were found at national and various sub-national scales. This therefore provided further challenges for the majority of the partners, who had to adapt their processes to best adjust for the limitations.

Further issues arose when attempting to consider these issues across multiple case studies. Where individually, the project partners could work to find a best solution to apply damage and loss data for their chosen applications, it still remained difficult, or even impossible in some cases, to harmonise the results across the different showcases. The varied sources for the collected damage data across the showcases also highlighted concerns of data sensitivity, with those showcases using insurance claims or post-disaster inspections in particular (e.g. the Kefalonia earthquake or the Tapani storm) finding it necessary to withhold certain portions of the data, unable to publish the aspects of the results, or even apply all of the information within the showcases.

Another factor that was brought to attention concerned the irregularities and lack of coordination between pre- and post-disaster damage data. For example, in the case study of the Lorca earthquake, it was found to be challenging to rely on pre-event risk assessments for predicting observed damages. In Serbia, forest fire data has mainly been collected for administrative and statistical purposes, and although more recent approaches aim to improve knowledge for risk management purposes, there remains a heterogeneity in the collected data, with negative implications in the potential for coordination between prevention and disaster management. When considering the data necessary to examine potential future scenarios data, these problems were further magnified, with the uncertain nature of the scenarios leading to the data being coarser, less reliable, and available for only a few of the considered disaster damage factors.

Overall, taking into account the variety of issues that arose across the case studies, the main thread that tied them together was a lack of coordination. Improvement in coordination among the various actors, from those that compile the data from its various sources, to the responsible authorities and stakeholders (e.g. insurers, and regional and national government agencies), would have brought significant added value to each application.

Looking at the data collected for flooding in Madeira, the processes (and therefore the quality of the data) varied massively even across municipalities. The quality of the application of loss and damage for risk prevention or management can then, at best, mirror the quality of the data that is collected. In finding data without common structure or organised collection, the LODE case studies have together highlighted the range of shared issues, from lack of coordination to poor quality data, that organisations across the European community may face.

6. The Lode project information system: from concept development to the design of the architecture to its implementation

Based on the interaction with the stakeholders of the LODE network and on the lessons learnt in the showcases, different requirements have been elicited for the information system designed and implemented. We can group such requirements in three main categories: conceptual, related to the data model and technical regarding the software under development. The LODE information system is a Database Management System designed to be multi-purpose, dynamic and flexible by comprising standardization. The actual information system is the result of many years of interactions between researchers, stakeholders and developers culminated in the tight development process within the Lode project lifetime.

Following the knowledge gained through different activities and events, the evidence that could be collected through the showcases and thanks to the different expertise of the research network the actual tool has been developed to respond to the need of an improved damage and loss data collection to account for damages according to a precise analysis of current practices, taxonomy and terminologies in use, and proper consideration of temporal and spatial scales.

LODE addressed the development of an information system that creates the path to collect homogeneous and comprehensive data that can be used according to the potential they intrinsically possess if collected with appropriate methodologies and tools.

6.1. Conceptual requirements

As for the first category, three main requirements have been set for the system that are:

- The need to provide a multisector representation of damage;
- The need to account for the timescale of both the damage and its “appearance” as well as of the moment when it is recorded and/or updated;
- The need to somehow report not only direct physical damage but also indirect one, in the form of systemic interaction among damages to different sectors and sub-sectors.

As for the need of multisector representation of damage, the experience gained in the Lorca 2011 earthquake showcase provide a relevant example of the issues at stake. The showcase addressed two key sectors, namely businesses and cultural heritage. For the Cultural Heritage sector, the data were monitored and updated during all the phases from the emergency until the end of the recovery and reconstruction works in 2019 with a detailed follow-up on the rehabilitation and retrofit actions.

However, in what regards the Business sector only a first preliminary estimate of the impact on local business was carried out. These estimates were based on evaluating damage and losses as obtained after a survey on approximately 2,000 firms performed during the three weeks immediately after the earthquake. Final figures on direct physical damage and loss of profit are available but limited to those businesses holding any insurance policy. A significant amount of damage / loss data for non-insured assets are thus missing.

Those two differences in the collection and availability of the disaster data limit the feasible analyses that could be carried out for each sector.

The available impact data on the Cultural Heritage sector, besides allowing the update and improvement of emergency and rehabilitation plans, provided (by asset) the disaggregation of emergency and rehabilitation/rebuilding costs and the identification of the different sources of funding. These include insurance compensation and both, the estimated and the final costs by year. The collected damage and loss data would facilitate the development of specific vulnerability assessment focusing on Cultural Heritage, which represents a key issue in new and updated Protection and Prevention Plans.

Damage and loss data from the Business sector would allow different general analysis and applications. They mostly relate to the updating and improvement of risk models, the development of suited prevention and mitigation actions, and to increase and improve resilience in a broader sense, i.e., not only to recover to the situation before the event, but to enhance it for better facing future threats.

As for the need to consider the timescale of damage the system that has been designed allows to collect data overtime in a more cyclic way than usually done and keep memory of such subsequent phases of data collection both to recognize “new” damage that may emerge later or is an indirect systemic consequence, and to update estimates that were initially done. This is what actually is already done in many countries by public authorities in charge. However, also due to the lack of appropriate means for managing the data, the latter are lost or scattered among different bureaus and datasets making the coordination very challenging or even impossible.

6.2. Design requirements

One important aim was easier data management enabling users to manipulate data for different purposes, which considers multiple hazards, consents a standard data collection by keeping flexibility and a modular structure that can be modified and improved if needed. The development has followed different phases and according to the experience gained through the research path, the tool has been revised and enhanced alongside the new insights and dynamic understandings by being faithful to the research vision.

The development has followed principles related to appropriate data quality standards.

The tool has been designed in order to allow a damage & loss data collection that is accurate, i.e. consistent data for different time periods and not affected by material errors; appropriate consistent data with the purposes for which they will be used; transparent when referring to the collection process. The proposed tool takes into consideration all the phases of damage and loss collection recording, storing, managing, maintaining an up-to-date documentation of the database, and performing queries to retrieve information.
It responds to the following main system's requirements:

- *Flexibility and standardization*: the model has been designed in both phases of conceptualization and implementation to be flexible, i.e. adaptable to different societal sectors and their specific characteristics but creating a structure that allows to collect information in a standardized fashion as much as possible through prefigured values to avoid errors and over redundancy.
- *Spatial and temporal characteristics*: the LODE system is designed to collect information at the asset level, however thanks to the designed structure it is possible to query the system for different spatial scales since the tool permits to automatically aggregate the information at different spatial scales (specific areas by filtering through street or district, municipal, regional, or whenever required for comparison among European regions, NUTS 2 and 3 levels); while regarding the temporal characteristics, every information that is recorded needs to be accompanied by the date of the survey and in addition the database allows to insert the date of occurrence of the damage (if available), therefore information can be retrieved by filtering by time. As damages may evolve in time, the model allows to represent not only the immediate, direct, physical impact of an event, but also the indirect and systemic consequences related to dependencies of the different elements of the same sector or of different sectors connections.
- *Damage causality and dependency: a* relevant features of the model lies in the embraced concept that damages are inter-connected and intra-connected, within the same sector or due to the dependency from other ones, the model allows to keep track of the causality of the damages occurrence through a main relationship named 'caused by' (i.e. a physical damage to the power system has caused a loss of service, the loss of service has caused business interruption)

6.3. Technical requirements

The following technical/software requirements have been fulfilled developing the architecture of the system and its implementation:

- *Modularity:* the structure has been implemented in modules this to integrate the concepts of flexibility and standardization (see next paragraph)
- *Open source platform* and software

- *Georeferentiation*: the system allows to collect georeferenced information, not only for the assets (i.e. location of a structure) but also for the damages (i.e. generally the location of an enterprise is connected to the legal address, but goods and assets are dislocated over large areas that often are even far from such address, therefore the LODE system has been designed to record also the geolocation of the surveyed damages)
- *Discretization:* in accordance to the knowledge acquired through the analysis of the hazardous events affecting the different societal sectors and following the understanding of the functioning of each of them a conceptual model that represents damages (physical and non-physical) and components (concrete or intangible) has been designed

The system provides the following functionalities:
- *Data collection*: through the LODE system data are collected according to precise schemes that eliminate redundancy and inconsistency, those schemes are delineated sector by sector with the objective to serve different purposes. Those data are organized through a relational database which consists in a collection of tables that store interrelated data.
- *Data storage*: A relational database management system allows to store and retrieve data represented in tables through different types of queries elaborated in advance to support a range of different purposes and multiple objectives such as the development of curate risk assessments and the understanding of damage mechanism, the delineation of real and robust trends, identification of priorities etc.
- *Data management*: The proposed approach steps forward the actual situation; most of the damage assessments are carried out manually filling pre-compiled forms with data that lose their interrelation or often datasets function only as a static archive of data collected from different and heterogeneous sources; a relational database system anticipates the use of data for multiple objectives allowing to properly collect them and to store large amount of data, permitting efficient search performance through prefigurated queries. The use of a well-designed database management system allows to store data directly into the archive and offers the opportunity to have timely available data and remote accessibility to the information.

6.4. Strengths of the Lode information system

In a nutshell, the LODE information system, rather than the classic paper-forms, allows to create a comprehensive inventory of georeferenced information, by storing large amount of data in an integrated and coordinated manner due to the predefined relationships among data which guarantees consistency in data collection, permits efficient search performance through a wide range of prefigurated queries. In addition, it allows rapid and more accurate filling of documentation and sharing of big damage and loss data, possible due to the potential of such information system that facilitates fast flow of information and connects instantaneously numerous organizations across wide geographic areas.

As mentioned different data uses can be envisaged once damage and losses after a disastrous event are appropriately collected, stored and managed in the Lode IS. The latter allows for multiple queries to be used from a list or created through the open source software to respond a wide range of questions. Each question can feed one or multiple types of analysis. For example, given a certain water depth or water velocity after a flood one may be interested to extract from the system the number of buildings that were affected, the number and length of roads that were not usable, the number of customers experiencing power cuts and the duration of the latter disruption.

There are additional benefits that should be accounted for. One of the key benefits is related to the fact that this new system will enhance disaster loss data interoperability across countries and regions as a consequence of the standardized approaches it considers for data collection and curation. As referred before, some of these standardized approaches are related with the common way damage and loss data will be collected and recorded, with the common terminology that is used by the system to establish all the disaster- and loss-related concepts, with the way data is georeferenced, or with the way the quality and the uncertainty of the data can be scored. However, there are other aspects of the disaster loss data recording process that are likely to be standardized. For example, utilizing the new system will require a definition of the damage and loss thresholds/criteria that define what is considered to be an event whose impacts must be recorded by the system. As a whole, the standardized format and structure of the data will therefore create the adequate conditions for sharing them across countries/regions/sectors/ professionals, eliminating also most of the language-related barriers. As a consequence, other benefits are also expected to arise. For example, sharing these detailed data is likely to guide research on disaster risk reduction (DRR) towards new areas by identifying knowledge and safety gaps highlighted by the available disaster loss data. In particular, researchers may gain access to data that will advance our understanding DRR needs of certain sectors that have not been the subject of sufficient research in the past. Furthermore, the availability of these standardized data will also provide a detailed basis to inform national-level decision-making regarding DRR investments and cost-effective DRR strategies, and to develop more DRR-targeted policy. Finally, it is also noted that standardizing the loss data recording methods also provides an opportunity to standardize the process of collecting loss data in the field and promote the use of methodologies that will ensure high quality data are obtained.

7. Challenges ahead

7. 7.1. Making an information system adopted by producers and users of data

Implementing a new information system for disaster loss data management involves a technological change in the way data is recorded, processed and curated. But introducing a technological change into a governmental institution is likely to present a series of challenges to the executives enforcing such a change and to the users of the new technology. Given the previously referred benefits of having robust disaster loss data, these challenges should not be taken lightly as they may undermine the overall objectives associated with the implementation of this new information system. In order to develop adequate strategies that will facilitate the referred transition, as well as to ensure the long-term sustainability and use of the proposed information system, challenges must be envisaged and acted upon. These challenges are divided in two categories that reflect issues related with the specific implementation of the information system within an institution (institutional-level challenges) and issues related with specific characteristics of the information system that may be seen as a barrier to its use in the short to the long term (software-related challenges). In addition to these challenges, a few key practical benefits of implementing the information system are also discussed.

7.1.1. Institutional-level challenges

- *Misconceptions and poor knowledge about the usefulness of the new system*: Institutions and organizations that can benefit from the implementation of a new system for disaster loss data collection and curation are often unaware of those benefits and how they will manifest in the long term. Such misconceptions can develop at upper levels of the institutional management as well as at more technical levels (i.e. among those directly involved in data collection and management). This issue can be further amplified by the inherent bureaucracy of institutions and organizations that often creates further barriers to the implementation of new systems. These issues can be addressed by presenting illustrative cases (real or conceptual) that clearly highlight the benefits of the new system, when introducing it to a new institution or organization.

- *Resistance from the users due to the additional workload implied by the use of the new system*: those directly involved in the data collection and data insertion in the new system are likely to see these additional activities as extra work that needs to be carried out in addition to their normal activities. Although this additional workload depends on the size of a given disastrous event (e.g. on the number of assets that are impacted and the magnitude of those impacts), institutions should commit specific staff dedicated to this type of activity to make sure that adequate data curation is ensured over time. The commitment of specific staff is then also expected to raise other concerns related to the associated financial costs. Still, such costs must be seen as an investment in disaster risk reduction since the data collected by the new system will be essential for the validation of disaster risk models and the development of adequate risk mitigation strategies, among other things (see section 4).

- *Resistance from the users due to the apparent complexity of the new system:* those directly involved in the data collection and data insertion in the new system are likely to find it overly complex or detailed, particularly if their institution only focusses on a particular sector and not on all the sectors covered by the system. These issues can be addressed by developing free training programmes that should be attended by those directly involved in the data collection and insertion, as well as detailed user manuals with examples illustrating the use of the system. In addition, to reduce the apparent complexity of the new system, the interface of the system may also integrate features that may facilitate its use. For example, each field of the system can have an information icon that provides basic information about the field to enhance usability. Furthermore, the interface may be redesigned in order to be more user-centred and more user-specific. For example, the development of user-specific interfaces that would only require data inputs related with the sector(s) of a given institution could also be envisaged. These specific interfaces would simplify the data insertion and would then integrate the data in the global multi-sector database of the country or region that runs in background.

- *Data privacy concerns:* the detailed data collected by the new system is expected to be accessed by professionals from multiple institutions and organizations. Some will be involved in the data collection and data insertion, others will be upper institutional management, while others will only be data users. To ensure data privacy issues are guaranteed, a legal framework needs to be established for creating the type of data creator and data user profiles that will ensure the necessary data privacy. Moreover, while this legal framework should also account for the current multi-sector fragmentation of the data creation and data use processes, the interdependency of these processes among different sectors cannot be forgotten to ensure that data users are able to get the full picture of disaster impacts.
- *Sensitive data concerns*: certain institutions or industries (e.g. critical infrastructures, insurance companies) may not be willing to report their data on disaster losses due to security concerns, the sensitive nature of the data, or to avoid exposing these data to competitors. A legal framework needs to be established allowing the creation of non-disclosure and confidentiality agreements to share these data for specific situations and with different levels of disaggregation among different data users.
- *Concerns related with the reliability of the system:* since this system is likely to have multiple sectors creating and accessing data from a central database, this may raise concerns about its reliability and vulnerability to data manipulation. Although the creation of user profiles may help to mitigate this issue, alternative architectures of the database may also be envisaged to address these concerns, e.g. using a database with a hybrid blockchain system to also enable data privacy issues to be addressed.

7.1.2. Software-related challenges

- *Sustainability and maintenance concerns:* the implementation and use of the new system is expected to be free of charge. However, this raises concerns regarding the sustainability of such a system in the long term. In particular, these concerns are related to who will fund and who will be in charge of developing upgrades to the system when news needs arise, providing updates to the system that may correct certain bugs, or developing new versions of the system when current software platforms need to be upgraded. Given these concerns, it is important to develop a central (EU-level) funding scheme to ensure the longevity of the system.

- *Concerns related with existing data:* many institutions and organizations have disaster loss data stored in Excel files with their own data format. To ensure that such data are not lost, it would be important to develop the possibility to integrate them into the new system. This requires the ability to upload the data of a given event as a whole into the new system, provided the data are formatted according to the database fields of the new system.
- *Concerns related with the necessary baseline data*: for a given event, the new system requires the availability of detailed baseline data about all the properties for which damage and loss data is entered into the new system. Collecting these data should, ideally, be performed before the occurrence of an event. However, accessing these data is often complex and very resource-demanding for a given institution as highlighted in section 4.2 on interoperability. Developing a connection between existing cadastral databases to automatically create part of these baseline data may help in this respect but available cadastral data are often incomplete or missing.
- *Concerns related to the use of different georeferencing methods*: given that different institutions may use different georeferencing methods, the new system needs to be able to accept these different methods and convert the data geolocation accordingly.

7.2. The role of citizens' and victims in damage reporting and analysis

Molinari et al. (2014) showed that damage and its severity is interpreted differently by different stakeholders depending on their responsibility and main objectives/mission in the field of disaster management. For example, civil protection officials were mainly focusing on harm to people and damage that required evacuation, whilst authorities in charge of infrastructures and economic development were concerned by unserviceability and business interruption. This led to the conclusion that there is no univocal and “objective” assessment of damage and losses, as the latter are perceived and ranked differently depending on the stakeholder. It can be therefore said that it is very hard or impossible to disconnect the physical and “hard” factors related to damage and impact from the social understanding and interpretation of its severity, tolerability, which depends also on considerations related to the reversibility of damage and to how much they are deemed to be the result of misconduct and malfunction of administrations and agencies that should have prevented them from happening. Clearly loss of human life is the highest concern, and in our own experience in the LODE project we could clearly sense the difference between events and areas where there were victims and those that suffered only damage to assets and infrastructures. Yet regarding the latter, communities sometime value damage to intangibles, including memorabilia or cultural heritage as even more important than damage to economic activities. This of course depends on many factors, that are mostly linked to culture, importance of the cultural heritage that has been lost also as an attraction and therefore as a source of revenue.

In our analysis of the showcases and of the available literature, the role of communities in estimating the damage and its severity for them is rather neglected. Mostly this is an activity that is understood as technical and bureaucratic necessary to obtain compensation but somehow far from the deeper needs of the affected victims. Yet, in many cases the latter are participating to the damage data collection actively, for example through self-declaration or requesting inspections in their property to evaluate their usability as we have seen in examples from Greece and Italy. The traditional process adopting papery forms or satellite images are not really involving citizens, yet validation on the ground is facilitated by the knowledge of the place of local people, as well as the knowledge regarding how it was before the impact.

With the rapidly spreading social media, there has been a growing interest by the scientific community but also by civil protection authorities and humanitarian aid agencies to get insight and information on damage and losses from pictures and texts that are shared by victims as well as by witnesses. In the last years several projects have been devoted to understand how to leverage this spontaneous production of data and information, whilst efforts have been carried out also to channel and coordinate such willingness to share through platforms such as Ushahidi or groups created by civil protection authorities in different countries (Havas et al., 2017; Roberts & Doyle, 2017).

However social media are not the only way in which until now citizens have contributed to damage data production: very often they are asked to provide a self-declaration that will then be certified by an agency or by a practitioner that is officially recognized or appointed for this task. Considering therefore the development of an information system such as the LODE one, differential levels of access for data input and queries will have to be foreseen, facilitating this way the dialogue between affected citizens and authorities in charge of damage estimation and compensation. A system like LODE has the advantage that not only text or pre-defined answers can be input but also pictures and videos, thus permitting a mixed quantitative and qualitative representation of the suffered damage. The active participation of citizens will not only represent a way to empower victims but also a net facilitation for officials in charge, with the advantage of saving time and time consuming exchange of files and transfer operations. We can say that we are almost there as parts of procedures and tools involving victims in damage declaration and also monitoring are already available and used in several countries. Considering the latter aspect, of monitoring the damage, open platforms such as those that are recently provided to inform about the progress of recovery and reconstruction may even constitute an important opportunity to achieve extended learning of the causes of damage, encourage participation of the affected communities to the choices related to how and where rebuild and rehabilitate what has been impacted.

7.3. Addressing intangibles and indirect damage more broadly

As follows from the detailed list of challenges ahead in making a system like the one developed within the LODE project actually used by involved administrations and stakeholders there is need to develop data management procedures and overall data governance throughout the full life data-cycle: from data acquisition, to use, up to disposal. As time is of great essence in disasters, for disaster damage and loss data to be appropriate, prompt, reliable, comparable, sustainable, disposing of an advanced information system is not enough, it must become embedded in existing procedures and processes. The LODE project has accomplished a step forward by developing a tool that incorporates important and key requirements, conceptual as well as technical. Yet to make it a tool used in practical situations, some further steps must be accomplished, including more longitudinal disasters studies and pilots to dig deeper into the association of available data with disaster impacts throughout the entire disaster cycle.

Some aspects/issues related to damage and loss data discussed in what follows, albeit recognized as extremely relevant as discussed in section 3 and 4 could not be fully included and implemented in the LODE information system; they still constituted challenges ahead for the further development of the tool or its updated and revised releases.

As discussed in section 3.3. the analysis of disaster impacts (and related information and data) should not be confined within the limits of "the physical outcomes", but should involve relief and recovery policies, and how these alter the pre-disaster conditions and causing an array of social and economic effects on communities and spatial settings. Those impacts unfold, in long time spans, as the conditions change and eventually shape what can be called as a (new?) normality.

As evidenced at each stage of the LODE project, it is not an easy task to identify a spectrum of social and economic impacts following a disastrous event. The task is enormous and has not been carried out yet; it thus appears as an essential pre-condition if the goal is to support -through recovery- building DRR policies and sustainable development. To this end, going from damage and loss data to disaster impacts is the subsequent key challenge in research and policy making.

But how would a research and policy agenda towards a better understanding of disaster impacts could be structured?

Furthermore, addressing intangible (or non-quantifiable) impacts seems long overdue. This implies that -in parallel to refining tools and systems for collecting and managing damage and loss data- methodologies and tools to effectively identify and record intangible (or non-quantifiable) impacts, require further development. To this end, an operationalization of methodologies for conducting qualitative research in post-disaster environments should be pursued.

Last but not least, whilst considerable progress was made in recording and managing damage and loss data due to sudden and localized disasters that are the main focus of the LODE project, at the antipode, the collection and management of disaster data due to recurrent, lingering and slowly unwrapping disasters remains a challenge. In this direction, more consistent effort needs to be placed in identifying disaster impacts and developing methods to collect appropriate data for better understanding these distinct impacts and for dispersing disaster effects from weaknesses, vulnerabilities and disparities already existing in the affected communities. Moreover, disasters of this type provide the opportunity to study the perception and acceptability of various risks (socioeconomic, life-cycle, health, environmental, and security) in societies and to better comprehend how disaster risk disseminates among different time spans. Disaster damage and loss data could then be more easily integrated in standard management procedures and overall data governance under "normal" developmental conditions.

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Annexes

Acropolis visit

After the closure of the LODE Final Workshop, a guided visit to the Acropolis took place and technical information about the monument's restoration was given to the participants in presence.

Annex 1: List of participants

1/7/21.

LODE Final Workshop
ATHENS, 1st/2nd July 2021

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8	VUS Spa	Italy	**Romano Menechini**	
9	CSIC	Spain	**Mariano García Fernández**	
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11	University of Porto	Portugal	**Esmeralda Paupério**	

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2/7/21

LODE Final Workshop
ATHENS, 1st/2nd July 2021

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LODE Final Workshop
ATHENS, 1st/2nd July 2021

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Faculty of Applied Ecology - Futura	Serbia	Suncica Vjestica	suncica.vjestica@futura.edu.rs		x		
Sector for Emergency Situations	Serbia	Andreja Mijatovic	andreja.mijatovic60@gmail.com		x		
Earthquake Planning and Protection Organization	Greece						
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Earthquake Planning and Protection Organization	Greece	Thekla Thoma	thomathekla@oasp.gr	x			
Earthquake Planning and Protection Organization	Greece	**Dionyssia Panagiotopoulou**	dpanagiot@oasp.gr	x			

	Earthquake Planning and Protection Organization	Greece	**Efthimios Lekkas**	elekkas@geol.uoa.gr	x			
	Earthquake Planning and Protection Organization	Greece	**Linda Pelli**	lpeli@oasp.gr	x			
	Earthquake Planning and Protection Organization	Greece	**Ioannis Dourakopoulos**	jdour@mail.ntua.gr	x			
	Earthquake Planning and Protection Organization	Greece	**Myrto Garis**	myrto.gari@gmail.com	x			
	Earthquake Planning and Protection Organization	Greece	**Spyros Santrivanopoulos**	spyros.santrivanopoulos@digitalearth.gr	x			
	Private Sector/Architect	Greece	Efthimia Dellinikola	delinko@gmail.com		x		
	Ministry of Culture	Greece	Eleni Toumpakari	etoumpakari@culture.g	x			
	Private Sector/Civil Engineer	Greece	**Aspasia Karamanou**	aspasia.karamanou@patt.gov.gr		x		
	Charokopeio University	Greece	**Pavlos Delladetsimas**	p.delladetsimas@hua.gr	x			
	Perfecture of Attica	Greece	**Miranda Dandoulaki**	mdand@tee.gr	x			
	Ministry of Infrastructure and Transport	Greece	Maria Kleanthi	mfkleanthi@yahoo.gr		x		
	Perfecture of Eastern Macedonia and Thrace	Greece	**Konstantinos Chouvardas**	chouvi@pamth.gov.gr		x		
	Perfecture of Attica/ Co-chair of WG4 "Public awareness preparedness and	Greece	Areti Plessa	aplessa@patt.gov.gr	x			
	Perfecture of Ionian Islands	Greece	**Eleni Mavrou**	eleni.mavrou@gmail.com	x			
	Civil Protection	Greece	Nikos Votsoglou	votsoglou@yahoo.com		x		
	Civil Protection	Greece	Georgios Xoutas	xoutasg@gmail.com		x		
	Civil Protection	Greece	Nikos Vorrias	vorrias.nick@gmail.com		x		

STAKEHOLDERS

Annex 3: Final workshop Program

LODE PROJECT

FINAL INTERNATIONAL WORKSHOP

ELECTRA PALACE HOTEL
Athens & On air

1° July Final International Workshop with Stakeholders

9.15
Welcome to the workshop by the hosting Institute OASP

Prof. E. Lekkas President of OASP
Maria Panoutsopoulou – OASP

9.40
Presentation of the results of the Lode Project: overall perspective

Scira Menoni – Polimi

10.00
The activities of the DRMK
The relevance of a multisector perspective considering also the Disaster Science Report 2020

Christina Corbane – JRC - Space Security and Migration; DRMKC
Ainara Casajus Valles – JRC DRMKC

10.20
Applications of post disaster damage data to Critical Infrastructures: the power system

Ilona Láng & Heikki Tuomervirta – FMI

10.35
Applications of post disaster damage data to Critical Infrastructures: the telecommunication system

Anna Faiella – Polimi

10.50 Coffee break

11.10
A perspective from the stakeholders

Carlo Papa – Enel Foundation
Carmela Melzi – Lombardia Region

LODE Loss Data Enhancement for DRR & CCA management

1° July

LODE PROJECT

FINAL INTERNATIONAL WORKSHOP

ELECTRA PALACE HOTEL
Athens & On air

11.25
An overview on the safety of transportation newtorks: the Safety4Rails project
Serena Chillè and Marina Trentin – Milan Municipality

11.40
Applications of post disaster damage data to the residential sector
Ioannis Dourakopoulos & Maria Panoutsopoulou – OASP

11.55
Collected seismic damage data for buildings: general characteristics and the Italian case
Maria Pia Boni – Polimi

12.10
Applications of post disaster damage data to evaluate the impact on natural assets Report 2020
Michailo Raktnic – Inzasum

12.25
Damage to cultural heritage: a proposal for implementation in the information system
Xavier Romao & Esmeralda Pauperio

12.40
Added value of empirical data in the case of the Lorca earthquake and its impact on cultural heritage
Mariano Garcia – CSIC

12.40
A perspective from an Interreg Project: Cheers
Giulia Pesaro – Polimi

13.10 Lunch

14.15
Introduction to the information system
Scira Menoni – Polimi

14.30
Demo of the information system
Sandro Salari – Polimi

15.20 Coffee break

15.40
Proposed development and integration within the RDH
Tiberiu Antofie – DRMKC

16.00
The development of a dashboard for rapid real-time disaster damage assessment for civil protection
Raquel Canet & Joan Muñoz – Catalunya Civil Protection

16.15
First results from testing the information system
Nikola Rakonjac – INZASUM
Nicola Berni – Umbria Region Civil Protection

16.30
Connection to the Copernicus service
Daniela Carrion – Polimi

17.00 – 17.20
Round Table and wrap up from day 1

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LODE PROJECT

FINAL INTERNATIONAL WORKSHOP

ELECTRA PALACE HOTEL
Athens & On air

2° July
Final International Workshop with Stakeholders

9.15
Applications of post disaster data to the agricultural sector
Anna Faiella – Polimi

9.30
Applications of post disaster data to the business sector
Maria José Jimenez – CSIC

9.45
Perspectives from stakeholders
Carlo Capra - Assolombarda

10.00
Applications of post disaster damage data for multi-sectors analysis
Remi Harris, Silvia Torresan & Elisa Furlan CMCC

10.15
Applications of post disaster damage data for multi-sectors analysis
Daniela Molinari – Polimi

10.30
A synthetic perspective on the added value of information system for emergency management and recovery
Nicola Berni – Umbria Region

10.45 Coffee break

11.05
Applications of post disaster damage data for multi-sectors analysis
Myriam Merad & Ioannis Kougkoulos CNRS

LODE Loss Data Enhancement for DRR & CCA management

2° July

LODE PROJECT

FINAL INTERNATIONAL WORKSHOP

ELECTRA PALACE HOTEL
Athens & On air

11.20
Reflections on the use of post disaster damage data: take away lessons
Miranda Dandoulaki – OASP

11.35
The relevance of 3D digital data to enhance disaster response
Mssimo Migliorini – Links Foundation

11.50
Perspectives from Stakeholders
Roland Nussbaum – AFPCN

12.05
A perspective from the stakeholders: the use of multiple applications in the insurance sector
Mia Ebeltoft – Climate Risk Advisory, Norway

12.40
A perspective from the Consorcio de Compensacion de Seguros
Francisco Espejo – CCS

12.45
Indirect financial impacts of disasters
Miles Parker – ECB

13.00 Light lunch

14.00
Breakout sessions to evaluate potential uses of the Information System

15.00
Breakout sessions to evaluate further usage of damage data

16.00 Coffee break

16.15
Plenary session

16.40 – 17.00
Round Table and wrap up of the Workshop

Purpose and added value of the workshop

Objectivies

The final workshop of the Lode project is meant to disseminate the results of the project that has been developed over the last 30 months. In particular the workshop is organized in three conceptual main sessions: the first is devoted to show the different uses of damage data in a number of sectors, ranging from residential, to business, critical infrastructures, and cultural heritage. The second session is devoted to illustrate and demonstrate the information system and its first test whilst the third is devoted to cross-sectoral applications meant to explore ways to make use of empirical damage and loss data to support machine learning and the evaluation of the performance of mitigation and risk reduction measures. As far as possible, each presentation offered by the Lode project will be followed by a comment and a reflection from a stakeholder, either a partner or a member of the network the Lode project has developed. The final objective being to understand what has been achieved insofar, what steps forward have been accomplished and how we should proceed from now on, what are the opportunities and the challenges ahead.

Added value for stakeholders

Stakeholders will have a key role in commenting what we have done and produced and will be also given the opportunity to share more broadly their thoughts in a highly dynamic dynamic and interactive blended workshop that foresees also some breakout sessions in the afternoon of the second day to collect impressions and opinions to guide us towards the end of the Lode project and next challenges ahead, as they are seen also by the stakeholders.

LODE Loss Data Enhancement for DRR & CCA management