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Update to the Disaster Risk Management Knowledge Centre loss database architecture for disaster risk management, 2018

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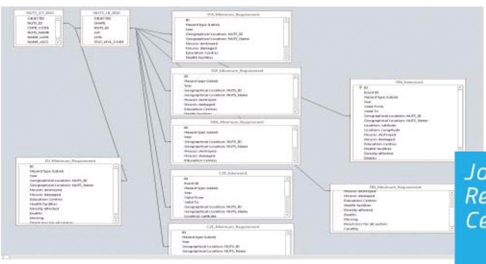
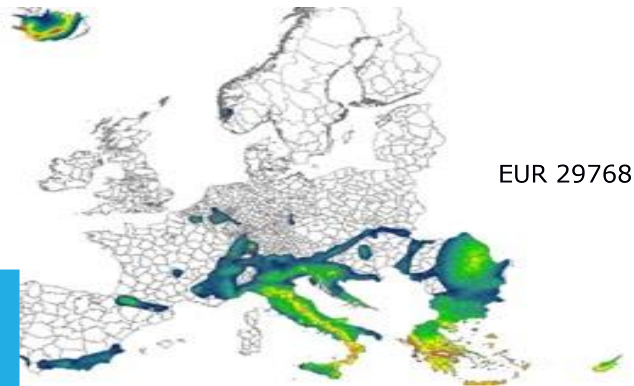
European Union disaster loss database





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Abbreviations

API	application programming interface
APSFRs	areas of potential significant flood risk
CDTE	Catalogo de daños por terremoto en España
CNIH	Catalogo nacional de inundaciones históricas
EAV	entity, attribute, value
(E)CQL	extended common query language
eMARS	Major Accident Reporting System
ETL	extract, transform, load
EU	European Union
GIS	geographic information system
ISO	International Organisation for Standardisation
JRC	Joint Research Centre
NRA	national risk assessment
SDGs	Sustainable Development Goals
SLD	styled layer descriptor
UN	United Nations
UNISDR	UN international strategy for disaster reduction

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Abstract

The reformed decision on a Union Civil Protection Mechanism ([1]), which entered into force on 1 January 2014, paved the way for more resilient communities by including in the mechanism key actions related to disaster prevention, such as developing national risk assessments (NRAs) and refining risk management planning. Under the decision, EU Member States agreed to 'develop risk assessments at national or appropriate sub-national level and make available to the Commission a summary of the relevant elements thereof by 22 December 2015 and every three years thereafter'. The decision also requires Member States, together with the European Commission, to develop guidelines on the content, methodology and structure of risk management capability assessments. The Commission has published risk assessment and risk mapping guidelines to assist Member States with their NRAs. Risk management capability assessment guidelines have also been developed.

The recent communication from the Commission, 'Strengthening EU disaster management: rescEU — Solidarity with responsibility' ([2]), calls on 'Member States and Commission to promote more systematic collection and dissemination of loss data, to enhance the collection of loss data and make use of loss data for optimised prevention and climate adaptation planning'.

Systematically collected, comparable and robust disaster damage and loss data are an essential element of the risk assessment and management processes. Thus, the Council of the European Union's conclusions on risk management capability of 24 September 2014 call on the Commission to 'Encourage the development of systems, models or methodologies for collecting and exchanging data on ways to assess the economic impact of disasters on an all-hazard basis'.

Under the current practices in disaster loss data recording across the EU, there are hardly any comparable disaster damage and loss data: differences exist in methods of data recording as well as in governance approaches to managing the data. The lack of standards for damage and loss data collection and recording represents the main challenge for data sharing and comparison, and in particular for cross-border cooperation, within the EU.

This report is based on an accurate analysis of several databases developed following a diversified number of purposes to collect, record and aggregate information regarding losses having occurred after a shock triggered by different hazards. The report proposes a common structure for a generic database able to accommodate and properly record the particularities of a vast variety of events triggered by any kind of hazard.

(1) European Commission, 'EU Civil Protection Mechanism' (http://ec.europa.eu/echo/what/civil-protection/mechanism_en).

(2) Communication from the Commission to the European Parliament, the Council and the Committee of the Regions, 'Strengthening EU disaster management: rescEU — solidarity with responsibility', COM(2017) 773 final, Brussels, 23.11.2017 (http://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1511770718312&uri=COM:2017:773:FIN).

Roles of the contributors

Francisco Ríos Díaz was responsible for designing the concept of the database architecture behind the Risk Data Hub, after studying relevant databases in Member States and international organisations, and wrote the report.

Montserrat Marín Ferrer, as the coordinator of Disaster Risk Management Knowledge Centre projects, oversaw the whole process.

Tiberiu Eugen Antofie provided methodological examples and contributed to structuring the historical event catalogue.

Stefano Luoni, as an external consultant, contributed to adapting the database architecture based on the Risk Data Hub platform.

Anna Faiella, as a trainee, contributed to the review of the data and the report.

1. Introduction

In the EU, each Member State has different authorities that are responsible for collecting data when a natural or technological hazard occurs. In some cases, the authorities in charge are at different levels (e.g. national, regional and municipal) and have to report back to the body that has the final responsible for storing the data, at the national level.

One of the reasons for having a multi-hazard loss database is so that Member States can have an overview of common data, structured by hazard, to facilitate the identification of weaknesses at national level and the well-informed establishment of priorities in order to reduce the current level of risk.

The database ought to be flexible enough to include different kinds of hazards and their specificities, and should help in implementing national, European and international policies and agreements such as the Sendai Framework ([3]), the EU Solidarity Fund ([4]), the Inspire directive ([5]) and the floods directive ([6]), as well as in producing national risk assessments (NRAs). The loss database will provide a common resource for a number of policies that need more data for more coherent, coordinated and knowledge-based implementation. It will also support complementarity across policies.

Almost every European country has its own database or databases. In most cases, they are organised according to hazard; some are in digital format and in other cases the data are still in Excel files or even on paper. The challenge in developing the loss database is to put together all the pieces of a puzzle that are scattered across Member States, gathering together information on different hazards, standards and methodologies in a sensible, understandable and structured way so that the database can be used as a tool to help in sharing cross-institutional data, in reporting to the various frameworks, in complying with the directives and in providing sound inputs to NRAs, as required by the EU Civil Protection Mechanism.

For this purpose, the Joint Research Centre (JRC) identified several national databases that followed good practices for loss data collection, studied them and suggested an architecture for a common loss database ([7]). All the identified loss databases were in digital format and they were chosen because they were compliant with a number of policies, either at national or at international level.

This report is related to other publications by the European Commission, such as *Risk Data Hub: web platform to facilitate management of disaster risks* ([8]) and *Risk Data Hub software and data architecture* ([9]).

([3]) UN Office for Disaster Risk Reduction, 'UN World Conference on Disaster Risk Reduction' (https://www.wcdrr.org/).
([4]) European Commission, 'EU Solidarity Fund' (https://ec.europa.eu/regional_policy/index.cfm/en/funding/solidarity-fund/).
([5]) European Commission, 'Inspire knowledge base' (https://inspire.ec.europa.eu/).
([6]) Directive 2007/60/EC of the European Parliament and of the Council of 23 October 2007 on the assessment and management of flood risks, OJ L 288, 6.11.2007, p. 27-34 (https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex:32007L0060).
([7]) European Commission, JRC, *Loss database architecture for disaster risk management*, Publications Office of the European Union, Luxembourg, 2018 (http://publications.jrc.ec.europa.eu/repository/handle/JRC110489).
([8]) http://publications.jrc.ec.europa.eu/repository/handle/JRC114120
([9]) http://publications.jrc.ec.europa.eu/repository/handle/JRC114712

2. International legislation and initiatives

With the common goal of reducing the risks posed by future disasters, legislation, initiatives and frameworks at both European and international levels have been created during the last few decades to find common targets and set milestones for the coming Horizon 2020. Some examples of European directives are listed in Section 2.1, but there are many other policies that contribute to the same goal and that have the same requirement: reliable data to ensure knowledge-based implementation. These include the European Radiological Data Exchange Platform ([10]), the European Community Urgent Radiological Information Exchange/Radioactivity Environmental Monitoring ([11]), the European Climate Adaptation Platform ([12]), Articles 35 and 36 of the Treaty establishing the European Atomic Energy Community ([13]) and the European programme for critical infrastructure protection ([14]).

2.1. European directives

1. The floods directive ([15])

The floods directive ([15]) focuses on the assessment and management of flood risks and prescribes the following three-step procedure.

First step. Preliminary flood risk assessment: the floods directive requires Member States to engage their government departments, agencies and other bodies to draw up a preliminary flood risk assessment, which has to consider impacts on human health and life, the environment, cultural heritage and economic activity, with a legislative completion date of December 2011.

Second step. Identification of areas of potential significant flood risk (APSFRs): the information needed for this assessment will be used to identify areas at significant risk, which will then be modelled in order to produce flood hazard and risk maps. These maps were to be in place by December 2013 and were to include detail on flood extent, depth and level for three risk scenarios (high, medium and low probability).

Third step. Flood risk management plans: these plans are meant to indicate to policymakers, developers and the public the nature of the risks and the measures proposed to manage them. However, they are not formally binding (e.g. in relation to land use planning). The plans were to be complete by December 2015. The floods directive prescribes the active involvement in the process of all interested stakeholders. The plans must focus on prevention, protection and preparedness, and take into account the relevant environmental objectives of Article 4 of Directive 2000/60/EC, commonly known as the water framework directive ([16]).

2. The Inspire directive ([17])

([10]) European Commission, JRC, 'European Radiological Data Exchange Platform', (https://eurdep.jrc.ec.europa.eu/Entry/Default.aspx).
([11]) European Commission, JRC, 'European Community Urgent Radiological Information Exchange (ECURIE) (https://rem.jrc.ec.europa.eu/RemWeb/activities/Ecurie.aspx).
([12]) European Environment Agency, 'Climate-ADAPT: sharing adaptation information across Europe' (http://climate-adapt.eea.europa.eu/).
([13]) 2000/473/Euratom: Commission recommendation of 8 June 2000 on the application of Article 36 of the Euratom Treaty concerning the monitoring of the levels of radioactivity in the environment for the purpose of assessing the exposure of the population as a whole, OJ L 191, 27.2.2000, p. 37-46 (http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX %3A32000H0473).
([14]) European Commission, 'European programme for critical infrastructure protection' (http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=LEGISSUM %3Al33260).
([15]) Directive 2007/60/EC of the European Parliament and of the Council of 23 October 2007 on the assessment and management of flood risks, OJ L 288, 6.11.2007, p. 27–34 (http://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:32007L0060).
([16]) European Commission, Directorate-General for Environment, 'The EU water framework directive — integrated river basin management for Europe' (http://ec.europa.eu/environment/water/water-framework/index_en.html).
([17]) European Commission, 'Inspire knowledge base' (https://inspire.ec.europa.eu/).

As defined in the directive, Inspire is 'an EU initiative to establish an infrastructure for spatial information in Europe that is geared to help to make spatial or geographical information more accessible and interoperable for a wide range of purposes supporting sustainable development'.

The Inspire directive lays down a general framework for spatial data infrastructure for the purposes of EU environmental policies, and policies or activities that may affect the environment. The directive entered into force on 15 May 2007.

Inspire is based on the infrastructures for spatial information established and operated by the Member States. The directive addresses 34 spatial data themes needed for environmental applications.

To ensure that the spatial data infrastructures of the Member States are compatible and usable in a cross-border context throughout the Union, the Inspire directive requires that additional legislation, or common implementing rules, be adopted for a number of specific areas (metadata; interoperability of spatial datasets and services; network services; and data and service sharing, monitoring and reporting). These rules have been published as Commission regulations or decisions.

The Commission is assisted in the process of adopting such rules by a regulatory committee, the Inspire Committee, composed of representatives of the Member States and chaired by a representative of the Commission (this is known as the comitology procedure).

3. The Seveso directive ([18])

Council Directive 82/501/EC is an EU law aimed at improving the safety of sites containing large quantities of dangerous substances. It is also known as the Seveso directive — after the Seveso disaster, which occurred in 1976 in Italy — and was superseded by the Seveso II directive.

4. The Seveso II directive ([19])

Council Directive 96/82/EC is an EU law aimed at improving the safety of sites containing large quantities of dangerous substances. It is also known as the Seveso II directive. It replaced the Seveso directive but was in turn modified by the Seveso III directive.

5. The Seveso III directive ([20])

Council Directive 2012/18/EU is an EU directive aimed at controlling major chemical accident hazards. It is also known as the Seveso III directive, is implemented in national legislation and is enforced by national chemical safety authorities.

The Seveso III directive updated the law to take into account, for example, changes in chemical classification regulations. It establishes minimum quantity thresholds for reporting and safety permits. It incorporates two lists, one that names individual substances, and another that designates hazard categories for those substances that

([18]) Council Directive 82/501/EC of 24 June 1982 on the major-accident hazards of certain industrial activities, OJ L 230, 5.8.1982, p. 1-18 (http://eur-lex.europa.eu/legal-content/ES/TXT/?uri=CELEX %3A31982L0501).

([19]) Council Directive 96/82/EC of 9 December 1996 on the control of major-accident hazards involving dangerous substances OJ L 10, 14.1.1997, p. 13-33 (http://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:31996L0082).

([20]) Directive 2012/18/EU of the European Parliament and of the Council of 4 July 2012 on the control of major-accident hazards involving dangerous substances, amending and subsequently repealing Council Directive 96/82/EC, OJ L 197, 24.7.2012, p. 1-37 (http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex %3A32012L0018).

have not been named separately. Documents required based on hazard and quantity are, for example, notifications under the major accident prevention policy, and the Seveso safety report.

2.2. Frameworks and international goals

6. The Sendai framework for disaster risk reduction 2015-2030 ([21])

The Sendai framework for disaster risk reduction 2015-2030 is an international agreement that was adopted by UN member states at the World Conference on Disaster Risk Reduction, which took place between 14 and 18 March 2015 in Sendai, Japan, and was endorsed by the UN General Assembly in June 2015. It is the successor agreement to the Hyogo framework for action 2005-2015, which had been the most comprehensive international accord to date on disaster risk reduction.

The Sendai document emerged after 3 years of talks, assisted by the UN international strategy for disaster reduction (UNISDR), during which UN member states, non-governmental organisations and other stakeholders made calls for an improved version of the Hyogo framework, with a set of common standards, a comprehensive framework with achievable targets and a legally based instrument for disaster risk reduction. Member States also emphasised the need to tackle disaster risk reduction and climate change adaption when setting the Sustainable Development Goals (SDGs), particularly in the light of an insufficient focus on risk reduction and resilience in the Millennium Development Goals.

The Sendai framework sets four specific priorities for action:

1. understanding disaster risk;
2. strengthening disaster risk governance to manage disaster risk;
3. investing in disaster risk reduction for resilience;
4. enhancing disaster preparedness for effective response and to 'build back better' in recovery, rehabilitation and reconstruction.

To support the assessment of global progress in achieving the outcomes and goals of the Sendai framework, seven global targets have been agreed:

1. substantially reduce global disaster mortality by 2030, aiming to lower the average global mortality per 100 000 during 2020-2030 compared with 2005-2015;
2. substantially reduce the number of affected people globally by 2030, aiming to lower the average global figure per 100 000 during 2020-2030 compared with 2005-2015;
3. substantially reduce direct disaster economic loss in relation to global gross domestic product by 2030;
4. substantially reduce disaster damage to critical infrastructure and disruption of basic services, among them health and educational facilities, including through developing their resilience, by 2030;
5. substantially increase the number of countries with national and local disaster risk reduction strategies by 2020;
6. substantially enhance international cooperation with developing countries through adequate and sustainable support to complement their national actions for implementation of the framework by 2030;

([21]) UN Office for Disaster Risk Reduction, 'Sendai framework for disaster risk reduction' (http://www.unisdr.org/we/coordinate/sendai-framework).

7. substantially increase the availability of and access to multi-hazard early warning systems and disaster risk information and assessments for the people by 2030.

7. The Sustainable Development Goals ([22])

The SDGs are a collection of 17 interrelated global goals set out by the UN. Each of the broad goals has several targets, and the total number of targets is 169. The SDGs cover a wide range of social development issues such as poverty, hunger, health, education, climate change, gender equality, water, sanitation, energy, environment and social justice. The SDGs are also known as *Transforming our world: the 2030 agenda for sustainable development* ([23]), or the 2030 agenda for short. The goals were developed to replace the Millennium Development Goals ([24]), which had a target date of 2015. Unlike the latter, the SDGs do not distinguish between 'developed' and 'developing' nations. Instead, the goals apply to all countries.

Paragraph 54 of UN Resolution A/RES/70/1 of 25 September 2015 ([25]) sets out the goals and targets. The UN-led process involved its 193 member states and global civil society. The resolution is a broad intergovernmental agreement that acts as the post-2015 development agenda.

The SDGs build on the principles agreed upon in Resolution A/RES/66/288 ([26]), entitled 'The future we want'. This was a non-binding document released as a result of the Rio+20 conference ([27]), held in 2012.

The Inter-agency and Expert Group on SDG Indicators, in its Report E/CN.3/2017/2 ([28]), proposes the use of the Sendai framework indicators recommended by the Open-ended Intergovernmental Expert Working Group on Indicators and Terminology Relating to Disaster Risk Reduction ([29]) to measure specific global targets for SDG 1 ('End poverty in all its forms everywhere'), SDG 11 ('Make cities and human settlements inclusive, safe, resilient and sustainable') and SDG 13 ('Take urgent action to combat climate change and its impacts') within the global indicator framework for the goals and targets of the 2030 agenda. This proposal was considered for approval by the UN Statistical Commission at its 48th session in March 2017. The use of these indicators will make possible simultaneous and consistent monitoring and reporting on the Sendai framework and on the SDGs.

8. National risk assessments ([30])

In 2001, the EU Civil Protection Mechanism was established to foster cooperation among national civil protection authorities across Europe. The mechanism currently

([22]) UN, 'About the Sustainable Development Goals' (http://www.un.org/sustainabledevelopment/sustainable-development-goals/).
([23]) European Commission, 'The 2030 agenda for sustainable development and the SDGs' (http://ec.europa.eu/environment/sustainable-development/SDGs/index_en.htm).
([24]) UN, 'We can end poverty: Millennium Development Goals and beyond 2015' (http://www.un.org/millenniumgoals/).
([25]) UN, Resolution adopted by the General Assembly on 25 September 2015, 70/1, 'Transforming our world: the 2030 Agenda for Sustainable Development' (https://goo.gl/Cg3dxQ).
([26]) UN, Resolution adopted by the General Assembly on 27 July 2012, 66/288, 'The future we want' (https://goo.gl/wPDb1E).
([27]) UN, 'United Nations Conference on Sustainable Development, Rio+20' (https://sustainabledevelopment.un.org/rio20.html).
([28]) UN, Economic and Social Council, Statistical Commission, 48th session, 7-10 March 2017, Report of the Inter-agency and Expert Group on Sustainable Development Goal Indicators, E/CN.3/2017/2 (http://undocs.org/E/CN.3/2017/2).
([29]) UN Office for Disaster Risk Reduction, 'Sendai framework: Open-ended Intergovernmental Expert Working Group on Indicators and Terminology Relating to Disaster Risk Reduction' (https://www.preventionweb.net/drr-framework/open-ended-working-group/).
([30]) European Commission, 'EU Civil Protection Mechanism' (http://ec.europa.eu/echo/what/civil-protection/mechanism_en).

includes all 28 EU Member States, in addition to the Iceland, Montenegro, North Macedonia, Norway, Serbia and Turkey.

Under the mechanism, the Member States are asked to provide a summary of their NRAs every 3 years. For this particular reason, a database that can cope with different hazards is vital to ensure that these reports provide the whole picture with regard to risks at national level.

Strengthening the EU Civil Protection Mechanism places disaster prevention and the reduction of risks at the core of our disaster risk management efforts. Prevention actions are required to reduce the impacts of hazards and to make societies stronger for when the next disaster strikes, while also reducing response needs. Increasing the resilience of the EU's infrastructure, ecosystems and societies is an essential element of effective disaster prevention.

Thorough investment by Member States in prevention and preparedness monitoring is of crucial importance. In this regard, the loss database will be a tool for monitoring and reporting on the successful implementation of prevention and preparedness plans by making available reliable data on the effective losses suffered after a shock and by keeping track of positive and negative trends.

The recent communication from the Commission, 'Strengthening EU disaster management: rescEU — Solidarity with responsibility' (COM(2017) 773 final), calls on 'Member States and Commission to promote more systematic collection and dissemination of loss data, to enhance the collection of loss data and make use of loss data for optimised prevention and climate adaptation planning'.

9. UN Framework Convention on Climate Change (the Paris Agreement) ([31])

The Paris Agreement is an agreement within the UN Framework Convention on Climate Change dealing with greenhouse gas emissions mitigation, climate change adaptation and finance starting in 2020. The agreement aims to respond to the global climate change threat by keeping the rise in global temperature this century well below 2 °C above pre-industrial levels and to pursue efforts to limit the temperature increase even further to 1.5°C above those levels.

([31]) UN Climate Change, 'The Paris Agreement' (http://unfccc.int/paris_agreement/items/9485.php).

3. National databases

There are various hazard-based databases in every Member State. Some are in digital format, while others are just in plain text files or Excel spreadsheets.

Some of them were studied for this report because they were considered to be a reference point for a particular hazard. The databases that have been taken into account are the following.

— **FloodCat:** an Italian catalogue of past floods designed by the Italian Civil Protection Department with the support of the Italian National Institute for Environmental Protection and Research, and developed by the CIMA Foundation.

— **CDTE and CNIH databases:** Spain has historical databases on earthquakes (CDTE — Catalogo de daños por terremoto en España) and floods (CNIH — Catalogo nacional de inundaciones históricas), dating back several decades.

— **AJDA:** a Slovenian database developed by the Ministry of Interior of Slovenia; it is multi-hazard and based on assets.

— **eMARS:** a database of technological hazards, compliant with the Seveso I, II and III directives.

— **EM-DAT:** an emergency events database developed by the Centre for Research on the Epidemiology of Disasters in Belgium.

— **Database from Consorcio de Compensación de Seguros:** a Spanish database covering insured losses from floods (riverine, pluvial and coastal), strong winds, earthquakes, tsunami, volcanic eruptions and meteorite impacts in Spain, maintained by the Consorcio de Compensación de Seguros, which is by law the Spanish public insurance company responsible for paying out for these losses. The database has a large number of data, as they have been being collected for several decades. Consorcio de Compensación de Seguros covers losses of property (residential, commercial, industrial, infrastructures, motor vehicles, etc.), personal damages and losses arising from interruption to business.

— **Desinventar:** a database developed by the UN Office for Disaster Risk Reduction and implemented in many countries.

3.1. FloodCat (Italy) ([32])

The floods directive asks the Member States to collect and provide information on past events and their consequences. In particular, Article 4 of the directive requires Member States to carry out a preliminary assessment (preliminary flood risk assessment) to identify the areas for which potential significant flood risks exist or might be envisaged.

The Italian government established by law (a directive of the President of the Council of Ministries, Dir.P.C.M. 24 February 2015) that the Civil Protection Department was to create a web geographic information system (GIS) platform named FloodCat, available to regional and river basin district authorities (floods directive competent authorities). The platform fulfils the function of creating a catalogue of flood events and, therefore, can be used to address the requirements of the directive. FloodCat is thus the official technological platform for collecting information on past floods in accordance with the EU floods directive.

FloodCat has been updated thanks to the Disaster Risk Management Knowledge Centre support service funded by the Directorate-General for European Civil Protection and Humanitarian Aid Operations and implemented by the JRC. The updated version takes into consideration the JRC's *Guidance for recording and sharing disaster damage and loss data* ([33]), as well as the indicators proposed in the Sendai framework.

([32]) Istituto Superiore per la Protezione e la Ricerca Ambientale, 'Valutazione preliminare del rischio di alluvioni' (http://www.isprambiente.gov.it/pre_meteo/idro/Val_prem.html).

([33]) http://publications.jrc.ec.europa.eu/repository/handle/JRC97287

For these reasons, FloodCat has been identified as a reference for data collection in the case of flood events and is compliant with the floods directive. It is also clearly of interest when considering a multi-hazard database schema.

According to the floods reporting schema, for each significant flood the following information should be reported:

- location (name of place, river basin, sub-basin and/or coastal area);
- category of flood (past or potential future flood);
- type of flood;
- extent (area of land inundated or length of river stretches or coasts);
- probability of flood event (frequency, recurrence);
- date of commencement and duration of flood;
- type and degree of adverse consequences for:
- human health
- the environment
- cultural heritage
- economic activity;
- other relevant information

Considering all the above, FloodCat has been designed based on three elements:

1. events
2. phenomena
3. damages.

3.1.1. Events

Events are the main element in FloodCat. An event is defined as a flood associated with a particular situation and time. An event can have several phenomena associated with it.

An event in FloodCat can be described using the following fields:

- event ID
- event name
- source of flooding
- event category
- start date
- time frame (duration)
- unit of management
- flooded area
- extent of land inundated or inundated length of river or stretch of coasts
- event recurrence or frequency
- other relevant information.

3.1.2. Phenomena

Phenomena are linked with events in FloodCat; it is normal for more than one phenomenon to be linked to an event.

Phenomena represent the definition of the event's dynamics in terms of mechanism, characteristics and localisation of the flood with which the impacts are associated. Each phenomenon is associated with only one characteristic and one or more mechanism.

A phenomenon in FloodCat can be identified using the following fields:

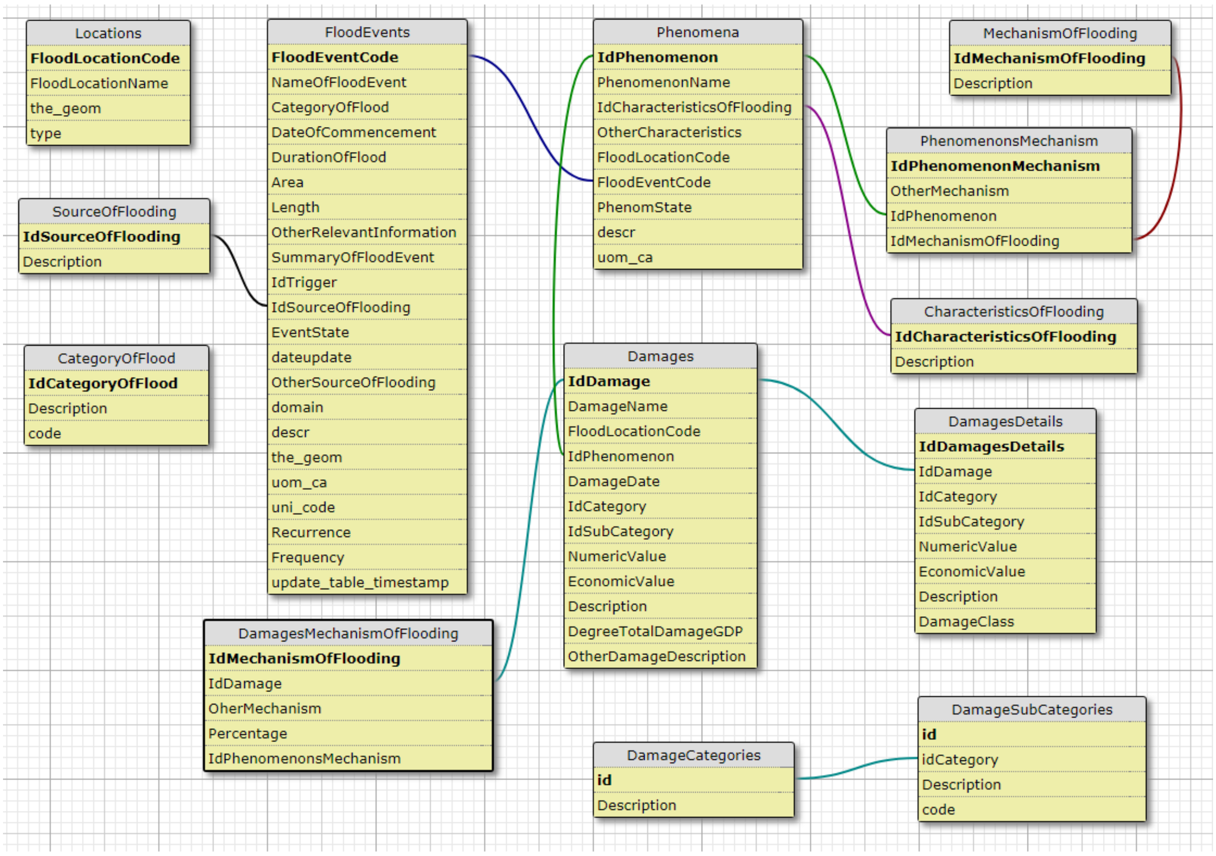
- ID of the event
- ID of the phenomenon
- phenomenon name
- phenomenon description
- characteristics of the flood
- mechanism of the flood
- location (area).

3.1.3. Damages

Damages are linked to phenomena and the fields that can be used for damages are:

- ID of the phenomenon
- ID of the damage
- name
- summary
- location code (area/point)
- date
- ID of damage category
- ID of damage subcategory
- numerical value
- economic value
- mechanism of flooding
- damage description
- degree of damage (damage class)
- ID of the event.

Figure 1. Diagram of the structure of the FloodCat database



3.2. CDTE and CNIH databases (Spain) ([34])

The Spanish CDTE was developed by the Spanish Department of Civil Protection and is based on agreements signed between the Directorate-General for Civil Protection, the insurance compensation consortium, the national geographical institute and the national centre for geographical information. Its main table is based on general event data such as:

- episode number code
- start date
- end date
- denomination of the episode
- type of event
- type of cause
- total amount of the episode
- author
- creation date
- update date
- modifying author.

The Spanish database also records the characteristics of the event, the causes, and human and material losses associated with the event (in relation to services, infrastructure, buildings, industries, etc.).

Human losses are not disaggregated by gender, age or income and are recorded only at an aggregated level.

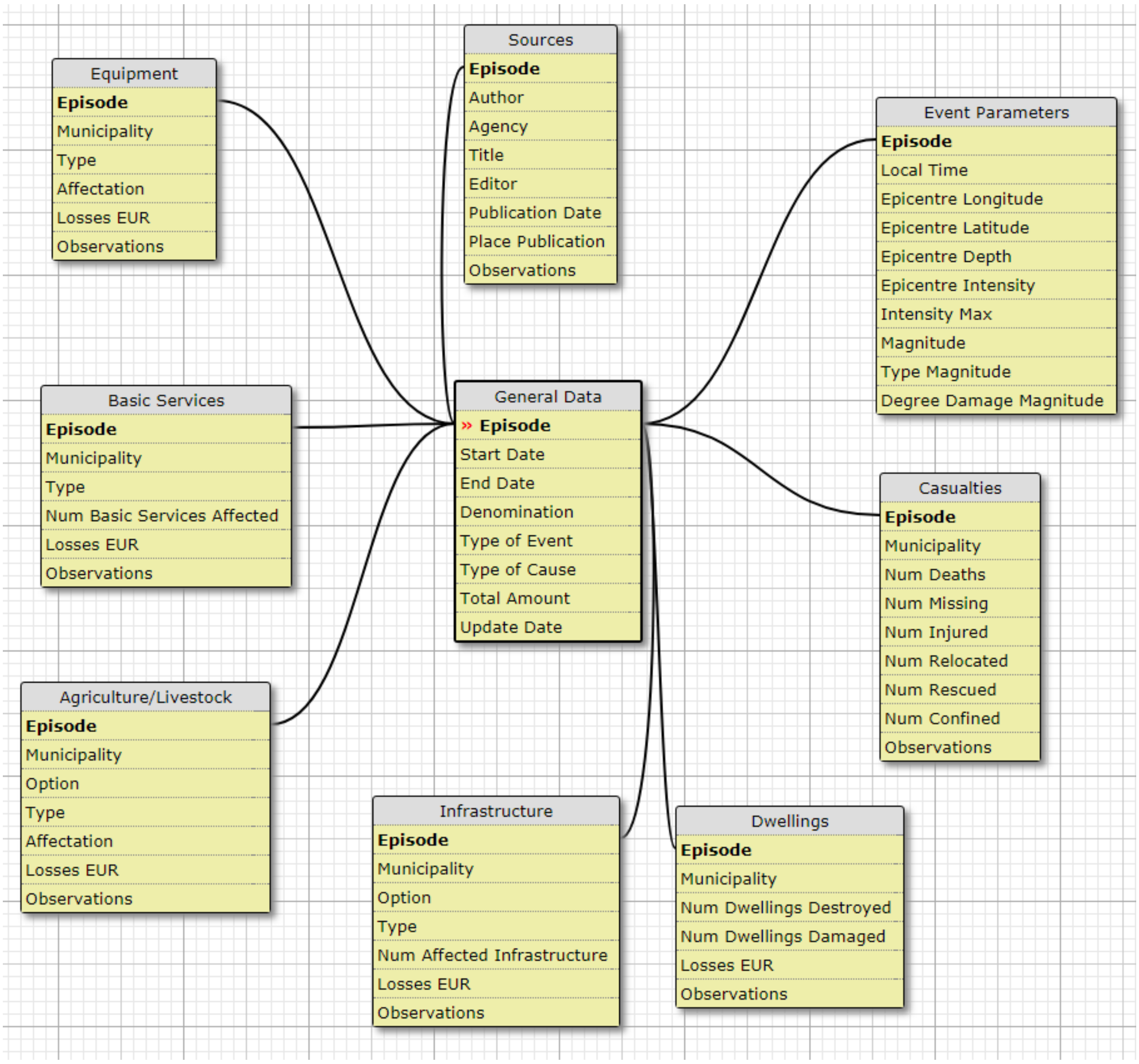
The entries for the other losses (in relation to infrastructure, buildings, agriculture and services, etc.) include basic information such as:

- municipality
- minor entity of population
- option
- type
- affectation
- losses in euros
- more detailed information.

([34]) Consor Seguros, 'Catalogue of earthquake damage in Spain: a tool to reduce disaster risk' (http://www.consorsegurosdigital.com/en/numero-06/front-page/catalogue-of-earthquake-damage-in-spain-a-tool-to-reduce-disaster-risk).

The structure of the CDTE is shown in Figure 2.

Figure 2. Diagram of the structure of the Spanish earthquakes database CDTE



3.3. AJDA database (Slovenia) ([35])

The Slovenian database is structure based on assets. It is different from the other databases that we have seen, as in this case there is a catalogue of assets even if there has been no event. When an event happens, it can be associated with one or more assets, depending on how many assets have been affected by it.

The damage evaluation methodology in Slovenia includes damage caused by natural disasters and industrial accidents. The damage groups include land, facilities, fixed and current assets (movable property and stocks, agricultural production, multiannual plantations), cultural property and loss of revenue from a holding.

The database is fed using external sources of information and regularly updated during the year, for example in the case of cadastral data (using information on how many people live in a given area, the data are disaggregated by age range, income bracket, etc.), prices for materials and repair costs.

Given this structure, when an event happens it is very easy to generate a compensation report. This can be done almost immediately, as all the information required (e.g. on prices and assets) is already linked to the event and up to date.

When an event happens, the people affected have to fill in some forms (different ones depending on the hazard) and provide an estimate of the costs and an indication of the affected assets. Later, these forms are digitalised and the information recorded in the AJDA system. After that, if necessary, an expert will do field research to assess the damage more specifically and arrive at a more accurate estimate of the compensation to be paid.

([35]) Ministry of Defence of the Republic of Slovenia, Administration for Civil Protection and Disaster Relief, 'Slovenian system of protection against natural and other disasters', PowerPoint presentation, April 2013 (http://dppi.info/sites/default/files/Slovenia1.ppsx); Ministry of Defence of the Republic of Slovenia, Administration for Civil Protection and Disaster Relief, 'Slovenian application for damage assessment on agricultural products and objects — AJDA', March 2017 (https://goo.gl/BwuFyL); AJDA home page (https://ajda.projekti.si).

3.4. eMARS ([36])

The Major Accident Reporting System (MARS, renamed eMARS after it went online) was stablished by the first Seveso directive in 1982. It has remained in place, with subsequent revisions in accordance with the later Seveso directives, including that in effect today. The purpose of eMARS is to facilitate the exchange of lessons learned from accidents and near misses involving dangerous substances in order to improve chemical accident prevention and mitigation of the potential consequences.

eMARS contains reports of chemical accidents and near misses that have been provided to the Major Accident Hazards Bureau of the JRC by the EU Member States, the European Economic Area countries, the Organisation for Economic Cooperation and Development countries and the UN Economic Commission for Europe countries (under the Convention on the Transboundary Effects of Industrial Accidents). Reporting an event to eMARS is compulsory for EU Member States when a Seveso establishment is involved and the event meets the criteria for a 'major accident', as defined by Annex VI to the Seveso III directive. For non-EU, Organisation for Economic Cooperation and Development and UN Economic Commission for Europe countries, reporting accidents to the eMARS database is voluntary. The information on the reported event is entered into eMARS directly by the official reporting authority of the country in which the event occurred.

Chemical accident reports from investigations can be powerful in raising awareness of potential failures that could cause major accidents in establishments using dangerous substances. They also provide the general public with access to accident information to aid local and national efforts to reduce chemical accident risks.

Reports in eMARS are not intended to serve as instruments for passing judgement on individual companies or countries associated with an accident. A blame culture surrounding the database would greatly reduce the sharing of information. For this reason, companies' names and locations are not identified in the database in order to maintain a focus on the value of the information in terms of lessons learned and to encourage complete and accurate reporting of what happened so that everyone can learn from it.

Some of the information contained in the eMARS database is as follows.

Profile table:

- title
- start date
- end date
- accident type
- reported
- Seveso II status
- industrial activity
- reason for reporting.
- Accident table:
- description
- fire details
- explosion details
- other.
- Site table:
- description
- installation/unit description

([36]) European Commission, JRC, 'The Minerva Portal of the Major Accident Hazards Bureau' (https://minerva.jrc.ec.europa.eu/en/minerva).

- process
- equipment
- initiating events
- other.
- Substances table:
- substances involved
- substance classification
- details.
- Causes table:
- description
- plant/equipment.
- Consequences table:
- human (injuries, fatalities, other)
- cause
- disruption.

Emergency response.

Lessons learned.

3.5. EM-DAT (Centre for Research on the Epidemiology of Disasters, Belgium) ([37])

EM-DAT is a global database on natural and technological disasters containing essential core data on the occurrence and effects of disasters in the world since the beginning of the 20th century. EM-DAT is maintained by the Centre for Research on the Epidemiology of Disasters at the School of Public Health of the Catholic University of Leuven in Brussels, Belgium.

Its main objectives are to assist humanitarian action at both national and international levels, to rationalise decision-making for disaster preparedness and to provide an objective basis for vulnerability assessments and priority setting.

The EM-DAT database records events that meet at least one of the following criteria:

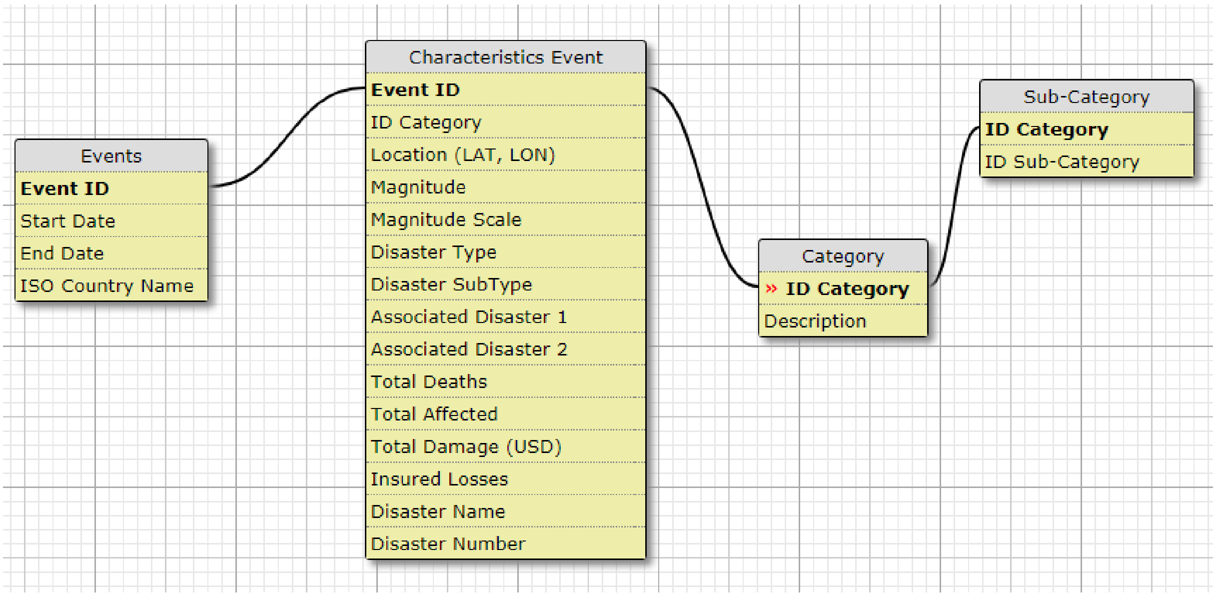
- 10 or more people dead;
- 100 or more people affected;
- the declaration of a state of emergency;
- a call for international assistance.

EM-DAT provides geographical, temporal, human and economic information on disasters at country level.

The structure of the EM-DAT database is based on events, linked to a table of characteristics of events.

Figure 3 illustrates how the EM-DAT database architecture is designed.

Figure 3. Diagram of the structure of the EM-DAT database



([37]) Centre for Research on the Epidemiology of Disasters, EM-DAT: the international disaster database (http://www.emdat.be/).

4. Proposed loss database architecture for disaster risk management

4.1. Common aspects

Every database studied for this report has its own characteristics and tracks enough information to serve the purpose for which it was designed. In most cases, the database records information on only one hazard, and only in the case of the Slovenian AJDA is the database designed to be multi-hazard.

That being said, AJDA is the most advanced database of those that we studied in detail. It could even be used as a case study or as a good practice example for other countries with similar characteristics, both in terms of the size of the country, which is relatively small, and from the point of view of the hazards to be recorded and their extent.

However, the Slovenian database cannot alone form the basis for the proposal for the loss database architecture at EU level, since every country has its own requirements. Changes would be needed to adapt its structure for a larger loss database.

Extracting a common set of information for every hazard is a difficult task and must be done carefully in order not to leave out any relevant information. The main challenge is building a complex but flexible database structure into which all the hazards can fit, without losing valuable information required for every hazard-oriented database.

The loss database for disaster risk management should be based on the following pillars:

- compliant with the various relevant directives and initiatives;
- able to collect and aggregate data to report to the Sendai Framework;
- contributes to the preparation of NRAs;
- contributes to monitoring the SDGs.

4.2. Elements

The databases that we studied mainly focused on events. In some cases, events are taken as single and independent facts, but, in others, as seen above, they can be related and one event can be identified as the result of another.

On the other hand, some databases are focused on assets. The assets can be of many kinds and can the database may include associated information. An asset damaged can lead to economic losses but also environmental, cultural and human costs for those living (houses), working (places of employment places), studying (schools, universities, etc.) or just passing through (shopping centres, cinemas, theatres, etc.) in an area where an event happens.

Even from the point of view of economic losses, these can be either direct or indirect. For this reason, assets are an important part of any disaster loss database.

For the loss database for disaster risk management, there are three corners of the triangle:

- events
- assets
- damages.

4.3. Events

Some of the databases that have been taken into account consider the event the main piece of information. Everything revolves around this element and the whole database is based on it.

Let us consider the event as one element — but not the only one — without which the loss database would not make any sense. It is one piece of information, but it is meaningless without the other two elements (assets and damages).

In our database, an event can happen on its own, as a cascade effect resulting from another or as the result of several others (e.g. the tsunami that occurred in Japan in 2011 after the earthquake and nuclear disaster at the Fukushima power plant).

This kind of information is not critical from the point of view of the damage or loss of human life, but it can help in identifying cascade effects, assessing potential risks and predicting cascade effects likely to happen in certain areas.

For this reason, in the proposed loss database schema, the main element (event) table would record the following information, common to all hazards:

- (identification data) event ID
- start date
- duration/end date
- denomination
- type of event
- update date
- ISO country name (International Organisation for Standardisation)
- methodology
- pedigree.

Linked with this events table would be another table with metadata information in the following fields:

- generated number (e.g. the Global Unique Disaster Identifier (GLIDE) number)
- URL
- title
- status.

The events table would also be linked to supporting tables. There would be one for every hazard, with the relevant hazard-only information, and another would contain the coping capacity information of the country or countries affected by the hazard.

The following would be the supporting tables.

- Coping capacity:
  - ISO country code
  - country name
  - coping capacity index.
- Earthquake:
  - magnitude
  - intensity
  - scale
  - depth
  - location (latitude/longitude)
  - affected population
  - affected area
  - radius.

- Tropical cyclone/hurricane:
  - category (Saffir-Simpson)

- max. wind speed
- affected population
- affected area
- radius.

- Storm surge:
  - max. sustained wind speed
  - max. storm surge height
  - affected area
  - affected population.
- Landslide/avalanche:
  - type of soil
  - speed of landslide/avalanche
  - depth of snow/landslide
  - affected area
  - affected population.
- Flood:
  - source of flooding
  - unit of management
  - flooded area/affected area
  - inundated length
  - frequency
  - recurrence
  - rainfall height
  - rainfall duration
  - characteristics of flooding
  - mechanism of flooding
  - water depth.
- Chemical/biological/technological hazard:
  - type of substance/allergen
  - infestation
  - danger level
  - wind direction
  - affected area
  - affected population
  - radius
  - exclusion area.
- Cyberattack/terrorist attack:
  - type of infrastructure affected
  - loss/damage of data
  - target of attack
  - destruction/loss of hardware
  - affected area
  - affected population.
- Volcano:
  - source
  - location (latitude/longitude)
  - wind direction
  - lava slide speed
  - affected area
  - affected population
  - radius.
- Cosmic:
  - magnetic disruption level
  - meteorite impact location (latitude/longitude)
  - solar and cosmic radiation level

- affected area
- affected population
- radius.
- Forest/wild/underground fire:
  - wind direction
  - affected area
  - affected population
  - radius.
- Drought:
  - air humidity
  - number of days since last rainfall
  - soil composition.
- Nuclear:
  - disaster scale
  - radiation leak
  - affected area
  - affected population
  - radius
  - exclusion area
  - type of radioactive material leaked.
- Tsunami:
  - wave height
  - wave speed
  - affected area
  - affected population.
- Climatological (cold or heatwave):
  - extreme temperature
  - number of days
  - recurrence
  - frequency
  - affected area
  - affected population.

4.4. Assets

The assets table contains all the information about different assets; its main source of information is cadastral data, to ensure up-to-date information on buildings, land and infrastructure. The cadastral data should be updated twice a year. The assets table contains the following fields:

- asset ID
- asset name
- asset description
- asset value
- asset location ID
- asset owner ID
- asset economic ID
- asset environmental ID
- asset heritage ID
- event ID.

Linked to the assets table there should be several supporting tables, described below.

Economic table

This table would provide further information on economic details, if any, associated with the asset and linked to the 'asset economic ID' code.

Cultural heritage table

This table would provide further information on cultural heritage details, if any, associated with the asset, such as an ID code identifying the type of cultural heritage, value, year, type of heritage or restoration costs, and linked to the 'cultural heritage ID' code.

Environmental table

This table would provide further information on environmental details, if any, associated with the asset, such as the kind of environmental damage, and effects, costs or associated impact, and linked to the 'environmental ID' code.

People table

The cadastral data should include data about the owners and people living in apartments, houses and flats, and do so in a disaggregated way, including information on:

10. gender (male/female)
11. age (under 18/adult/senior)
12. income (low/medium/high)
13. disability (yes/no).

This table should be linked with the assets table by the asset ID, which identifies every individual asset. It should also be linked with the events table by the event ID to make it possible to link events to human losses that are not associated with assets (e.g. deaths that occurred in the open air). The fields for this table are:

- asset ID
- event ID
- number of males
- number of females
- number of males aged under 18
- number of females aged under 18
- number of male adults (aged 18-65)
- number of female adults (aged 18-65)
- number of male seniors (aged 65+)
- number of female seniors (aged 65+)
- number of males on low income
- number of females on low income
- number of males on medium income
- number of females on medium income
- number of males on high income
- number of females on high income
- number of males with disability
- number of females with disability.

Prices table

The prices table should be updated twice a year. It contains the price per square metre of buildings depending on the area (using an area code*)* to make it possible to rapidly asses the direct loss when an event affects a property. In addition, this table includes information about the costs of repairing individual parts of assets, such as windows, walls, doors and roofs, with the prices updated regularly. This table includes a field for value, which should contain the aggregated value of the asset before any event has happened. This table is linked to the assets table by the asset ID code. The fields are:

- asset ID
- area code
- item ID
- item description
- value
- total value.

In addition, the assets table is linked to a location table, where the precise location of the asset is displayed:

- location ID
- latitude
- longitude
- area code
- street
- commune
- region/province
- ISO country code
- country name.

4.5. Damages

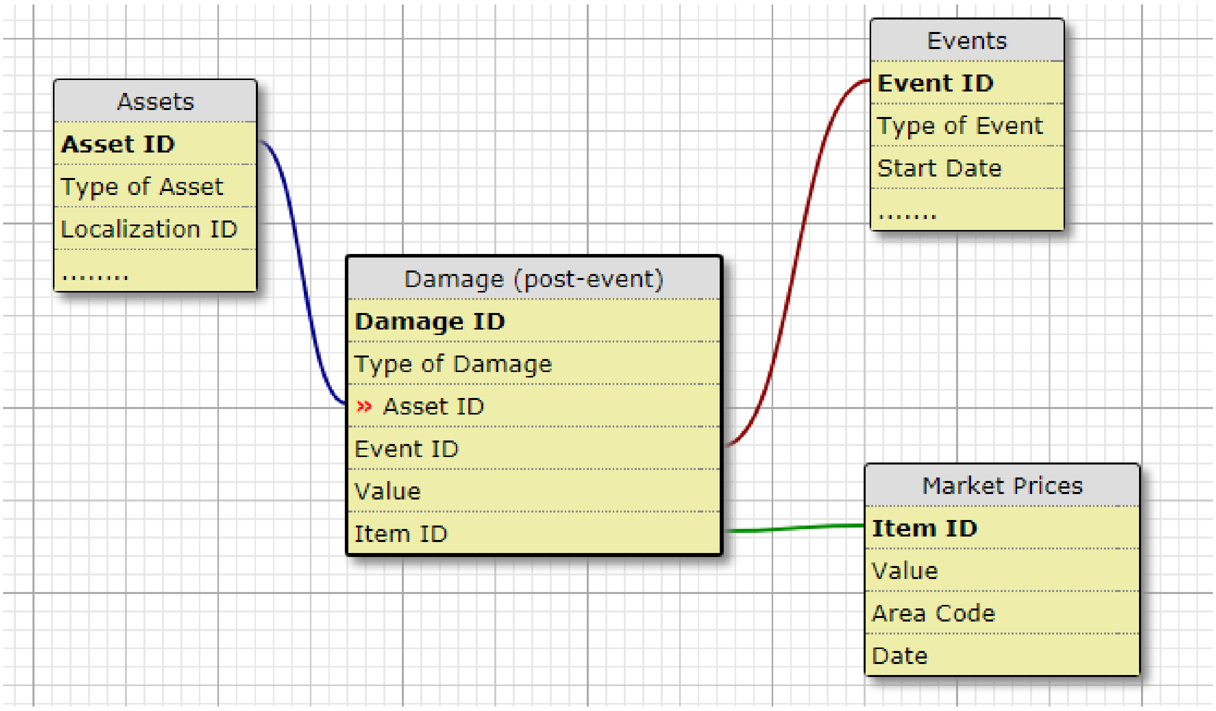
Damage occurs due to an event and an asset suffers damage. The damages table contains a figure for the percentage of damage caused to an asset.

Just as there is a value table associated with the assets, and these data are considered to be the pre-event information on the asset, the damages table is intended to indicate the extent of the damage that has been inflicted on the asset; this information is the post-event information on the asset.

This table provides information on the percentage of damage, which items were damaged, the extent of the damage and the cost of it. As there is cost involved, this table is fed into by the market price table, which contains up-to-date prices for the items, or the price per square metre depending on the area code of the asset (updated twice a year).

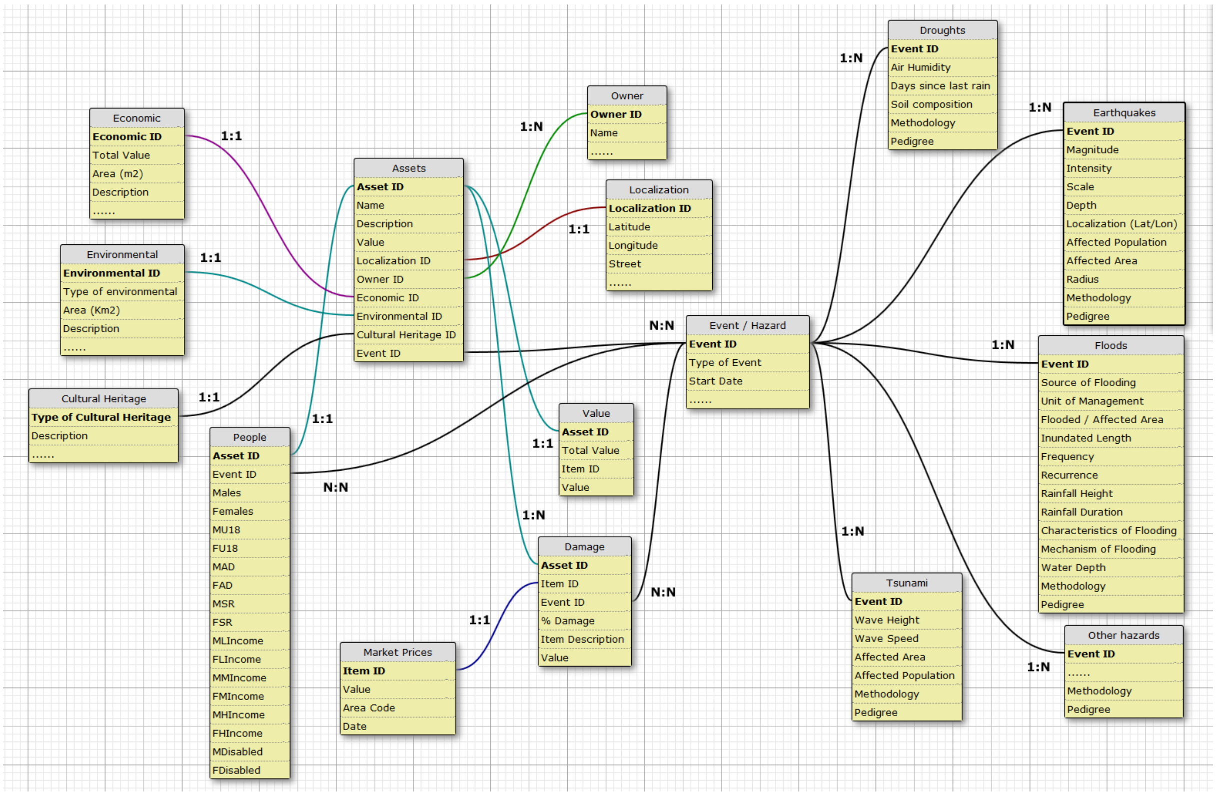
The damages table will be linked to the events table by the event ID, to the assets table linked by the asset ID and to the market price table linked by the item ID.

Figure 4. How damages are linked to assets, events and market prices



4.6. Loss database architecture

Figure 5. Diagram of the loss database architecture



Economic
Economic ID
Total Value
Area (m2)
Description
......
Environmental
Environmental ID
Type of environmental
Area (Km2)
Description
......
Cultural Heritage
Type of Cultural Heritage
Description
......
Assets
Asset ID
Name
Description
Value
Localization ID
Owner ID
Economic ID
Environmental ID
Cultural Heritage ID
Event ID
Owner
Owner ID
Name
......
Localization
Localization ID
Latitude
Longitude
Street
......
People
Asset ID
Event ID
Males
Females
MU18
FU18
MAD
FAD
MSR
FSR
MLIncome
FLIncome
MMIncome
FMIncome
MHIncome
FHIncome
MDisabled
FDisabled
Value
Asset ID
Total Value
Item ID
Value
Damage
Asset ID
Item ID
Event ID
% Damage
Item Description
Value
Market Prices
Item ID
Value
Area Code
Date
Event / Hazard
Event ID
Type of Event
Start Date
......
Droughts
Event ID
Air Humidity
Days since last rain
Soil composition
Methodology
Pedigree
Earthquakes
Event ID
Magnitude
Intensity
Scale
Depth
Localization (Lat/Lon)
Affected Population
Affected Area
Radius
Methodology
Pedigree
Floods
Event ID
Source of Flooding
Unit of Management
Flooded / Affected Area
Inundated Length
Frequency
Recurrence
Rainfall Height
Rainfall Duration
Characteristics of Flooding
Mechanism of Flooding
Water Depth
Methodology
Pedigree
Tsunami
Event ID
Wave Height
Wave Speed
Affected Area
Affected Population
Methodology
Pedigree
Other hazards
Event ID
......
Methodology
Pedigree
1:1
1:1
1:1
1:1
1:N
1:1
1:1
N:N
1:N
1:1
N:N
N:N
1:N
1:N
1:N
1:N
1:N

5. Adaptation of the database architecture for the Risk Data Hub

5.1. Challenges identified

5.1.1. How to represent exposure, vulnerability and past events together

The Risk Data Hub is intended to handle different type of datasets, making them available on a unique portal to help end users in many tasks related to disaster risk management.

The data used come from models and from archives on past events. While models tell us what could happen, archives tell us what has already happened, on a specific date, under specific circumstances; therefore, these two types of data cannot be visualised in the same way.

The data also relate to many natural hazards (technological hazards are to be included in a future version), and every hazard has its own peculiarities, which is why data inputs differ from hazard to hazard.

Considering this, the first challenge consists of storing different types of data in a single database and presenting them in a way that preserves their specificity in a single user interface.

Our proposal to achieve this involves including a main entity **damage assessment**, which, along with the overall flexible design, will enable the system to manage and present data about different types of analysis. A more detailed explanation is included in section 5.3.5 on the database architecture.

5.1.2. Harvesting data from multiple sources

Given the wide area of interest, there cannot be only a single source of data. The Risk Data Hub works with many scientific partners that provide the application with the outputs from their work. These are typically models used for populating the risk analysis datasets of the Risk Data Hub, but sometimes archives on past events are included.

While the models have good coverage and are produced on a regular basis by scientists, the collection of loss data is not homogeneous or well defined and structured; that is why the availability of data, especially on a large scale, is limited.

The scientific, economic and political issues that cause this lack of availability of data are not a concern of this report. Technically speaking, one way of getting as many data as possible is to connect with different sources.

This challenge has led to the development of a dedicated data integration flow for each data source activated. The Risk Data Hub has an ETL (extract, transform, load) layer, which is needed to transform the data extracted before inserting them into the database.

5.1.3. Identification and classification of events

The identification of events is still a matter of discussion in the scientific community and it is not homogeneous among different hazards.

The Risk Data Hub identifies events in the following ways.

- **An event is identified by hazard, country and date.** This means that, for example, a single meteorological event that covers an area shared by two countries will generate exactly two events in the system, even if distant, non-adjacent regions in the same countries are affected.
- **An event is a macro entity that may include multiple phenomena.** This means that, while an event may affect a whole country and last for several days (or weeks), there are individual phenomena that map the event to a more specific location and date, such as single burned areas caused by a vast forest fire.

5.1.4. Unique coding of events

Every data source has its own means of assigning a code to an event; furthermore, events included in various sources may overlap. Therefore, a new code has to be assigned to ensure a consistent archive.

In the Risk Data Hub, the code composition is implemented as follows:

[Hazard] (2-character code)

+ [Country] (2-digit ISO country code)

+ [Begin Date] (in YYYYMMDD format)

+ [GLIDE Number] (4-digit serial number)

An example would be the following.

When a new event is imported into the system, it has a status equivalent to 'draft' and it needs to be moderated and approved before it is published. Only when the event is approved is the Risk Data Hub code generated; this ensures that the sequence of GLIDE numbers is consistent with that of the published events.

5.1.5. Country corner and user privileges

The Risk Data Hub publishes European-wide datasets, but the whole system is designed to work also at national or regional level. A single institutional user that is responsible for its country is able to upload data and choose whether or not to share this data with other users or groups.

The logic is based on two main points:

- a user belongs to one or multiple groups and each group has some basic permissions;
- each dataset in the system has a unique owner that can set visibility and permissions for it.

Example 1. The group of administrators of the Austrian country corner has privileges allowing members to manage all datasets assigned to the Austria region. A user who belongs to this group uploads two layers and decides, for the first one, to grant viewing rights to all groups and, for the second one, to grant full rights only to the group 'Austria_Administrators'. As a result, the first layer will be visible to (but not editable by) all users, even those who are not registered with the site (because they belong to group 'Anonymous'), while the second layer will be visible to and editable by only the users in the group 'Austria_Administrators'.

Example 2. A country corner administrator uploads data for a new damage assessment and chooses to grant editing rights to the administrators group and only viewing rights to the group of non-admin users of the country corner in question. As a result, a non-registered user or a user of another country corner will not be able to see anything relating to that damage assessment.

5.1.6. Scalability and performance

Since the Risk Data Hub is expected to store and manage large amounts of data, scalability is a matter that must be addressed to keep the application healthy and responsive.

This report is not a technical guide, or a list of design patterns in Python or any other language. Here, we want to just state that performance is taken into consideration and that there some relevant practices and tools already in use, as well as others that will be applied in the near future.

The following measures are proposed to achieve the performance goals.

- Use of database indices.
- Optimisation of queries.
- Use of GeoWebCache: this is a tool that comes with GeoServer and caches tiles generated by Web Map Service (WMP) calls. Tiles can be cached either after a call to a WMS service or through a bulk seeding process.
- Caching of Django views: Django integrates a configurable caching system for its views, allowing multiple page requests to consume resources only once after the cache expiration.
- 'Reselect' tool for React: the client application keeps the data retrieved from the back-end application programming interface (API) in its own internal 'store' and makes a new call to the API only if data are not already stored in it; this saves both bandwidth and system resources.

Further improvements will include the following.

- Deployment of GeoServer on a dedicated machine.
- Use of a non relational database: when the data stored start to exceed a certain amount, old-fashioned relational databases start to suffer a deterioration in their performance. The use of a NoSQL database should solve this problem, but at this point the technology selection process is not complete, as there are several constraints to be considered in relation to GeoNode and GeoServer.

5.2. Technologies

After collecting and analysing the main requirements of the platform to be developed, it was time to choose the technologies and tools to be used. Some of those choices are mentioned in the previous section, and they were the result of looking into previous work in this field, which showed that significant projects had been based on **GeoNode** and **GeoServer**.

The system architecture as a whole is composed of several layers, from the ETL layer that extracts data from external sources to the front end of the website.

Essentially, the project has been built using Django (a Python web framework), with GeoNode as the dependency, PostGIS as the database back end and a client application developed with ReactJS.

GeoNode is mainly used for uploading and managing vector and raster layers. Inventory, analysis and loss data are loaded into a dedicated database.

Specific layers are created in GeoServer by SQL views and are used to extract and filter data to show on maps.

The basic operations performed by Risk Data Hub application against the PostGIS database are:

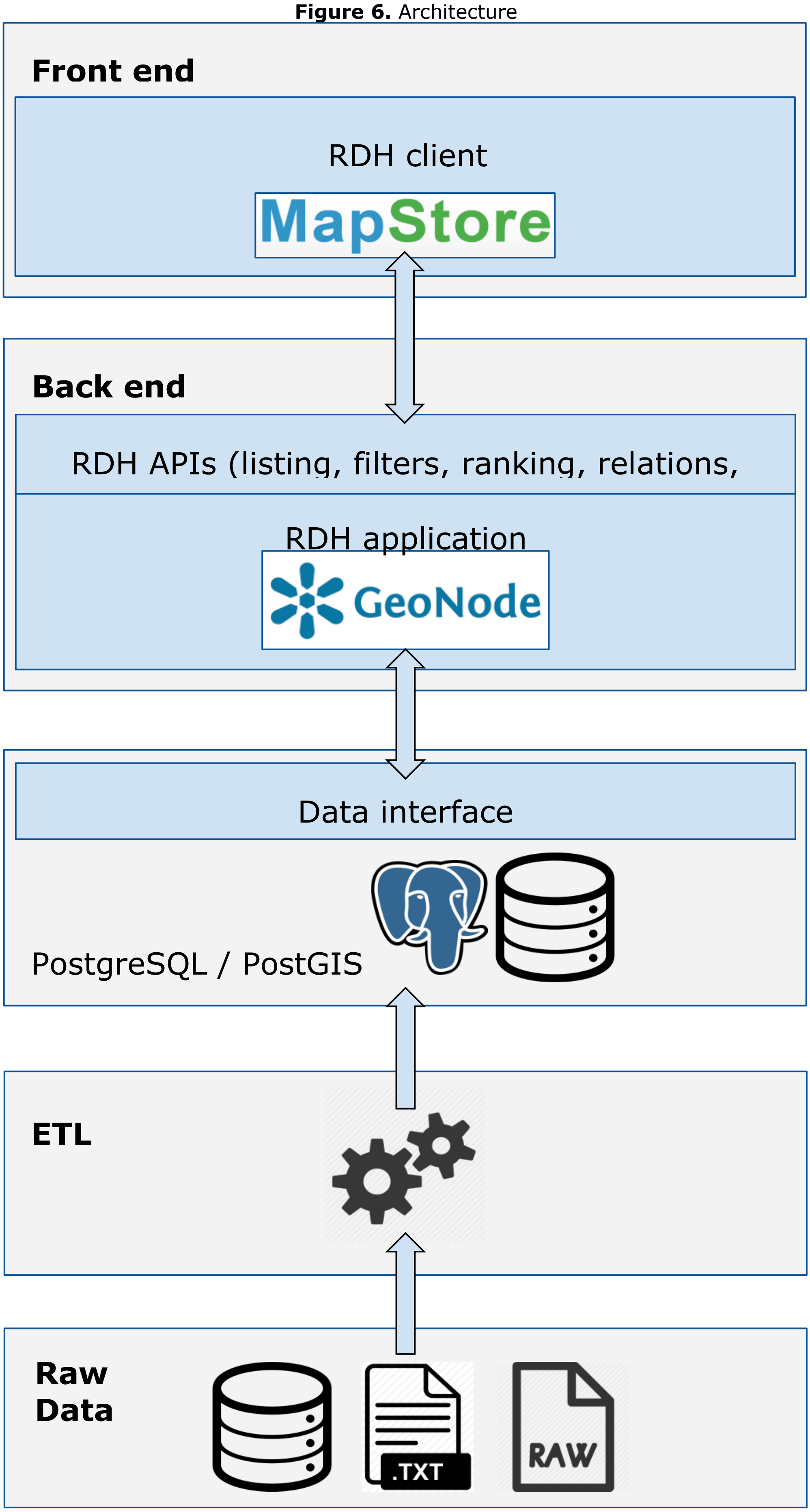
- data extraction and pre-processing (pg/plsql + Python code);
- spatial queries to extract spatial relations between datasets;
- extracting administrative division boundaries.

The basic operations performed by the Risk Data Hub application against GeoServer are:

- making Open Geospatial Consortium/WMS service calls to view layers on maps;
- using (E)CQL (extended common query language) to filter layers and contents on maps;

- using SLDs (styled layer descriptor) to style multiple geometries and geometry types;
- applying SLD filters for styling contents;
- applying Geofence rules to restrict access to layers and services;
- using GeoWebCache for tile caching.

Figure 6. Architecture



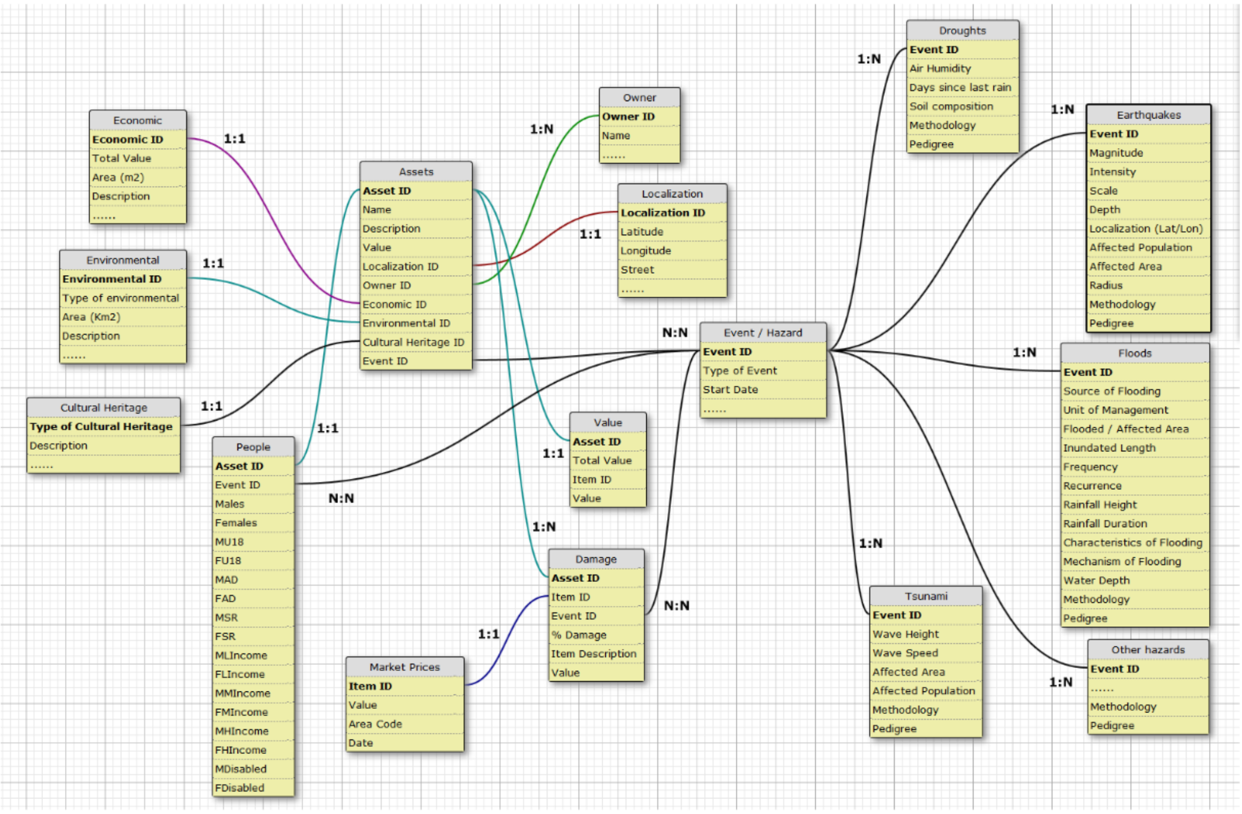
5.3. Database upgrade

5.3.1. Evolution of the loss database architecture

The implementation of the underlying concept of the Risk Data Hub required data to be stored for different purposes, such as **risk analysis**, **inventory of assets** and **damage assessments**.

The database was designed after the **loss database for disaster risk management** proposed in a recent EU publication ([38]). The result was at the same time an abstraction and an extension of that model.

Figure 7. Diagram of the loss database as in 2018



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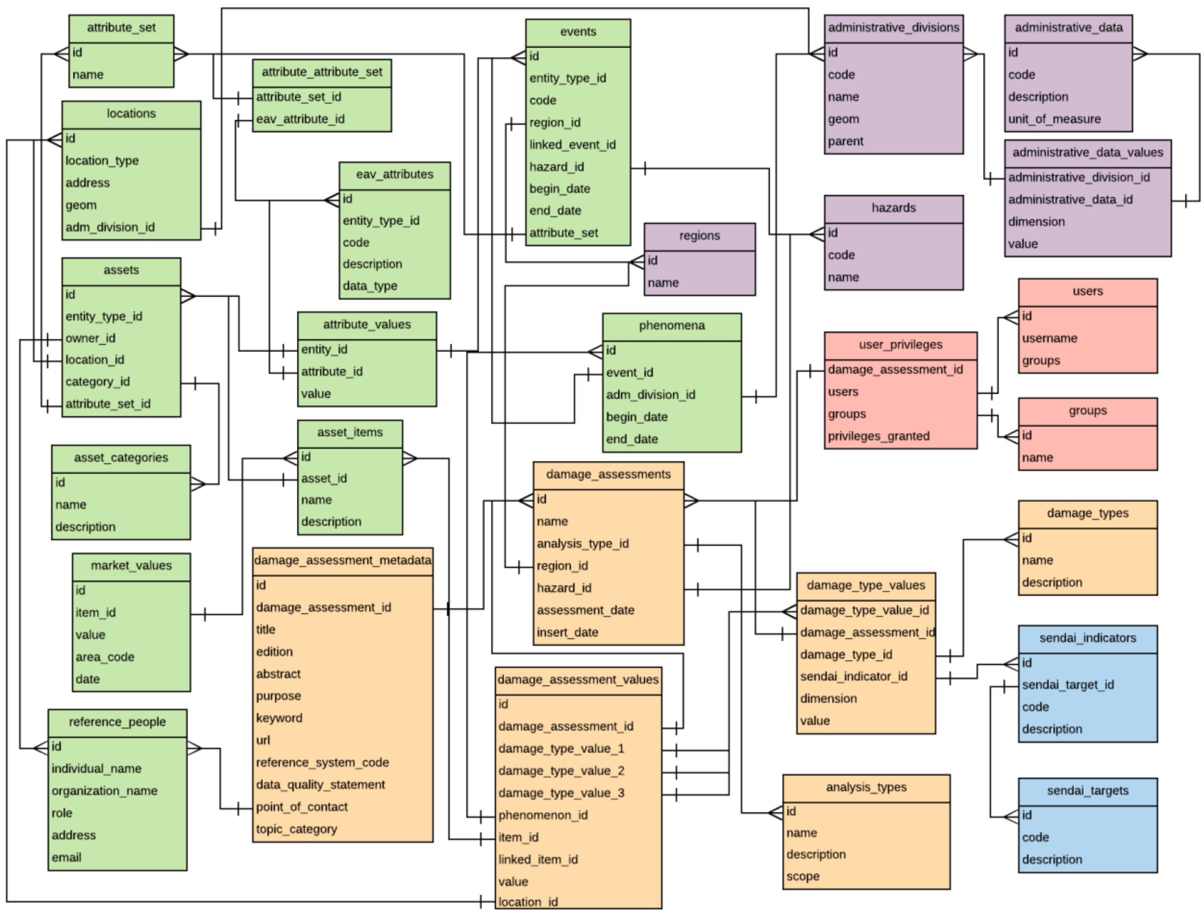
[38] http://dx.doi.org/10.2760/647488

Figure 8. Diagram of the Risk Data Hub database: tables are in different colours, corresponding to specific functionalities within the application



5.3.2. Changes to the database architecture

Events

The event entity has been split into 'macro events' and 'phenomena', as explained above. An event table linked to a number of external tables (e.g. the hazards table) no longer exists: all event attributes are stored in a centralised table, implementing the **EAV** (entity, attribute, value) data model. Since attributes may differ from hazard to hazard, each event is bound to a specific **attribute set** that ideally equals a hazard.

Assets

Like the events, the assets have been split into 'macro assets' and 'items': each macro asset may contain one or multiple items (e.g. a house containing pieces of furniture). Damages are linked to items, not to macro assets. Asset attributes are not described by an additional table for every type; they use the EAV data model and are also divided into categories. Fox a maximum abstraction, People are considered a specific asset category.

Locations

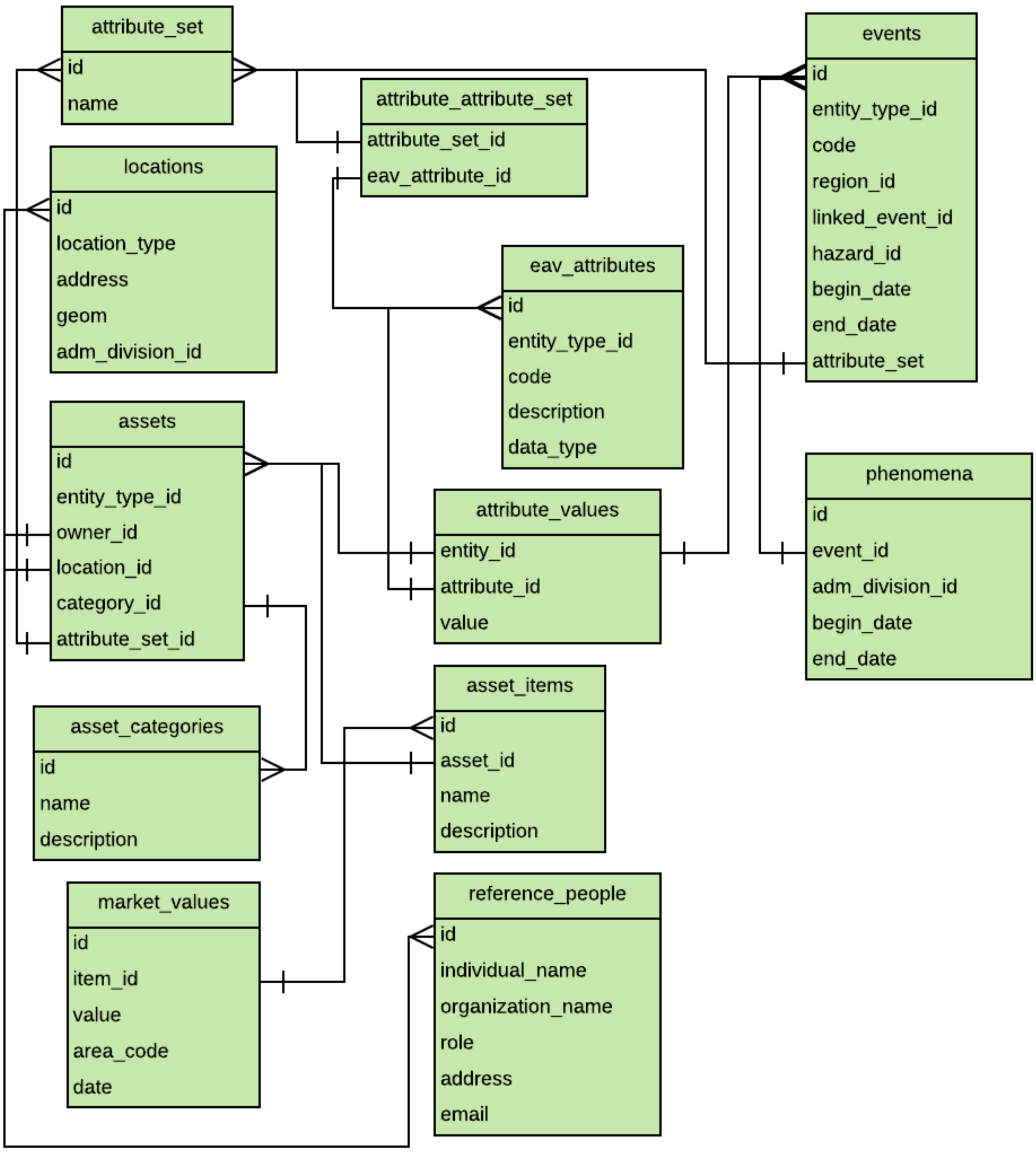
A location entity still exists, but types of locations are also defined (e.g. fixed location, non-fixed location, people), and types are linked to damages as well; in this way, every individual instance of damage may have a specific location, as the damage location may differ from the asset location. The damage location could be a point or a polygon that defines an extent.

As mentioned above, the Risk Data Hub database implements an abstraction of the loss database; this is shown as the (green) inventory section of the diagram (Figure 9). The other sections enable the additional functionalities to exist.

Entity inventory

This inventory allows all the required data on entities (both assets and events) to be stored. The number of columns for assets and events is limited, because all possible descriptive fields are managed using the EAV data model, which makes it possible to define new attributes at any time, without the need to change the database structure.

Figure 9. Inventory



locations

Description: this entity is useful for storing the location of any type of asset (fixed, non-fixed, people), or the extent of an individual instance of damage.

Fields:

- id (int) — unique identifier;
- location_type (enum) — e.g. fixed asset;
- address (varchar);
- geom (binary) — geometry (could be point or polygon);
- administrative_division_id (int) — reference to administrative_divisions.

assets

Description: generic entity affected by event (also includes people).

Fields:

- id (int): unique identifier;
- entity_type (enum) — defines entity type for mapping fitting attributes;
- owner_id (int) — reference to reference_people;
- asset_location_id (int) — reference to locations;
- asset_category_id (int) — reference to categories;
- attribute_set_id — reference to attribute_set.

asset_items

Description: individual item included in the asset (equates to asset in the simplest case).

Fields:

- id (int) — unique identifier;
- asset_id (int) — reference to assets;
- name (varchar).

asset_categories

Description: categories for assets, e.g. buildings, infrastructure or people.

Fields:

- id (int) — unique identifier;
- name (varchar);
- description (varchar).

market_values

Description: market value of items.

Fields:

- id (int) — unique identifier;
- item_id (int) — reference to assets;
- value (decimal);
- area_code (varchar);
- date (datetime) — start validity date.

reference_people

Description: could be the owner of an asset, author of a publication, etc.

Fields:

- id (int) — unique identifier;

- individual_name (varchar);
- organisation_name (varchar);
- role (varchar);
- address (varchar);
- city (varchar);
- zipcode (varchar);
- country (varchar);
- email (varchar).

eav_attributes

Description: attributes relevant to events and assets (and more) are defined in a single place. This feature makes it possible to define new attributes at any time, without the need to change the structure of a database.

Fields:

- id (int) — unique identifier;
- entity_type_id (int) — defines entity type for mapping fitting attributes;
- data_type (varchar) — defines data type (varchar, text, integer, decimal, datetime);
- name (varchar);
- description (varchar).

attribute_values

Description: attribute values are stored in dedicated tables for each type of data (varchar, text, integer, decimal, datetime).

Fields:

- entity_id (int) — identifier of entity (event or asset);
- attribute_id (int) — identifier of eav_attribute;
- value.

The database diagram provided with this document (Fig. 8) includes a simplified view of the EAV data model implemented. In fact, a table for each data_type/entity_type exists in the database (e.g. event_attribute_values_varchar, event_attribute_values_text, etc.).

attribute_set

Description: attribute sets are used to link attributes to specific instances of an entity.

Fields:

- id (int) — unique identifier;
- name (varchar).

attribute_attribute_set

Description: this is a relation between attribute_set and eav_attribute, so it is basically the content of an attribute set.

Fields:

- attribute_set_id — reference to attribute_set;
- eav_attribute_id — reference to eav_attribute.

events

Description: an event is a generic entity that may be the cause of damage.

Fields:

- id (int) — unique identifier of the event;

- entity_type_id (int) — defines the entity type for mapping fitting attributes;
- region_id (int) — could be Europe, or any country corner;
- linked_event_id (int) — optional link to an event identified as the cause of the current one (chained events);
- hazard_id (int) — identifier of the hazard (e.g. flood);
- begin_date (datetime) — start date of recognised event;
- end_date (datetime) — start date of recognised event;
- attribute_set_id — reference to attribute_set.

phenomena

Description: a phenomenon is part of a major event and has a specific location and related assessed damage.

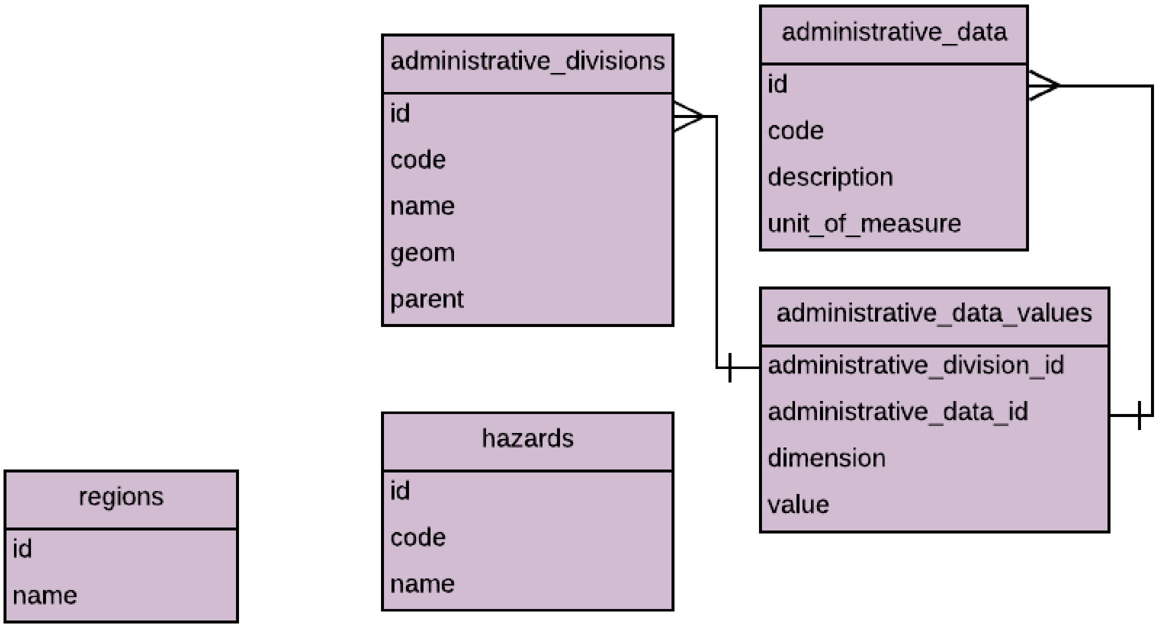
Fields:

- id (int) — unique identifier;
- event_id (int) — related event;
- administrative_division (int) — maps location of phenomenon;
- begin_date (datetime) — start date of recognised event;
- end_date (datetime) — start date of recognised event.

5.3.3. Entity administrative data

This section gathers entities used for basic characterisation of data stored for the damage assessments.

Figure 10. Administrative data



hazards

Description: definition of the hazard (e.g. river flood).

Fields:

- id (int) — unique identifier;
- code (varchar) — e.g. FL for flood;
- description (varchar).

administrative_divisions

Description: this entity stores basic data on administrative divisions.

Fields:

- id (int) — unique identifier;
- code (varchar) — 2-digit ISO code countries, or relevant Nomenclature of Territorial Units for Statistics code according to Eurostat;
- name (varchar) — name of administrative division;
- geom (binary) — spatial data;
- parent_id (int) — parent administrative division.

regions

Description: this is crucial for ownership management of data and visibility. Each user in the system belongs to a specific region and so do the data owned by that user.

Fields:

- id (int) — unique identifier;
- name (varchar) — name of region (e.g. Europe, or a country corner, such as Austria).

administrative_data

Description: definition of data related to administrative divisions (GDP, population, area, etc.).

Fields:

- id (int) — unique identifier;
- code (varchar) — e.g. GDP;
- description (varchar) — description of data;
- unit_of_measurement (varchar) — e.g. million EUR.

administrative_data_value

Description: relation between administrative data and administrative divisions.

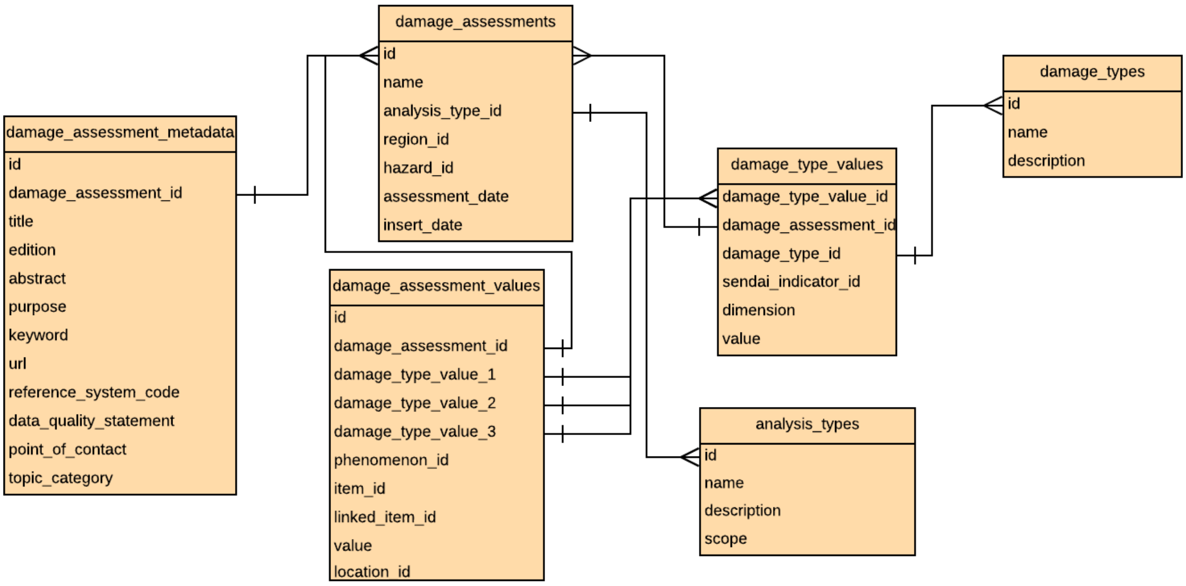
Fields:

- administrative_division_id (int);
- administrative_data_id (int);
- dimension (varchar) — e.g. GDP in 2018;
- Value (decimal).

5.3.4. Entity damage assessment

This section represents the core of the Risk Data Hub, as it defines the damage assessments and how the datasets are organised. The **analysis_type** entity basically defines a dataset in terms of data analysed (buildings, people) and of scope (risk analysis or historical events). The **damage_type** defines the dimensions used to measure data within the assessment (e.g. climate change scenarios, return periods of events).

Figure 11. Damage



analysis_types

Description: defines the type of data analysed (e.g. population, buildings, economic values).

Fields:

- id (int) — unique identifier;
- name (varchar);
- description (varchar).

damage_assessments

Description: definition of data measured.

Fields:

- id (int) — unique identifier;
- name (varchar) — name given (unique);
- analysis_type_id (int) — reference to analysis type;
- region_id (int) — reference to region, needed for risk analyses that do not use events;
- hazard_id (int) — reference to hazard, needed for risk analyses that do not use events;
- assessment_date (datetime) — date declared for the assessment;
- insert_date (datetime) — date of insertion in the database.

damage_types

Description: definition of the scenario under consideration. This is useful for complex analyses with predicted values in different declinations for a given scenario (e.g. climate change).

Fields:

- id (int) — unique identifier;
- name (varchar) — name given (unique);
- description (varchar).

damage_type_values

Description: relation between damage_assessment and damage_type.

Fields:

- id (int) — unique identifier;
- damage_assessment_id (int) — reference to damage assessment;
- damage_type_id (int) — reference to damage type;
- sendai_indicator_id (int) — reference to Sendai indicator;
- dimension (varchar) — e.g. axis of a graph;
- value (varchar) — value of damage type for a given assessment and dimension.

damage_assessment_value

Description: value assigned to the loss for a given phenomenon, damage assessment, damage type and item.

Fields:

- id (int) — unique identifier;
- damage_assessment_id (int) — reference to damage assessment;
- damage_type_value_1(2,3)_id (int) — damage type specific to damage assessment;
- phenomenon_id (int) — reference to phenomenon;
- item_id (int) — reference to asset_items;
- linked_item_id (int) — e.g. makes it possible to map people to a building;
- value (decimal);
- location_id (int) — reference to location, to store the location (extent) of the individual instance of damage.

damage_assessment_metadata

Description: complementary description of damage assessment publication.

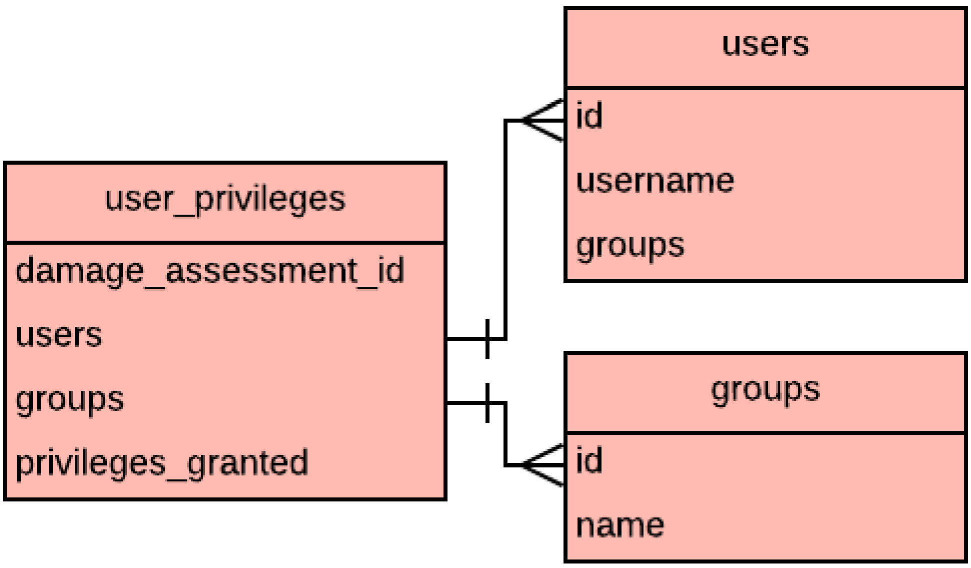
Fields:

- id (int) — unique identifier;
- damage_assessment_id (int) — reference to damage assessment;
- title (varchar);
- edition (varchar);
- abstract (varchar);
- purpose (varchar);
- keyword (varchar);
- url (varchar);
- reference_system_code (varchar);
- data_quality_statement (text);
- point_of_contact (int) — point of contact for the publication (reference_people);
- author (int) — author of publication (reference_people);
- topic_category — e.g. environmental, infrastructure, etc.

5.3.5. Entity authorisation

These entities ensure that the datasets are properly managed by their owners, which may allow other users to perform operations (view, create, edit or delete).

Figure 12. Authorisation



users

Description: users registered.

Fields:

- id (int) — unique identifier;
- username (varchar);
- groups (array) — list of groups the user belongs to.

groups

Description: groups of users for permission purposes.

Fields:

- id (int) — unique identifier;
- name (varchar) — name given (unique).

user_privileges

Description: privileges assigned to a group or single user to perform actions against a damage assessment (view, create, edit, delete).

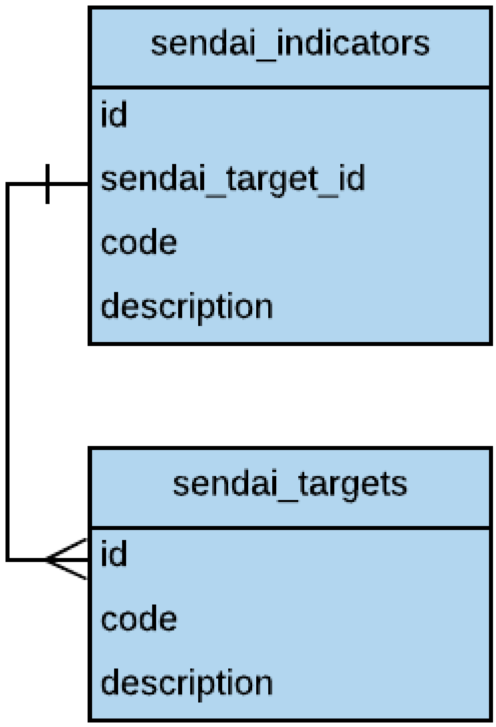
Fields:

- damage_assessment_id (int) — reference to damage assessment;
- users (array) — list of users for current entry;
- groups (array) — list of groups for current entry;
- privileges_granted (array) — list of privileges granted for current entry.

5.3.6. Additional information

This additional section collects entities that are not strictly relevant to the main functionalities of the application. These tables are used only to store a mapping between the assessments performed by the Risk Data Hub and the Sendai indicators, while outputs useful for Sendai reporting are generated, when the available data are consistent, using a logic implemented in the source code of the application.

Figure 13. Extra information – Sendai framework



sendai_targets

Description: Sendai target as defined by UNISDR specifications.

Fields:

- id (int) — unique identifier;
- code (varchar) — unique;
- description (varchar).

sendai_indicators

Description: Sendai indicator as defined by UNISDR specifications.

Fields:

- id (int) — unique identifier;
- sendai_target_id (int) — reference to target;
- code (varchar) — unique;
- description (varchar).

6. Conclusions

This report explains the multi-hazard database architecture and concludes with an update to the previous proposal of December 2017. The main aim of this proposed architecture is to be able to maintain the multi-hazard approach, and it has been modified over time in order to adjust to the specific needs that arose during the development of the Risk Data Hub, while ensuring that it fulfils its initial purpose.

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