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MSc Civil Engineering for Risk Mitigation

Sendai Framework indicators based database for loss accounting: conceptualization and application on the June 2013 floods of Vall d'Aran and Pyrenees case study

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To the Lord, the Almighty.

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Abstract

The world has lately seen an increase on efforts towards reducing disaster losses and damages as part of a global initiative on reducing disaster risk. However, factors such as population growth in hazard exposed areas, rapid urbanization, environmental degradation among others, have developed on an increased global risk. A review of the global efforts in the past decade towards reducing disaster losses and damages is done and compared against this decades' goals in the same field. This document focuses on the Sendai Framework for Disaster Risk Reduction's indicators to monitor the Global Targets and in their importance for the development of a global damage and loss database which could be used from a local level to collect, store and query the most relevant data to be of use and aggregated towards a global performance measure.

As an instrument to facilitate the calculation of the Sendai Framework indicators to monitor the Global Targets, a damage and loss database is conceptualized where the minimum requirements for the calculation of the indicators to monitor the global targets were considered. The June 2013 flood in the Vall d'Aran and the Pyrenees was chosen as the case study to measure the capability of the conceptualized database to calculate the Sendai Framework indicators and its spatial aggregation considerations. As a result, it was possible to identify different problems that the current damage and loss collection practices might present when calculating the indicators. Consequently, some recommendations are done towards addressing these problems.

Key words: Sendai Framework; indicators; damage data collection; damage database; loss accounting.

Abstract Italiano

Assistiamo oggi a un vero incremento negli sforzi per ridurre le perdite e i danni causati da disastri. Questi sforzi sono parte di un'iniziativa globale riguardante la riduzione del rischio. Ciononostante, diversi fattori come la crescita della popolazione in aree a rischio, la rapida urbanizzazione, il degrado ambientale, hanno portato a un rischio globale maggiore. Una revisione degli sforzi globali si è quindi verificata nell'ultima decada portando alla definizione di nuovi obiettivi per la riduzione dei rischi a livello locale, nazionale e globale. La presente tesi si concentra sull'accordo di Sendai per la riduzione del rischio da disastri per il periodo 2015-2030. In particolare, il presente lavoro si propone di analizzare i requisiti in termini di dati di danno a livello locale, da raccogliere, archiviare e interrogare per il calcolo degli indicatori definiti nel Sendai Framework for Disaster Risk Reduction.

In questo lavoro, è stato concettualizzato un database per l'organizzazione dei dati di danno e delle perdite umane, economiche e delle infrastrutture. L'alluvione de giugno 2013 in Vall d'Aran e Pirenei è stato scelto come caso di studio per misurare la capacità del database concettualizzato nel calcolo degli indicatori del Sendai Framework, incluse le considerazioni di aggregazione della scala spaziale. Come risultato, è stato possibile identificare diverse problematiche che le attuali pratiche di raccolta danni e perdite possono presentare per il calcolo degli indicatori predefiniti dal Framework. Finalmente, alcune raccomandazioni sono state sviluppate per affrontare queste problematiche.

Parole chiave: Sendai Framework; indicatori; raccolta dati danni; database; valutazione dei danni.

Introduction

The world has lately seen an increase on efforts towards reducing disaster losses and damages as part of a global initiative on reducing disaster risk. However, factors such as population growth in hazard exposed areas, rapid urbanization, environmental degradation among others, have developed on an increased global risk (CRED, EM-DAT, & UNISDR, 2016). Different strategies forming part of this effort agree on the need to improve and widen the collection practices to better understand how to reduce disaster losses and damages.

Loss and damage data constitute the principal outcome indicator for disaster risk reduction (DRR), they are also a key input for disaster risk and risk management research (UNDP, 2013). Damage and loss recording is a global key concern. This concern is evident in the existence of several damage recording related databases around the world.

Several loss and damage databases have been developed in the past years (UNDP, 2013), from 2005 to 2015 the number of nationally owned databases of disaster loss and damage increased from 12 to 85. In Europe alone, there are some databases which contain quantitative data for hazardous events of the last 60 years. Of these, the most important are EM-DAT implemented by Universite de Louvain, which offers limited on-line data access through different search options; NatCatSERVICE by Munich-Re considers other sectors like the industry and commercial sectors.

The European Community Joint Research Center has identified in a recent study by (De Groeve et al., 2013; 2014; 2015) at least three application areas for disaster loss and damage data as shown in Figure 1:

- **Disaster loss accounting**: the primary motivation for recording disaster loss with the aim to document the trends and aggregate statistics informing local, national and international disaster risk reduction programmes;
- **Disaster forensics**: which identifies the causes of the disaster through measuring relative contribution of exposure, vulnerability, coping capacity, mitigation and response to the disaster, with the aim to improve disaster management from lessons learnt; and

- **Risk modelling**: which aims to improve risk assessment and forecast methods, for which loss data are needed for calibrating and validating model results to infer vulnerabilities.

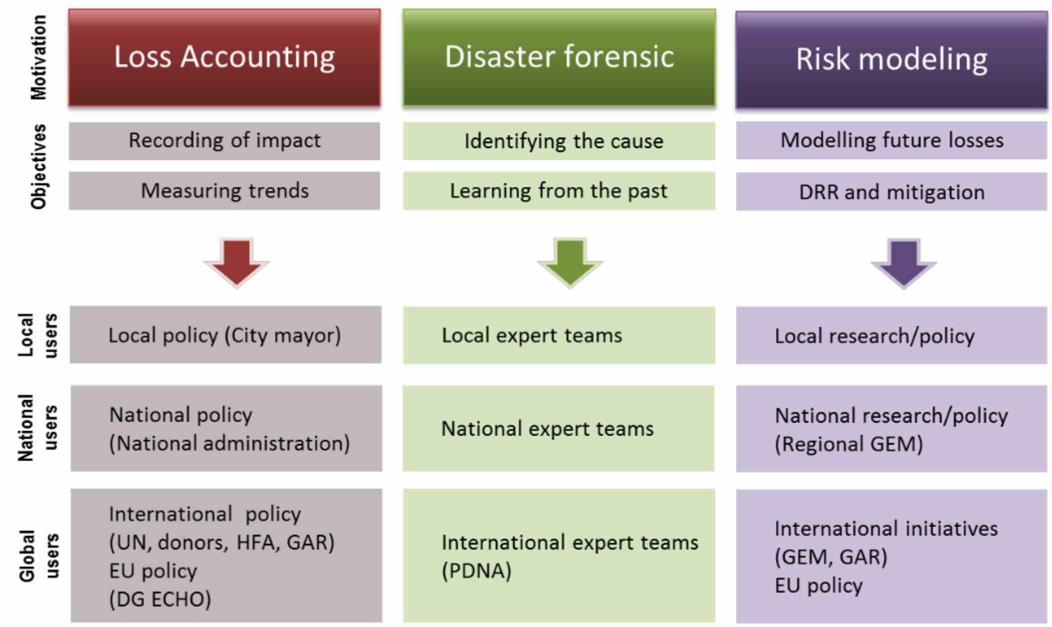

Figure 1 Conceptual model for application areas for loss data. Taken from (De Groeve et al., 2013).

Of the previously mentioned application areas, this document focuses in loss accounting as a mean to keep a systematic track of damage data to identify trends and more specifically to respond to the Sendai Framework for Disaster Risk Reduction. As shown in Figure 1, it also presents different scales from a local to a global one.

A comparative review of country-level and regional disaster loss and damage database done by (UNDP, 2013), describes some specific disaster and risk management applications for loss accounting:

1. Guiding relief, recovery and reconstruction programmes following disasters
2. Assessing risks for future disasters
3. Calibrating the cost-effectiveness of investments intended to reduce losses
4. Tracking loss patterns and trends
5. Performing thematic analysis
6. Tracking, monitoring and evaluating the outcome indicators on loss and damage

Loss accounting is the principal motivation for recording loss and damage data, as it can be used to document the trends of the losses, measure the performance of the different disaster risk reduction (DRR) policies or to support decision making through cost benefit analyses.

Chapter 1 pretends to give the reader a widened view on the importance of reducing disaster loss, and how the damage and loss data collection can help achieve this goal. On the first section, a review on the Hyogo Framework for Action is done, where its history and results are examined to later conclude on its usefulness. Afterwards, the Sendai Framework for Action is introduced in the second section of this chapter, where its targets and the stablished indicators to measure them are discussed. Finally, the IDEA project (Improving Damage assessments for Enhanced cost-benefit Analyses), which this document aims to support, is introduced.
A thorough analysis of the Sendai indicators to monitor the Global Targets, is done within Chapter 2 . The minimum data collection requirements for computing the Sendai indicators, are considered during the fragmented analysis carried on them. A discussion on the spatial aggregation of the indicators when considered from a local level is also maintained.

In Chapter 3 as an instrument to facilitate the calculation of the Sendai Framework for Action targets, a damage and loss database is conceptualized where the minimum requirements for the calculation of the indicators to monitor the global targets were considered. This database is based on advanced work by the Politecnico di Milano group working on the IDEA project. The conceptualized database with its entity relationship diagram and relational model is presented and discussed.

The case study is presented in Chapter 4 where a description of the event and the affected areas of the case study is realized. The chapter then proceeds to depict the practices on damage data collection in Spain at its different levels. Finally, considering the damage data collection practices and the collected data for the case study, the database is employed to analyze the level of fulfillment of the same, and how can this be seen from the Sendai Framework for Action's point of view.

Finally, the Chapter 5 will present the conclusions of this thesis through the presentation of the lessons learned from it. Moreover, it will give some recommendations for future development of this field, basically based on the identified challenges to be faced. It can be seen as the guiding path for future improvements on the national practices for damage data collection and recording while aiming towards a better global understanding of the disaster risk reduction.

Chapter 1

Global efforts to reduce disaster loss

This chapter pretends to give the reader a widened view on the importance of reducing disaster loss, and how the damage and loss data collection can help achieve this goal. On the first section, a review on the Hyogo Framework for Action is done, where its history and results are examined to later conclude on its usefulness. Afterwards, the Sendai Framework for Action is introduced in the second section of this chapter, where its targets and the stablished indicators to measure them are discussed. Finally, the IDEA project (Improving Damage assessments for Enhanced cost-benefit Analyses), which this document aims to support, is introduced.

1.1 The Hyogo Framework for Action (2005-2015)

Following the 2004 Indian Ocean earthquake and tsunami that was described as one of the "worst disasters" in recent history (Rodriguez, Wachtendorf, Kendra, & Trainor, 2006), and the disastrous effects of the Hurricane Katrina in 2005, a general lack of preparedness and planning towards disaster risk was displayed globally, causing that the last decade presented strong efforts on reducing disaster risk and disaster losses.

During the second UN Conference on Disaster Risk Reduction (UNCDRR) which took place in Kobe, Japan, from 18 to 22 January of 2005, the Hyogo Framework for Action (2005 – 2015): Building the Resilience of Nations and Communities to

Disasters was adopted by 168 UN member states and later that same year on the 22nd of December, it was endorsed by the UN General Assembly in the Resolution 60/195, International Strategy for Disaster Reduction.

The Hyogo Framework for Action (HFA) was based on a global concern on the number and scale of the natural disasters and their impact, recognizing the need to further develop and make use of scientific and technical knowledge to build resilience to natural disasters, emphasizing on the need to increase disaster risk reduction (UN General Assembly, 2005).

The expected outcome of the HFA was *"The substantial reduction of disaster losses, in lives and in the social and economic assets of com-munities and countries"* which the Global Assessment Report on Disaster Risk Reduction 2015 said was only partially achieved (United Nations, 2015).

The HFA introduced five priorities for action (UNISDR, 2005) from which the effectiveness of the framework was measured:

1. Ensure that disaster risk reduction is a national and a local priority with a strong institutional basis for implementation.
2. Identify, assess and monitor disaster risks and enhance early warning.
3. Use knowledge, innovation and education to build a culture of safety and resilience at all levels.
4. Reduce the underlying risk factors.
5. Strengthen disaster preparedness for effective response at all levels.

These priorities on action presented at the end of the decade different results on terms of losses, making it hard to declare the HFA either a success or a failure. Three mega-disasters[1] characterized the Hyogo decade: the Indian Ocean tsunami, Cyclone Nargis and the Haiti earthquake, challenging the possibility to analyze the global loss trend.

To illustrate this idea, take the storms. They represented almost a quarter of the global disaster based fatalities, presenting a severe increase against the previous decade (from nearly 65.000 to 174.000 fatalities). This abrupt change was characterized mainly by the Cyclone Nargis's devastating pass through Myanmar in 2008, but despite global population growth in hazard-exposed areas most countries presented a downward trend on storms related fatalities (CRED et al., 2016).

As depicted in the Poverty & Death: Disaster Mortality (1996-2015) by (CRED et al., 2016) other disaster subcategories which couldn't be simplified in a global trend are the heatwave deaths which, despite being the third most fatal disaster

[1] A mega-disaster is characterized by more than 100.000 fatalities, according to (CRED et al., 2016).

type in the last decade, presented a downward trend respect to the decade before. This was mainly for an important decrease in the heatwave deaths in Europe (minus Russia, where a sharp increase was shadowed by Europe's general decrease).

All in all, the HFA proved that reducing disaster risk is a cost-effective investment in preventing future losses. Even though it worked by raising public and institutional awareness on disaster loss reduction, people and assets exposure has increased faster than the decrease of vulnerability, displaying a worrying global situation. This lead to the creation of a new framework, the Sendai Framework for Action (2015-2030) that is immediately discussed.

1.2 The Sendai Framework for Action (2015-2030)

During the third UN Conference on Disaster Risk Reduction (UNCDRR) which took place in Sendai City, Miyagi Prefecture, Japan, from 14 to 18 March of 2015 the Sendai Framework for Disaster Risk Reduction 2015 – 2030 was adopted by 187 UN member states and later that same year on the 3rd of June it was endorsed by the UN General Assembly (UN General Assembly, 2015a).

As it was mentioned before, the Sendai Framework for Action (SFA) was introduced as a continuation of the work that was made during the las decade by the HFA where, despite the efforts, heavy death toll occurred (around 770.000) and approximately 1.5 billion people were affected by disaster occurrences. The urgency to lessen human and material exposure, vulnerability and consequently loss is important.

Disaster Loss is specially mentioned in the official expected outcome of the SFA, which the UN Office for Disaster Risk Reduction has stated is: "*The substantial reduction of disaster risk and losses in lives, livelihoods and health and in the economic, physical, social, cultural and environmental assets of persons, businesses, communities and countries*".

Data on loss and damage is considered in the framework as an important mean to achieve the first "priority for action", Understanding Disaster Risk. Through this priority, the framework calls for the collection of disaster loss data in different scales and levels (local, national, regional) in the context of event-specific hazard, exposure and vulnerability (UNISDR, 2015c).

The United Nations Office for Risk Reduction has set a strong emphasis on risk management instead of disaster management, on which the HFA was mainly emphasized. Furthermore, it aims towards multi-level and multi-sector management of disaster risk from every considerable hazard type.

Based on the experiences acquired during the HFA period, this Framework has set four specific priorities for action (UNISDR, 2015c):

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.*

Seven different global targets for reducing disaster risk were also determined in the SFA with the purpose of supporting the assessment of the global progress in achieving the goal of the same (UNISDR, 2015c). The seven global targets which will be measured globally are:

a) *Substantially reduce global disaster mortality by 2030, aiming to lower the average per 100,000 global mortality rate in the decade 2020–2030 compared to the period 2005–2015;*
b) *Substantially reduce the number of affected people globally by 2030, aiming to lower the average global figure per 100,000 in the decade 2020–2030 compared to the period 2005–2015;*
c) *Reduce direct disaster economic loss in relation to global gross domestic product (GDP) by 2030;*
d) *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;*
e) *Substantially increase the number of countries with national and local disaster risk reduction strategies by 2020;*
f) *Substantially enhance international cooperation to developing countries through adequate and sustainable support to complement their national actions for implementation of the present Framework by 2030;*
g) *Substantially increase the availability of and access to multi-hazard early warning systems and disaster risk information and assessments to people by 2030.*

These targets invite to a global enhancement on the data collection procedures to facilitate their measurements. As described in the previous chapter, the UN Office for Disaster Risk Reduction pretends to achieve by 2020 the implementation of a national loss database on every member state. This would ease works on global disaster damage and disaster loss trend analyses.

Therefore, beyond the seven global targets, the Open Ended Intergovernmental Working Group (OEIWG) on indicators and terminology relating to disaster risk reduction established by the UN General Assembly was tasked with the creation of indicators that would allow an easier following-up of the targets progress and the global implementation of the SFA. The following sub-chapter goes into further detail on the indicators to monitor the global targets of the SFA.

1.2.1 Indicators to monitor Global Targets

Monitoring and review of the progress and implementation of the Sendai Framework for Action is key for its proper use, therefore the OEIWG on indicators and terminology relating to disaster risk reduction established by the UN General Assembly, had the task to create indicators to report on progress at a regional, national and local level. These indicators are crucial towards achieving the expected outcome of SFA and its global targets.

The OEIWG has had two formal sessions (as of this document) where the indicators to monitor global targets were conceived and have been discussed by an expert group as well as member states. Disaster risk terminology for the UN was also updated and can be found in the document "Terminology related to Disaster Risk Reduction. Updated Technical non-paper" by (UNISDR, 2016b).

From these targets, the first four are directly related with damage and losses incurring in the direct urge of reducing people losses, direct economic losses and damage losses, which aim more directly toward the aim of the present research.

The indicators on which this document is developed, as on the 30th of September 2016 are the most updated as of this document (UNISDR, 2016c), slightly differing from the indicators set in the second formal session of the working group from 10th to 11th February of 2016. Based on the wider relevance of the first four global targets for this document, only their respective indicators are shown in the Table 1:

Table 1 Indicators to Monitor Global Targets of SFA, as of 30th September 2016 (UNISDR, 2016c)

Target A: Substantially reduce global disaster mortality by 2030, aiming to lower average per 100,000 global mortality between 2020-2030 compared to 2005-2015	
A-1	Number of deaths/deceased and missing/presumed dead due to hazardous events per 100,000.
A-2	Number of deaths/deceased due to hazardous events.
A-3	Number of missing/presumed dead due to hazardous events.
Target B: Substantially reduce the number of affected people globally by 2030, aiming to lower the average global figure per 100,000 between 2020-2030 compared to 2005-2015	
B-1	Number of affected people [by hazardous event] per 100,000.
B-2	Number of injured or ill people due to hazardous events.
B-3a	Number of evacuated people due to hazardous events.
B-3b	Number of relocated people due to hazardous events.
B-4	Number of people whose houses were damaged due to hazardous events.
B-5	Number of people whose houses were destroyed due to hazardous events.
B-6	Number of people who received aid including food and non-food aid due to hazardous events.
B-7	Number of people whose livelihoods were disrupted, destroyed or lost due to hazardous events.
Target C: Reduce direct disaster economic loss in relation to global gross domestic product (GDP) by 2030	
C-1	Direct economic loss due to hazardous events in relation to global gross domestic product.
C-2	Direct agricultural loss due to hazardous events.
C-3	Direct economic loss due to industrial facilities damaged or destroyed by hazardous events.
C-4	Direct economic loss due to commercial facilities damaged or destroyed by hazardous events.
C-5	Direct economic loss due to houses damaged by hazardous events.
C-5b	Damage and loss of administrative buildings.
C-6	Direct economic loss due to houses destroyed by hazardous events.
C-7	Direct economic loss due to damage to critical infrastructure/public infrastructure caused by hazardous events.
C-8	Direct economic loss due to cultural heritage damaged or destroyed by hazardous events.
C-9	Direct economic loss due to environment degraded by hazardous events.
C-10	Total insured direct losses due to hazardous event.

Target D: 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	
D-1	Damage to critical infrastructure due to hazardous events.
D-2	Number of health facilities destroyed or damaged by hazardous events.
D-3	Number of educational facilities destroyed or damaged by hazardous events.
D-4	Number of transportation infrastructures destroyed or damaged by hazardous events.
D-4b	Kilometers of road destroyed or damaged per hazardous event.
D-4c	Number of bridges destroyed/damaged by hazardous event.
D-4d	Kilometers of railway destroyed / damaged by hazardous event.
D-4k	Number of airports destroyed / damaged by hazardous event.
D-4l	Number of ports destroyed / damaged by hazardous event.
D-1 bis	Number of electricity plants / transmission lines destroyed or damaged by hazardous events.
D-5	Number of times basic services have been disrupted due to hazardous events.

As it can be seen in the table above, Target A focuses mainly in population's mortality by events and so do its indicators. Target B focuses people affected by a disaster. On the other hand, Target C aims to calculate the direct disaster economic losses. Finally, Target D pretends to account disaster damage to critical infrastructure and disruption of services.

Accordingly, the Sustainable Development Goals from the 2030 Agenda for Sustainable Development, which was endorsed and adopted by the UN General Assembly on the 25th September 2015 (UN General Assembly, 2015b), has been a key player on the creation and update of the indicators through each official and unofficial session. It is a strong bond that exists between the indicators and some of the Sustainable Development Goals (SDG). The related SDGs to the indicators are shown in the following table.

Table 2 Related SDGs to the indicators to monitor global targets of SFA. Adapted from (UNISDR, 2015a, 2015b)

Goal and Target addressed	
Goal 1	**End poverty in all its forms everywhere**
1.3	Implement nationally appropriate social protection systems and measures for all, including floors, and by 2030 achieve substantial coverage of the poor and the vulnerable.
1.4	By 2030, ensure that all men and women, the poor and the vulnerable, have equal rights to economic resources, as well as access to basic services, ownership and

	control over land and other forms of property, inheritance, natural resources, appropriate new technology and financial services, including microfinance.
1.5	By 2030, build the resilience of the poor and those in vulnerable situations and reduce their exposure and vulnerability to climate-related extreme events and other economic, social and environmental shocks and disasters.
Goal 2	**End hunger, achieve food security and improved nutrition and promote sustainable agriculture**
2.1	By 2030, end hunger and ensure access by all people, in particular the poor and people in vulnerable situations, including infants, to safe, nutritious and sufficient food all year round.
2.2	By 2030, end all forms of malnutrition, including achieving, by 2025, the internationally agreed targets on stunting and wasting in children under 5 years of age, and address the nutritional needs of adolescent girls, pregnant and lactating women and older persons.
2.3	By 2030, double the agricultural productivity and incomes of small-scale food producers, women, indigenous peoples, family farmers, pastoralists and fishers, including through secure and equal access to land, other productive resources and inputs, knowledge, financial services, markets and opportunities for value addition and non-farm employment.
2.4	By 2030, ensure sustainable food production systems and implement resilient agricultural practices that increase productivity and production, that help maintain ecosystems, that strengthen capacity for adaptation to climate change, extreme weather, drought, flooding and other disasters and that progressively improve land and soil quality.
Goal 3	**Ensure healthy lives and promote well-being for all at all ages**
3.6	By 2020, halve the number of global deaths and injuries from road traffic accidents.
3.8	Achieve universal health coverage, including financial risk protection, access to quality essential health-care services and access to safe, effective, quality and affordable essential medicines and vaccines for all.
3.9	By 2030, substantially reduce the number of deaths and illnesses from hazardous chemicals and air, water and soil pollution and contamination.
3.c	Substantially increase health financing and the recruitment, development, training and retention of the health workforce in developing countries, especially in least developed countries and small island developing States.
3.d	Strengthen the capacity of all countries, developing countries, for early warning, risk reduction and management of national and global health risks.
Goal 4	**Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all**
4.a	Build and upgrade education facilities that are child, disability and gender sensitive and provide safe, non-violent, inclusive and effective learning environments for all.
Goal 9	**Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation**
9.1	Develop quality, reliable, sustainable and resilient infrastructure, including regional and transborder infrastructure, to support economic development and human well-being, with a focus on affordable and equitable access for all.
9.4	By 2030, upgrade infrastructure and retrofit industries to make them sustainable, with increased resource-use efficiency and greater adoption of clean and

	environmentally sound technologies and industrial processes, with all countries acting in accordance with their respective capabilities.
Goal 11	**Make cities and human settlements inclusive, safe, resilient and sustainable**
11.2	By 2030, ensure access for all to adequate, safe and affordable housing and basic services and upgrade slums.
11.5	By 2030, significantly reduce the number of deaths and the number of people affected and substantially decrease the direct economic losses relative to global gross domestic product caused by disasters, including water-related disasters, with a focus on protecting the poor and people in vulnerable situations.
11.c	Support least developed countries, including through financial and technical assistance, in building sustainable and resilient buildings utilizing local materials.
Goal 13	**Take urgent action to combat climate change and its impacts**[2]
13.1	Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries.
13.2	Integrate climate change measures into national policies, strategies and planning.
13.b	Promote mechanisms for raising capacity for effective climate change-related planning and management in least developed countries and small island developing States, including focusing on women, youth and local and marginalized communities.
Goal 14	**Conserve and sustainably use the oceans, seas and marine resources for sustainable development**
14.2	By 2020, sustainably manage and protect marine and coastal ecosystems to avoid significant adverse impacts, including by strengthening their resilience, and act for their restoration to achieve healthy and productive oceans.
Goal 15	**Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss**
15.3	By 2030, combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods, and strive to achieve a land degradation-neutral world.

The previous table specifically shows every SDG that have been related with the indicators described on Table 1. This represents a positive correlation between the two UN programs, allowing both accords to lead towards a decrease on disaster damages and losses.

These indicators have been source of tremendous discussion among different stakeholders, primarily because the minimum requirements stablished to calculate the indicators, hence the overall global progress through them, imply a challenge for governments at local, national and regional levels.

[2] Acknowledging that the United Nations Framework Convention on Climate Change is the primary international, intergovernmental forum for negotiating the global response to climate change.

For this matter, the European Commission Directorate-General for European Civil Protection and Humanitarian Aid Operations (ECHO) has funded the IDEA project, which attempts to respond to the very limited reliability of data currently used to support cost benefit analysis in the field of natural hazards mitigation.

1.3 The IDEA Project

The ongoing IDEA project (Improving Damage assessment enhancing cost-benefit Analyses) funded by DG-ECHO, G.A.N. ECHO/SUB/2014/694469), is aimed at improving current practices in data collection, storing, and use to support enhanced and more reliable cost benefit analyses (ECHO, 2014).

According to (ECHO, 2014), the four main objectives of the IDEA project are:

1. Support more effective mitigation measures in the aftermath of a disaster, by analyzing damage data according to a forensic perspective. Knowing how different components of risk (hazard, exposure, vulnerability) contributed to the final damage, is crucial for developing guidance for the most effective recovery and reconstruction investments, in order to reduce the risk for the future;
2. Show how better data may better inform pre-event risk modelling, so as to develop more reliable cost benefit analysis of measures that are taken today to prevent a future disaster. Improved and new data incur greater costs of collection that need to be balanced by the added value they provide to the assessments;
3. Focus on damage to critical infrastructures and economic activities as key to identify the impact of a disaster on the economy of the affected region.
4. Develop tools that will enable public administrations to manage damage and losses data for multiple purposes: compensation within the financial arrangements existing in each country, forensic investigation to guide recovery toward effective investments, better risk assessments for future events, to feed more reliable cost benefit analyses of mitigation measures. The improvement of both damage data quality and procedures to collect and manage them is of paramount importance in view of more frequent disasters provoked by meteo-related events as a consequence of climate change.

Based on the different practices and procedures that the involved stakeholders carry on their respective civil protection authorities, the IDEA project pretends to consider the different needs for which the damage and loss data is collected and used. As said before, the IDEA project is funded by the European Commission Directorate-General for European Civil Protection and Humanitarian Aid Operations (ECHO). The partners of the IDEA consortium are:

- Politecnico di Milano – *Leading Partner*
- Umbria Region Civil Protection
- Oxford Brookes University
- Agencia Estatal Consejo Superior de Investigaciones Científicas (CSIC)
- Catalunya Regional Civil Protection

One of the study cases that the IDEA project uses to test its results is the severe floods of June 2013 in Vall d'Aran and the Pyrenees, for which this study will be tested later in the 4th Chapter of the present document.

Chapter 2

SFA based indicators

The Sendai indicators to monitor the Global Targets presented in Table 1, are further analyzed in this chapter. The minimum data collection requirements for computing the indicators, established by (UNISDR, 2016c), are considered during the fragmented analysis carried on the indicators. A discussion on the spatial aggregation of the indicators when considered from a local level is maintained.

2.1 SFA indicators categorization

Being damage and losses at the center of this document, only the first four global targets from the SFA (A to D) are considered. The first two targets (A and B) are mainly targeting people related indicators, mortality and level of affectation are its key points. Target C is focused on the direct disaster economic loss accounting. Finally, target D centered on disaster damage to infrastructure. A more thorough analysis is elaborated in this sub-chapter.

Disaster mortality has seen important decline in some countries and regions over the last decade. Nevertheless, as reported by (CRED et al., 2016) there is still a great deal of work to overcome the correlation that disaster mortality and income present. Therefore, some specific minimum requirements are set in order to calculate the indicators that measure Target A *(Substantially reduce global disaster mortality by 2030, aiming to lower average per 100,000 global mortality between 2020-2030 compared to 2005-2015)*.

Table 3 presents the minimum data collection requirements coming from the updated technical non-paper on the indicators to monitor global targets by (UNISDR, 2016c).

Table 3 Minimum data collection requirements for indicators to monitor Target A of the SFA

Target A: Substantially reduce global disaster mortality by 2030, aiming to lower average per 100,000 global mortality between 2020-2030 compared to 2005-2015		
A1	**A2**	**A3**
Number of deaths/deceased and missing/presumed dead due to hazardous events per 100,000.	Number of deaths/deceased due to hazardous events.	Number of missing/presumed dead due to hazardous events.
Minimum requirements		
Poverty level	Poverty level	Poverty level
Sex	Sex	Sex
Age	Age	Age
Disability	Disability	Disability
Geographic location	Geographic location	Geographic location

These minimum requirements are considered as a disaggregation which has some stablished possible values to be considered.

- Poverty level is determined based on the international poverty line established by the World Bank on $1.90 US dollars[3], thus characterizing the attribute as above or below the poverty line.
- Sex is disaggregated onto female or male.
- Age is categorized in three
    - Children, from 0 to 14 years old;
    - Adults, from 14 to 64 years old;
    - Older people, more than 64 years old.
- Disability is categorized in with or without disabilities.
- Geographic location is reduced to a municipality level.

[3] The World Bank defines the international poverty line as an international monetary threshold which sets that people below it, are considered to be in poverty. As of October 2015, it is set on $1.90 US dollars.

Clearly, indicator A1 strongly depends on the indicators A2 and A3, which is why the UN Office for Disaster Risk Reduction has stablished (UNISDR, 2016a) for its calculation the equation (1).

$$A_1 = \frac{A_2 + A_3}{Population} * 100.000 \quad (1)$$

Indicators A2 and A3 are calculated by the direct count of either dead people or missing people respectively, for the analyzed event. This data can be easily aggregated towards a national and global level by just summing the numbers on each indicator from every local and regional source, avoiding double count.

Considering the population growth, the number of affected people has had an upward tendency in the Hyogo decade, especially in low and middle-income countries (CRED et al., 2016), the SFA introduced through the Target B, the goal to reduce the number of affected people globally. This target is measured from the indicators that the OEIWG has set. Table 4 presents the minimum requirements coming from the updated technical non-paper on the indicators to monitor global targets by (UNISDR, 2016c).

Table 4 Minimum data collection requirements for indicators to monitor Target B of the SFA

Target B: Substantially reduce the number of affected people globally by 2030, aiming to lower the average global figure per 100,000 between 2020-2030 compared to 2005-2015							
B1	**B2**	**B3a**	**B3b**	**B4**	**B5**	**B6**	**B7**
Number of affected people [by hazardous event] per 100,000.	Number of injured or ill people due to hazardous events.	Number of evacuated people due to hazardous events.	Number of relocated people due to hazardous events.	Number of people whose houses were damaged due to hazardous events.	Number of people whose houses were destroyed due to hazardous events.	Number of people who received aid including food and non-food aid due to hazardous events.	Number of people whose livelihoods were disrupted, destroyed or lost due to hazardous events.
Minimum requirements							
Poverty level	Poverty level	Poverty level	Poverty level	Poverty level	Poverty level	Poverty level	Poverty level
Sex	Sex	Sex	Sex	Sex	Sex	Sex	Sex
Age	Age	Age	Age	Age	Age	Age	Age
Disability	Disability	Disability	Disability	Disability	Disability	Disability	Disability
Geographic location	Geographic location	Geographic location	Geographic location	Geographic location	Geographic location	Geographic location	Geographic location

Target B presents the same minimum requirements as Target A. This is because both targets are mainly focused on people, either mortality of level of affectation. The minimum requirements will allow the establishment of more precise national, local and global trends considering the disaggregation made with the five different attributes on both targets, giving a boost on studies of vulnerable population facing a disaster.

Some of the indicators of this target present difficulties, for instance there might arise trouble when counting the homeless people as they don't classify neither as evacuated nor relocated for indicator B3. This is a warning signal for governments to eradicate this social problem by means of social policies and other type of help. Another indicator that may generate inconvenience is the indicator B6, where the food and medical aid is difficult to count for it might be coming from different ONGs, privates and public entities.

As well as on indicator A1, the indicator B1 consists on summation of the values of the others indicators (except indicator B7) as described in (2).

$$B_1 = \frac{Sum(B_2 \dots B_6)}{Population} * 100.000 \tag{2}$$

Additionally, it is important to highlight that indicators B4 and B5 are calculated based on another indicator, Average number of Occupants per House of each country (AOH), using the equations (3) and (4). Hence, this indicator starts out from an indicator which might be too aggregated for the affected area of a disaster.

$$B_4 = \#\ of\ houses\ damaged * AOH \tag{3}$$

$$B_5 = \#\ of\ houses\ destroyed * AOH \tag{4}$$

As the indicators B4 and B5 remark, a disaster losses and damages are not only human, they also bear an economic load that must be accounted for. Thus, the importance of Target C: *Reduce direct disaster economic loss in relation to global gross domestic product (GDP) by 2030.* The minimum requirements for this target are presented on the following

Table 5.

Table 5 Minimum data collection requirements for indicators to monitor Target C of the SFA

Target C: Reduce direct disaster economic loss in relation to global gross domestic product (GDP) by 2030										
C1	**C2**	**C3**	**C4**	**C5**	**C5b**	**C6**	**C7**	**C8**	**C9**	**C10**
Direct economic loss due to hazardous events in relation to global gross domestic product.	Direct agricultural loss due to hazardous events.	Direct economic loss due to industrial facilities damaged or destroyed by hazardous events.	Direct economic loss due to commercial facilities damaged or destroyed by hazardous events.	Direct economic loss due to houses damaged by hazardous events.	Damage and loss of administrative buildings.	Direct economic loss due to houses destroyed by hazardous events.	Direct economic loss due to damage to critical infrastructure/public infrastructure caused by hazardous events.	Direct economic loss due to cultural heritage damaged or destroyed by hazardous events.	Direct economic loss due to environment degraded by hazardous events.	Total insured direct losses due to hazardous event.
Minimum requirements										
	Type of crop	No. of industrial facilities damaged or destroyed	No. of commercial facilities damaged or destroyed	No. of houses damaged	No. of administrative buildings affected	No. of houses destroyed		No. of buildings, monuments and fixed infrastructures of cultural heritage assets	Hectares of Forest affected	
	No. of Ha of type of crop affected	Level of affectation	Level of affectation	Size of facility	Level of affectation	Size of facility		> Cost of rehabilitation or reconstruction	Level of affectation	
	Type of livestock	Size of facility	Size of facility		Size of facility			No. of mobile cultural heritage assets (such as artworks) damaged		
	No. of type of livestock lost							> Cost of rehabilitation or reconstruction		
								No. of mobile cultural heritage assets (such as artworks) destroyed		
								> Market value		

Despite of being simple and clear, the indicators from Target C present a variety of difficulties on the minimum requirements of data collection and on the calculation of the indicator. This perks are therefore, developed and explained.

Indicator C1, as well as indicators A1 and B1, is a compound indicator consisting on the summation of most of the indicators of the target, basically resulting in the main indicators to measure directly the progress on the achievement of the global targets. Indicator C1 is calculated by means of the equation (5).

$$C_1 = \frac{Sum(C_2 \ldots C_9)}{GDP} \tag{5}$$

Where the Gross Domestic Product (GDP) used, comes from the World Bank indicators. The OEIWG on indicators and terminology relating to disaster risk reduction established by the UN General Assembly stablished that for the calculation of the global targets the global GDP must be used, excluding any comments on disaggregation of this indicator. Under this circumstances it is suggested to use the most spatially disaggregated GDP that agrees with the spatial reach of the disaster event database.

Indicators C2 to C9 are calculated similarly by using the general equation (6) for direct economic loss.

$$\text{Direct economic loss} = (\text{a}) * (\text{b}) * (\text{c}) \tag{6}$$

Where,

- (a) number of physical assets affected (e.g. number of facilities damaged);
- (b) size of the physical assets;
- (c) unit cost (e.g. per square meter, per kilometer, per hectare)

The minimum data requirements for the calculation of the indicators to monitor global target C, presents some minimum requirements for which there is already a set of possible values to evaluate with.

- Level of affectation is disaggregated into damaged or destroyed.
- Size of facility is disaggregated into small, medium and large; this is evaluated based on stablished national ranges. This requirement might be difficult to evaluate depending on each country's data collection policies and possibilities.

Worth mentioning is the lack of requirements that appears in Table 5 on indicators C7 and C10. The indicator C7, relies on data from target D to be calculated, which is why that indicator does not consider a minimum requirement of data collection for its calculation, that is the summation of the economic loss calculated on indicators D2 to D4, considering only D4b which is acknowledges only roads.

Indicator C10 is not calculated by the governmental entities normally, only when good data on insurance market penetration indexes is available; instead it could be reported by insurance and reinsurance companies. Although this indicator presents a certain difficulty level of calculation, it can facilitate the analysis on the proportion of uninsured to insured economic losses due to hazardous events (UNISDR, 2016a).

So far, the first three targets have considered human and economic losses, leaving now Target D with damage, as it proposes to "*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".* The Table 6 presents the minimum data collection requirements to properly calculate indicators to monitor global target D.

Indicator D1, as well as the previous targets first indicators, is the direct responsible for the measurement of the progress of the target since it requires data from the other indicators in the target to be computed. The difference here relies in the vast variety and difference among the indicators on this target, thus making indicator D1 an economic indicator representing the damage to infrastructure. Therefore, the computation of indicator D1 is done with the Direct Economic Loss (DEL) on equation , applied to all the other indicators and summed for the computation of indicator D1, as shown in equation (7).

$$D_1 = \mathrm{Sum}(D_{2_{DEL}} \ldots D_{5_{DEL}}) \qquad (7)$$

Some of the indicators on this target like sub-indicators D4d, D4k and D4l, affront the challenge of stablishing a baseline, since there is not previously recorded damage and loss data on railways, ports and airports in most national databases.

The UN Office for Disaster Risk Reduction recommends for indicator D5 to consider under basic services the following (UNISDR, 2016a):

- Healthcare services
- Education services
- Transport sector
- Solid waste management
- Water supply
- Sewage system
- Power/energy system
- Emergency response
- ICT

Table 6 Minimum data collection requirements for indicators to monitor Target D of the SFA.

Target D: 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										
D1	**D2**	**D3**	**D4**	**D4b**	**D4c**	**D4d**	**D4k**	**D4l**	**D1bis**	**D5**
Damage to critical infrastructure due to hazardous events.	Number of health facilities destroyed or damaged by hazardous events.	Number of educational facilities destroyed or damaged by hazardous events.	Number of transportation infrastructures destroyed or damaged by hazardous events.	Kilometers of road destroyed or damaged per hazardous event.	Number of bridges destroyed/ damaged by hazardous event.	Kilometres of railway destroyed / damaged by hazardous event.	Number of airports destroyed / damaged by hazardous event.	Number of ports destroyed / damaged by hazardous event.	Number of electricity plants / transmission lines destroyed or damaged by hazardous events.	Number of times basic services have been disrupted due to hazardous events.
Minimum requirements										
	Level of affectation	Level of affectation	Level of affectation	Level of affectation	Level of affectation	Level of affectation	Level of affectation	Level of affectation	Level of affectation	Basic services
	Size of facility	Size of facility	Transportation mode	Type of road						

As it was aforesaid, the indicators to monitor the SFA global targets have been the center of an important discussion among UN Member States which has, so far, taken place in two formal meetings. The importance of the indicators lies on the possibility to compare information on disaster risk reduction based on the data with which their respective indicators were calculated.

Consequently, the indicators try to reach disaster from local or municipal spatial scale to then be aggregated towards a national level, this with the sole purpose of measuring the achievement of the global targets.

Just like disaster risk, damage and losses are most detailed at a smaller spatial scale, and as it is aggregated towards a larger scale details are lost (Cardona & Carreño, 2011). The desire to aggregate the indicators to a national level relies mostly in the difference of the decision-making at each level and the need to measure the accomplishment of the global targets.

Therefore, to question the aggregability of the SFA indicators to monitor the global targets is compulsory.

It is important to highlight some of the differences that the necessary data to calculate the indicators have with the data currently being collected in some databases. This will present a challenge when the indicators are calculated and compared, which is why it is called upon for revision.

- Most of the national databases consider all events, no matter their scale, but despite of this, there are some national and international databases that present certain requirements to input a disaster event.
- Most of the databases neglect disasters produced by a non-natural hazard, generating a void for this data.
- There is not an established global procedure on the time scale of recording data. Some disasters occur within an hour or less, but some others can last for months or even years (i.e. an earthquake and a drought respectively).
- Counting of fatalities must also have an established procedure on its time scale recording.

For the correct aggregation of the indicators, a normalization based on population is required to properly compare them with another spatial unit (local, regional, national or international) or another event.

Chapter 3

Damage and loss recording database conceptualization

The purpose of collecting disaster damage and loss data is to improve policies and future actions, as it was said before, for this purpose a damage and loss database is conceptualized. A database is an organized collection of related data which facilitates the selection of desired pieces of data, generally through a computer program. As an instrument to facilitate the calculation of the SFA targets, a damage and loss database is conceptualized where the minimum requirements for the calculation of the indicators to monitor the global targets were considered. This databased is based on advanced work by the Politecnico di Milano group working on the IDEA project. The following sup-chapters present the conceptualized database with its entity relationship diagram and relational model.

Even though one of the aims of the disaggregation made for the SFA indicators is to analyze global trends for the previously mentioned minimum requirements, there will not necessarily be enough data for the disaggregation, as it is specified in Colombia's National Plan for Disaster Risk Reduction 2015 – 2025 (UNGRD, 2016) that, despite of being based on the SFA chooses to ignore the minimum requirements. On the other hand, it does contemplate the calculation of the indicators through loss accounting, as it is the case for most databases.

It is important to mention that the data that can calculate the SFA indicators but without the required disaggregation, generally comes from high scale damage assessments (DA). A high scale damage assessment (HSDA) can be compared to a preliminary DA that does not goes too deep into damage detail. By high scale it refers to a wider understanding of the extent and distribution of the damage and how the population was affected.

The fact that an HSDA exists, does not imply that no further assessments may be done, instead it could be said that it first provides a DA in the emergency time scale, than the usual DAs, giving a broadened view of the impact of the disaster before a detailed assessment is done. In Figure 2 a clear representation of the HSDA and the detailed DA is shown in the emergency time scale.

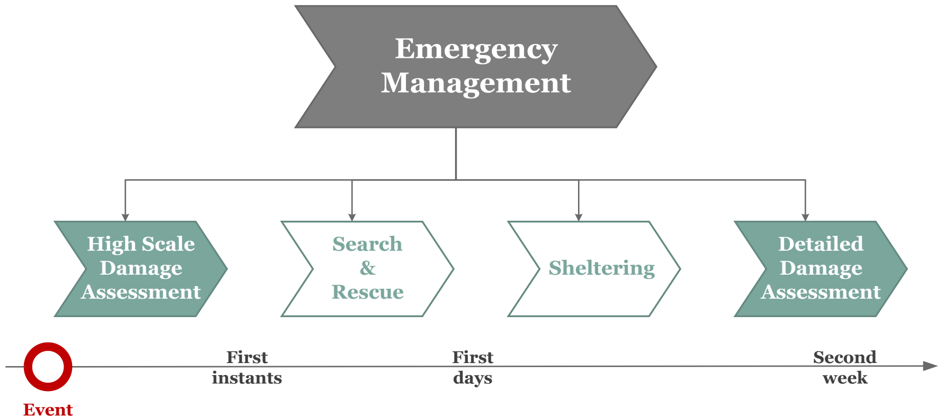

Figure 2 Emergency management time scale

Therefore, the HSDA must be part of the database presented in this chapter. For this, the concept of spatial scale and its importance for a consistent collection of HSDA are introduced in the following subchapter.

3.1 Entity-Relationship Diagram

An Entity Relationship Diagram (ERD) is a graphical representation used for the conceptual design of database applications. The basic object that the ERD represents is an entity, each entity has attributes, which are generally represented as rectangles and ellipses respectively; the relationships between the entities are represented with diamonds, based on Chen's notation.

A general overview of the conceptualized ERD is presented in Figure 3, where the main entity is the Event. The proposed database starts from the event because disaster damage and loss data are collected worldwide by event, facilitating future comparisons among events. The entity Event is linked with four main general relationships. The first one is the event produced a high level damage assessment; second, the event caused direct physical damage; third, the event provokes outages and the last one corresponds to the event affecting people. These relationships are based on the expected damages and losses from the hazardous event as depicted in the first four global targets of the SFA.

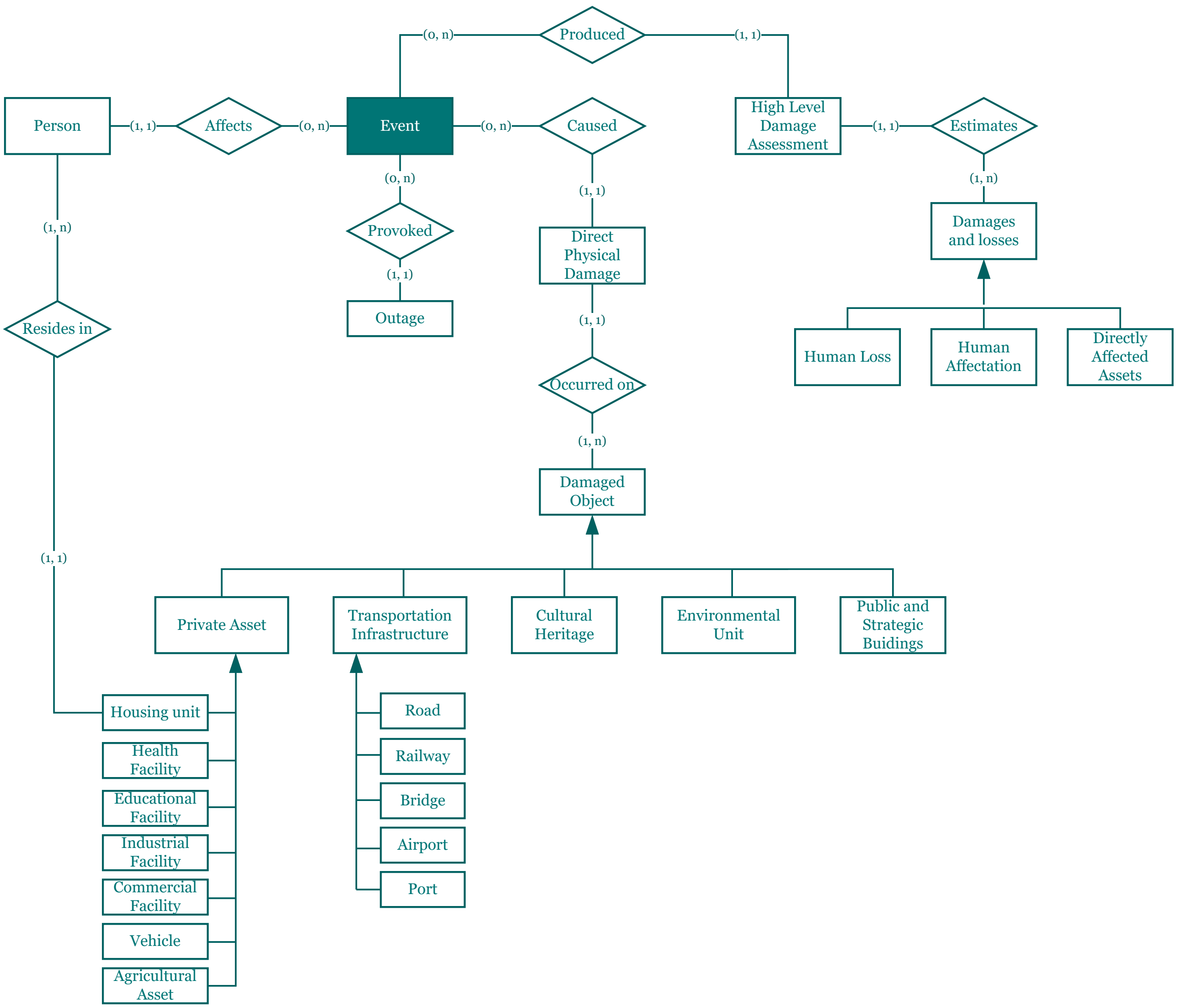

Figure 3 General ERD of the database

A deeper analysis of all the entities represented in the ERD on Figure 3 is presented next, where the relation between the entities and the indicators to monitor the SFA global targets is stablished, and the attributes representing some properties of interest that further describe the entities are described as well.

Relationships among two entities have cardinality ratios which specify the maximum number of relationship instances that an entity can participate in

(Elmasri & Navathe, 2010); i.e. a cardinality ratio (0, 1) means that if there is any relationship, it is optional and allows maximum one.

The ERD shows that the first and second relationships have a “Master-Slave” relation, being the entity Event the master, and the correspondent Direct Physical Damage or High-level Damage Assessment, the slave. This is based on the cardinality of the relationship where, for the first case, from the Event entity the cardinality is (0, n), meaning that the event might either cause no direct physical damage at all or many[4]. From the other side of the relationship the cardinality indicates (1, 1) meaning that direct physical damage is strictly related to one and only one event. This type of relationship generates especial connection between the two involved relationships, that will be further in this subchapter.

The attributes of the **Event** entity are shown in Figure 4. This entity is set to record the characteristics of the hazardous event, which will aid during comparison of the accounted data. Next, a description of each attribute is developed.

- **Event_ID**: This is the key attribute. It is automatically generated by the database management system in consistence with the order in which different events are inserted.
- **Type:** Describes the type of hazardous event[5] that is going to be recorded.
- **Severity:** Defines the severity of the hazardous event, per its type.
- **Coordinates:** Inputs the coordinates where the event took place.
- **Start_Date:** Inputs the date when the hazardous event started.
- **Finish_Date:** Inputs the hazardous event finalizes.
- **Country:** Inputs the country which the event took place, and for which the loss accounting in the database is being done.
- **Region:** Inputs the region in which the event took place. If the event affected more than one region, list the affected region.
- **Municipality:** Inputs the municipality in which the event took place. If the event affected more than one municipality, list the affected municipalities.

[4] By n, it refers to any number of related entities (zero or more) (Elmasri & Navathe, 2010).
[5] Occurrence of a natural, technological, biological or human-induced phenomenon in a particular place during a particular period of time due to the existence of a hazard (UNISDR, 2016b).

Figure 4 Event entity and its attributes

The first relationship coming from the **Event** entity, is Event caused Direct Physical Damage, as depicted in Figure 3. From the **Direct Physical Damage** entity, another relationship surges, Direct Physical Damage occurred on Damaged Objects. These two entities are shown in Figure 5 and Figure 6.

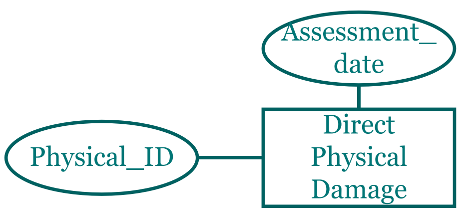

Figure 5 Damage entity and its attributes

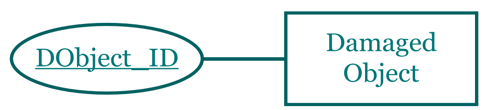

Figure 6 Damaged Object entity and its attributes

The entity **Damaged Object** that is shown in the Figure 3 is, as a matter of fact, a generalization or superclass of the five connected entities. These entities, or subclasses are:

- Cultural Heritage Asset
- Environmental Unit
- Public and Strategic Buildings
- Transportation Infrastructure
- Private Assets

The first three subclasses from the list above are illustrated in the Figure 7, Figure 8 and Figure 9 with their correspondent attributes. Having in mind that the goal of this database is to collect the minimum required data to calculate the SFA indicators to monitor the first four global targets, the attributes of these entities aim to collect the correct data for this purpose. An analysis on each of the attributes is made.

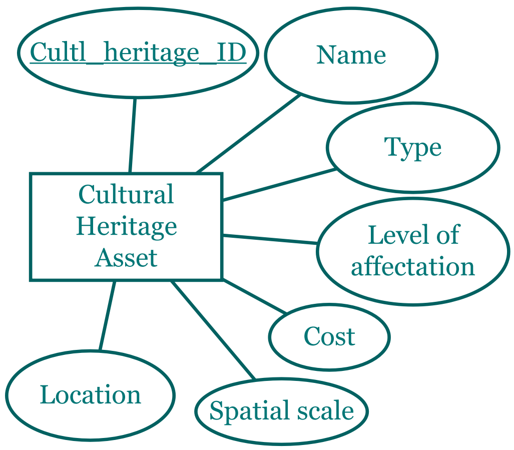

Figure 7 Cultural Heritage entity with its attributes

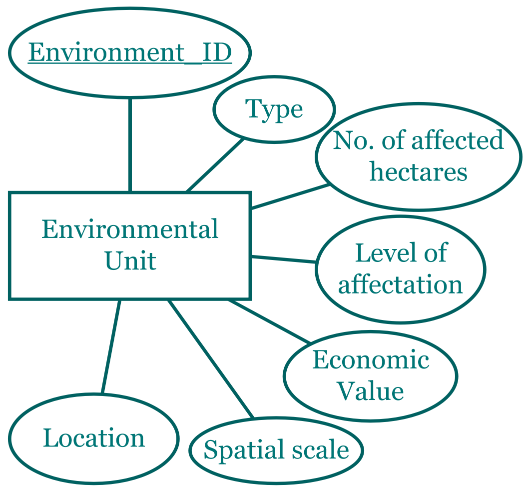

Figure 8 Environmental Unit entity with its attributes

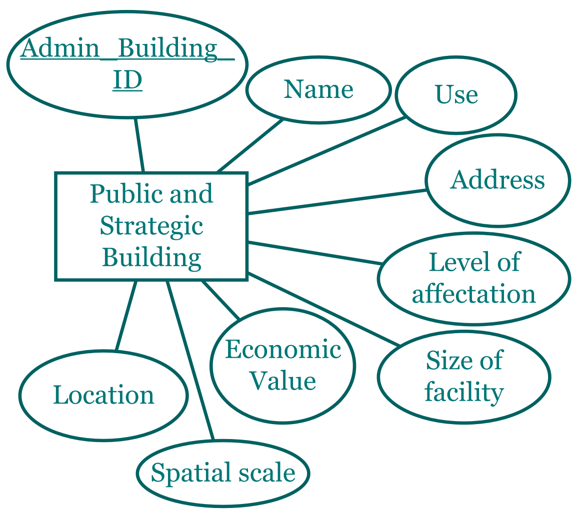

Figure 9 Public and Strategic Building entity with its attributes

For the **Cultural Heritage Asset** entity shown in Figure 7, which collects data for the calculation of **indicator C8** *"Direct economic loss due to cultural heritage damaged or destroyed by hazardous events",* the following attributes were considered:

- **Cultl_heritage_ID**: This is the key attribute. It is automatically generated by the database management system in consistence with the order in which different cultural heritage assets are inserted.
- **Name**: Corresponds to the name of the cultural heritage item.
- **Type**: Inputs the type of cultural heritage asset that is being recorded (monument, building, fixed infrastructure or mobile assets).
- **Level_of_affectation**: Describes the level of affectation of the cultural heritage asset (damaged or destroyed).
- **Cost**: Approximate value of the cost of rehabilitation, reconstruction or market value of the asset, depending on its type.
- **Spatial_scale:** Describes the spatial scale of the location of the asset (municipality, province or region).
- **Location**: Location of the asset based on its spatial scale.

For the **Environmental Unit** entity shown in Figure 8, which collects data for the calculation of **indicator C9** *"Direct economic loss due to environment degraded by hazardous events"*, the following attributes were considered:

- **Environment_ID**: This is the key attribute. It is automatically generated by the database management system in consistence with the order in which different environmental units are inserted.
- **Type**: Describes the type of environmental unit that is being recorded according to the land use.
- **Number of affected_Ha**: Inputs the number of affected hectares of the environmental unit type being recorded.
- **Level_of_affectation**: Describes the level of affectation of the environmental unit (low, medium or high).
- **Economic_value**: Approximate value of the cost of rehabilitation, reconstruction or market value of the asset, depending on its type.
- **Spatial_scale:** Describes the spatial scale of the location of the asset (municipality, province or region).
- **Location**: Location of the asset based on its spatial scale.

For the **Public and Strategic Building** entity shown in Figure 9, which collects data for the calculation of **indicator C5b** *"Damage and loss of administrative buildings"*, the following attributes were considered:

- **Admin_Building_ID**: This is the key attribute. It is automatically generated by the database management system in consistence with the order in which different public and strategic buildings are inserted.
- **Name**: Inputs the name of the building.
- **Use**: Describes the use of the public and strategic building that is being recorded.
- **Address**: Inputs the address of the building (municipality, region and country have already been input in the Event entity).
- **Level_of_affectation**: Describes the level of affectation of the public and strategic building (low, medium or high).
- **Economic_value**: Approximate value of the cost of rehabilitation or reconstruction of the public and strategic building.
- **Spatial_scale:** Describes the spatial scale of the location of the asset (municipality, province or region).
- **Location**: Location of the asset based on its spatial scale.

Figure 10 Transportation Infrastructure Asset entity with its attributes

For the **Transportation Infrastructure Asset** shown in Figure 10**,** a deeper generalization is made as shown in Figure 3, where five subclasses are illustrated. The Figure 11, Figure 12, Figure 13, Figure 14 and Figure 15 represent these five subclasses with their respective attributes. These entities collect data for the calculation of **indicators D4** *"Number of transportation infrastructures destroyed or damaged by hazardous events"***,** (including its subchapters **D4b, D4c, D4d, D4k** and **D4l**) and **C7** *"Direct economic loss due to damage to critical infrastructure/public infrastructure caused by hazardous events"* (since it partially depends on indicator D4), the following attributes were considered:

- **Road_Infr_ID**, **Bridge_Infr_ID**, **Railway_Infr_ID**, **Airport_Infr_ID** and **Port_Infr_ID**: These are the key attributes of the five subclasses respectively. They are automatically generated by the database management system in consistence with the order in which different transport infrastructure assets are inserted.
- **Name**: Inputs the name of the transportation infrastructure asset that is being recorded.
- **Level_of_affectation**: Describes the level of affectation of the transportation infrastructure asset (low, medium or high). **Economic_value**: Approximate value of the cost of rehabilitation or reconstruction of the transportation infrastructure asset.
- **Spatial_scale:** Describes the spatial scale of the location of the asset (municipality, province or region).
- **Location**: Location of the asset based on its spatial scale.
- **Type_of_road**: Only for the **Road** entity, it inputs type of road that is being recorded (unpaved, paved, highway).
- **Affected_lenght**: Only for the **Road** and **Railway** entities, the affected length must be recorded in kilometers.

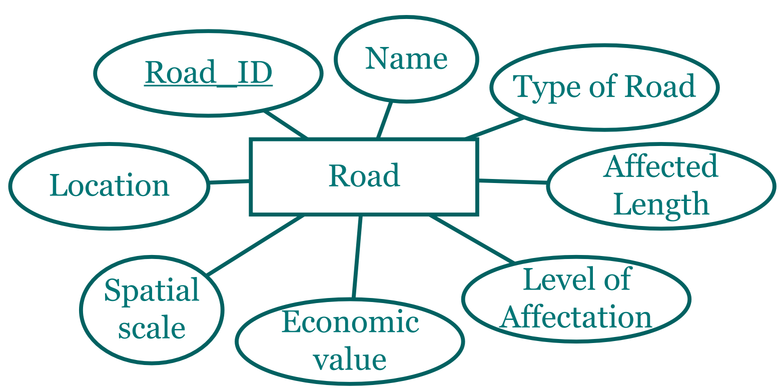

Figure 11 Road entity with its attributes

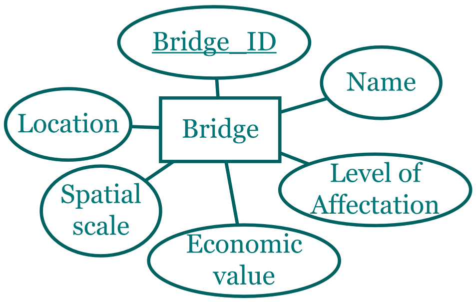

Figure 12 Bridge entity with its attributes

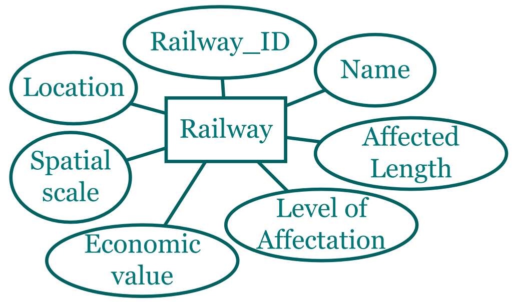

Figure 13 Railway entity with its attributes

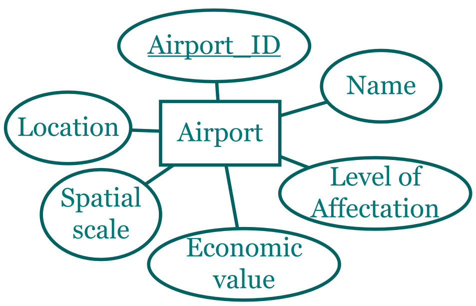

Figure 14 Airport entity with its attributes

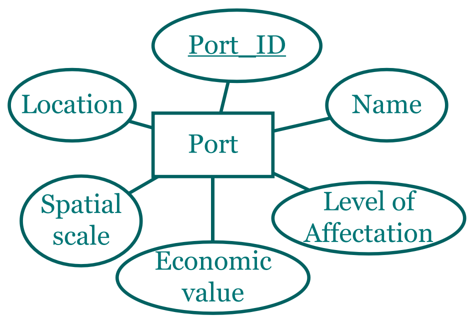

Figure 15 Port entity with its attributes

The last Damaged Object subclass entity is **Private Assets**. Next, a deeper generalization is made as shown in Figure 3. The following Figure 16, Figure 17, Figure 18 and Figure 19 depict the first four subclasses of the **Private Asset** entity and their attributes.

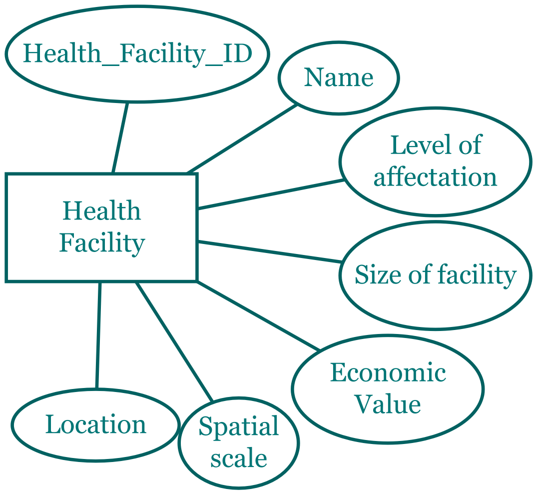

Figure 16 Health Facility entity with its attributes

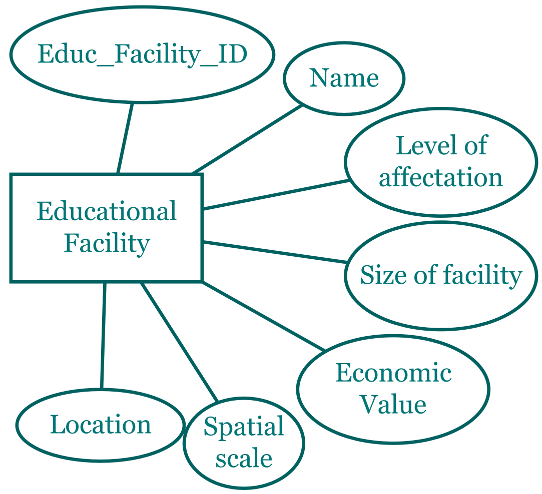

Figure 17 Educational Facility entity with its attributes

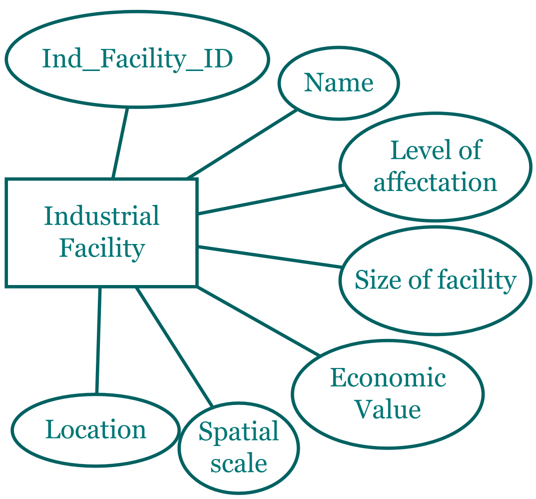

Figure 18 Industrial Facility entity with its attributes

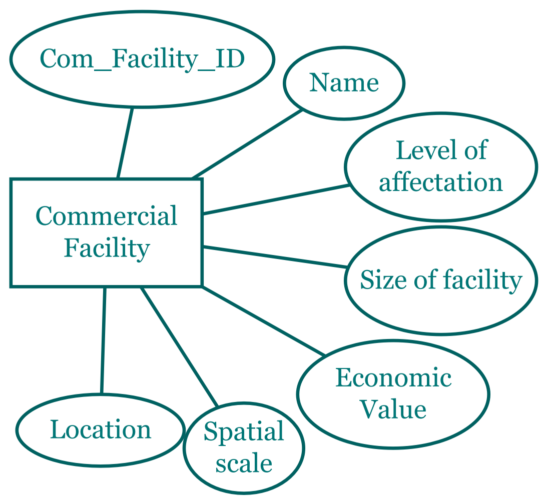

Figure 19 Commercial Facility entity with its attributes

The first four subclasses of the Private Assets collect data for the calculation of the **indicators C3, C4, D2, D3** and consequentially **C1, C7 and D1**. For further details on these indicators, please refer to Chapter 2 where they are thoroughly discussed. The attributes of these four entities are discussed next, where the reader can find they are all similar because the four subclasses are all entities.

- **Health_facility_ID**, **Educ_facility_ID**, **Ind_facility_ID** and **Com_facility_ID**: These are the key attributes for the four entities respectively. They are automatically generated by the database management system in consistence with the order in which different private asset facilities are inserted.
- **Name**: Inputs the name of the private asset that is being recorded.
- **Level_of_affectation**: Describes the level of affectation of the private asset (low, medium or high).
- **Size_of_facility**: Describes the size of the private asset facility (small, medium, large).
- **Economic_value**: Approximate value of the cost of rehabilitation, reconstruction or market value of the affected private asset.
- **Location**: Location of the asset based on its spatial scale.
- **Spatial_scale:** Describes the spatial scale of the location of the asset (municipality, province or region).

The **Vehicle** entity is also a subclass of the **Private Asset** entity that responds to **indicator D4 and C10** (partially), and it is shown in Figure 20 with its attributes that present only one difference with the previous subclasses, the addition of another attribute as well as its own key attribute **Transp_Unit_ID**.

- **Vehicle_class:** inputs the class of the vehicle by means of transportation (car, truck, motorcycle, boat, airplane, train, etc.).

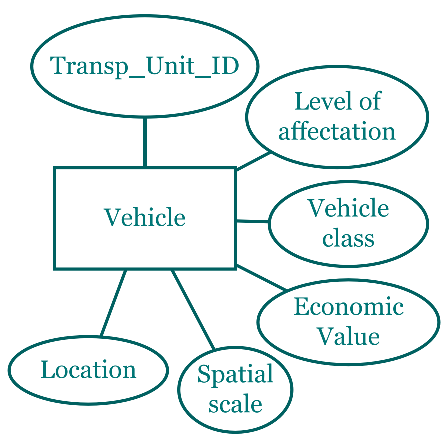

Figure 20 Vehicle entity with its attributes

One more subclass differs from the previously described group, **Agricultural_Asset**. It can be seen in the Figure 21 the attributes that will assist on the calculation of the **indicator C2** "*Direct agricultural loss due to hazardous events*". The attributes of this entity are discussed next.

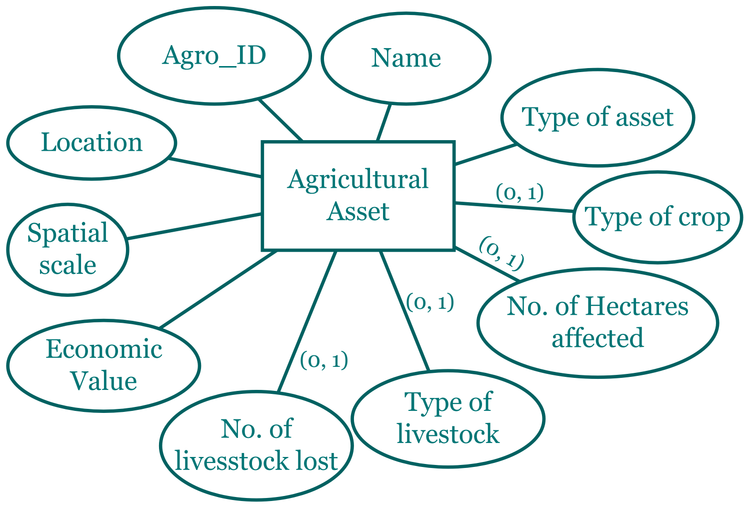

Figure 21 Agricultural Asset entity with its attributes.

- **<u>Agro_facility_ID</u>**: This is the key. It is automatically generated by the database management system in consistence with the order in which different agricultural assets are inserted.
- **Name**: Inputs the name of the agricultural asset that is being recorded.
- **Type_of_asset**: Inputs the type of agricultural private asset (crop or livestock).
- **Type_of_crop**: *(0, 1)* In case the type of asset is crop, inputs the type of crop that is being registered, otherwise it is NULL.
- **No_of_crop**: *(0, 1)* In case the type of asset is crop, inputs the number of affected hectares of the type of crop that is being registered, otherwise it is NULL.
- **Type_of_livestock**: *(0, 1)* In case the type of asset is livestock, inputs the type of livestock that is being registered, otherwise it is NULL.

- **No_of_livestock**: *(0, 1)* In case the type of asset is livestock, inputs the number of lost livestock of the type that is being registered, otherwise it is NULL.
- **Economic_value**: Approximate value of the cost of rehabilitation, reconstruction or market value of the affected private asset.
- **Location**: Location of the asset based on its spatial scale.
- **Spatial_scale:** Describes the spatial scale of the location of the asset (municipality, province or region).

The last subclass of the **Private Asset** entity is **Housing_Unit**, which will be discussed further on after discussing the **Person** entity. This is based on the stronger relation between the latter two entities, which will also be described at the end of this subchapter and on the next subchapter.

The second relationship coming from the **Event** entity is: event produced high-level damage assessment, linking the event and high level assessment entities. The High-level Assessment Entity, depicted in Figure XXXX, has a relationship linking it with the entity Damage and Losses, this relationship is shown in Figure 23 and is called, High-level Damage Assessment estimates Damage and Losses.

Figure 22 Entity High-level Damage Assessment and its attribute

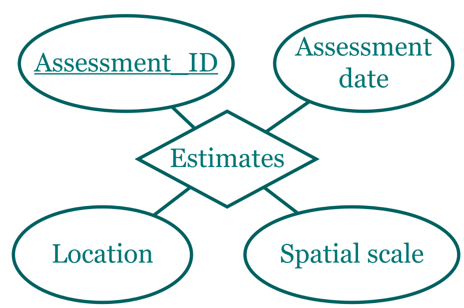

Figure 23 Relationship High-level Damage Assessment estimates Damage and Losses, and its attributes

The High-level Damage Assessment estimates Damage and Losses relationship, shown in Figure 23 considers the following attributes:

- **Assessment_ID**: This is the key attribute. It is automatically generated by the database management system in consistence with the order in which different assessments are estimated.

- **Assessment_date:** Inputs the date on which the assessment was done (it is recommended for this date to be within the first days after the emergency, as described in Figure 2). This date is important because it will work as a constant update of the impact of the event.
- **Spatial_scale:** Describes the spatial scale of the location of the assessment (municipality, province or region). This attribute is important because the different reports or news on damage and losses, may have different spatial scales in terms of administrative levels.
- **Location**: Location of the assessed damages and losses based on its spatial scale.

The entity **Damages and Losses** that is shown in the Figure 3 is, as a matter of fact, a generalization or superclass of three connected entities. These entities, or subclasses are:

- Human loss
- Human Affectation
- Directly Affected Assets

The first two subclasses from the list above are illustrated in the Figure 24 and Figure 25 with their correspondent attributes. Then, the third subclass represented in Figure 26 is presented as well. Having in mind that the goal of this section of the database is to calculate the indicators in a different spatial scale without considering the minimum requirements so more aggregated reports can be used and updated in the database during the emergency timeline, the attributes of these subclasses correspond to this need.

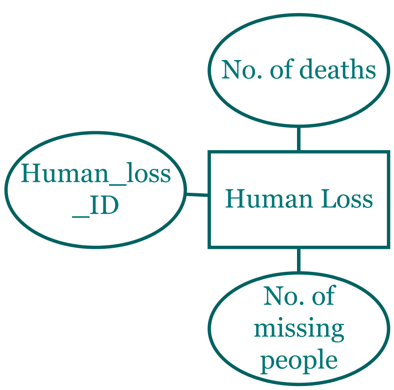

Figure 24 Human Loss entity and its attributes

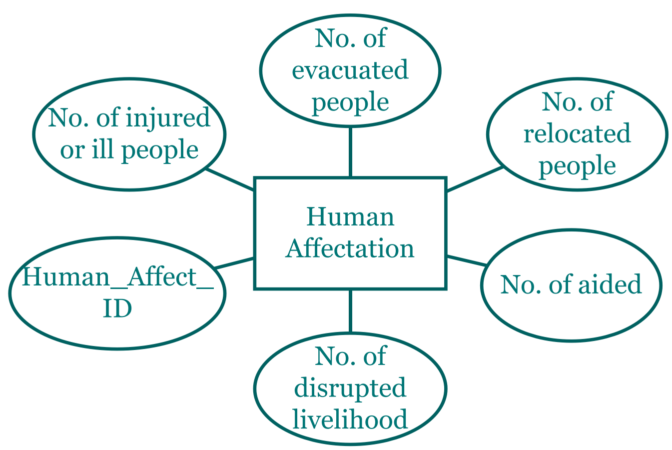

Figure 25 Human Affectation entity and its attributes

For the **Human Loss** entity shown in Figure 24, which collects data for the calculation of **indicators of Global Target A**. The following attributes were considered:

- **<u>Human Loss _ID</u>**: This is the key attribute. It is automatically generated by the database management system in consistence with the order in which different human loss reports are inserted.
- **No_of_deaths**: Corresponds to the number of dead people reported as to the assessment date of the report, in the location specified in the **estimates** relationship.
- **No_of_missing**: Corresponds to the number of missing people reported as to the assessment date of the report, in the location specified in the **estimates** relationship.

For the **Human Affectation** entity shown in Figure 25, which collects data for the calculation of **indicators of Global Target B**. The following attributes were considered:

- **<u>Human Affect _ID</u>**: This is the key attribute. It is automatically generated by the database management system in consistence with the order in which different human affectation reports are inserted.
- **No_of_injured**: Corresponds to the number of injured or ill people reported as to the assessment date of the report, in the location specified in the **estimates** relationship.
- **No_of_evacuated**: Corresponds to the number of evacuated people reported as to the assessment date of the report, in the location specified in the **estimates** relationship. By evacuated, it refers to temporarily displaced as a consequence of the hazardous event.
- **No_of_relocated**: Corresponds to the number of relocated people reported as to the assessment date of the report, in the location specified in the **estimates** relationship. By relocated, it refers to permanently displaced as a consequence of the hazardous event.
- **No_of_aided**: Corresponds to the number of people that received food or medical aid reported as to the assessment date of the report, in the location specified in the **estimates** relationship.
- **No_of_disrupted**: Corresponds to the number of people whose livelihood was disrupted or destroyed by the hazardous event, reported as to the assessment date of the report, in the location specified in the **estimates** relationship.

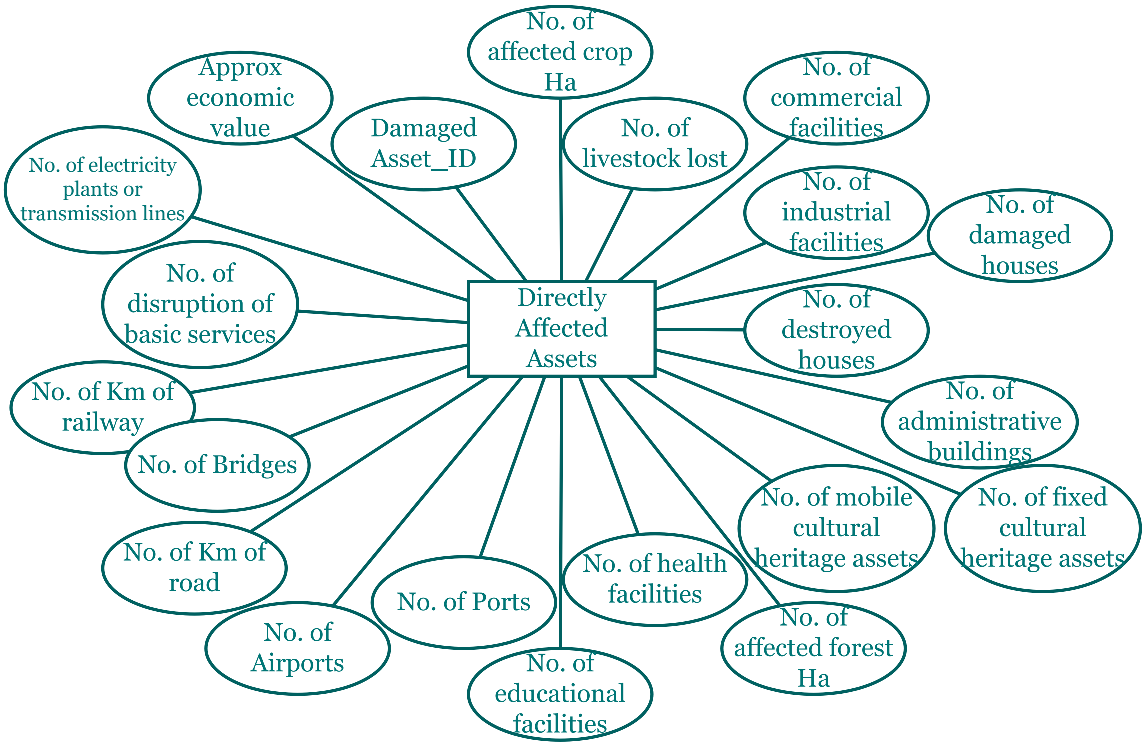

Figure 26 Directly Affected Assets entity and its attributes

For the **Directly Affected Assets** entity shown in Figure 25, which collects data for the calculation of **indicators of Global Target B**. The following attributes were considered:

- **<u>Damaged Asset ID</u>**: This is the key attribute. It is automatically generated by the database management system in consistence with the order in which different directly damaged assets reports are inserted.

The next 19 attributes correspond to the number of different types of assets (characterized in the name of the respective attribute), where the only input is a number that comes directly from the damage reports. This means that all of these 19 attributes are optional (0, 1).

- No_affected_crop_Ha
- No_livestock_lost
- No_commercial_fac

- No_industrial_fac
- No_damaged_houses: housing units
- No_destroyed_housed:
- No_admin_build
- No_fixed_cult_her
- No_mobile_cult_her
- No_affected_forest_Ha
- No_health_fac
- No_educational_fac
- No_ports
- No_airports
- No_bridges
- No_km_roads
- No_km_railways
- No_times_bs_disruption
- No_power_plants

The last attribute of this entity is an estimation of the approximate economic value for replacement or reconstruction of the damaged or destroyed assets pointed out before.

- Approx_Economic_Value

The third relationship coming from the **Event** entity is: event provoked outages, linking the event and outage entities. This relationship is illustrated in Figure 27, where an attribute called **Outage_time**, that registers the time in which the outage is recorded, can also be seen.

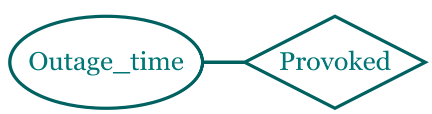

Figure 27 Relationship Event provoked Outage, and its attributes

The **Outage** entity shown in Figure 28, which collects data for the calculation of **indicator D5** *"Number of times basic services have been disrupted due to hazardous events"*, considers the following attributes:

- **Outage_ID**: This is the key attribute. It is automatically generated by the database management system in consistence with the order in which different outages are inserted.
- **Basic_service**: Inputs the basic service that was disrupted. The possible values considered are listed next.
    - Healthcare services
    - Educational services
    - Transport sector
    - Solid waste management
    - Water supply
    - Sewage system
    - Power/energy system
    - Emergency response
    - ICT
- **Start_Date:** Inputs the date when the outage started.
- **Finish_Date:** Inputs the outage finalizes.
- **Cause:** Describes the cause of the outage.
- **Economic_value:** Cost of reparation of the basic service network.
- **Spatial_scale:** Describes the spatial scale of the location of the outage (municipality, province or region).
- **Location**: Location of the outage based on its spatial scale.
- **Impact**: Approximate percentage of the selected spatial scale that was affected with the outage.

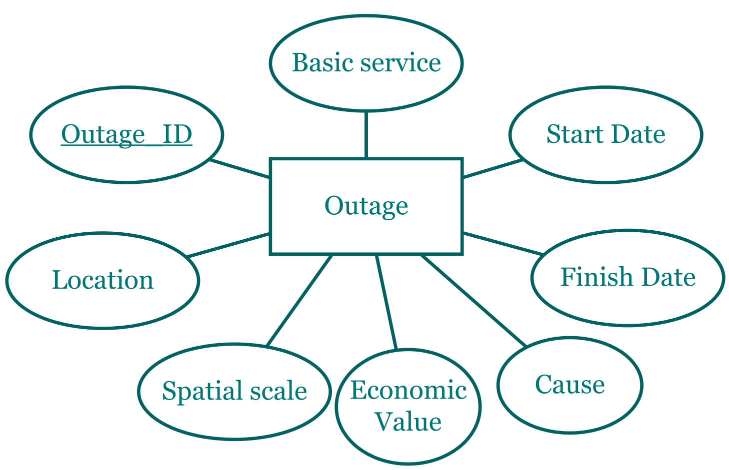

Figure 28 Outage entity and its attributes

The fourth and last relationship coming from the **Event** entity is: event affected a person, linking the event and person entities. This relationship is illustrated in Figure 29, where an attribute called **Affectation_date**, that registers the date in which the affected person is recorded, can also be seen. This is also a "master-slave" relationship, based on the cardinalities between the two entities.

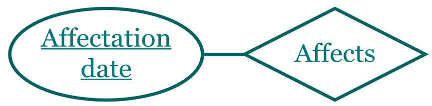

Figure 29 Relationship Event affects Person, and its attributes

The **Person** entity shown in Figure 30 which collects data for the calculation of **indicators correspondents to Global Targets A and B**, that are strongly tied to people's mortality and affectation, considers the following attributes:

- **Person_ID**: This is the key attribute. It corresponds to the identification number of the person that is being registered in the database.
- **Name:** Inputs the name of the person being registered.
- **Surname:** Inputs the surname of the person being registered.
- **Age:** Inputs the age of the person.
- **Disability:** Inputs whether the person was disabled or not before the hazardous event.
- **Address:** Inputs the residence address of the person.
- **Municipality:** Inputs the municipality where the person resides.
- **Region:** Inputs the region to which the municipality belongs.
- **Missingness[6]:** Inputs whether the person is missing or not (yes or no).
- **Vital_status:** Inputs whether the person is alive or dead.
- **Health_status**: Inputs whether the person is injured, ill or healthy.
- **Housing_status**: Inputs whether the person is relocated, evacuated or normal.
- **Relief_aid**: Inputs whether the person received (food or medical) aid or not (yes or no).
- **Livelihood_disruption**: Inputs whether the livelihood of the person was disrupted or not (yes or no).

[6] Defined as the quality or condition of being missing by the Oxford English Dictionary.

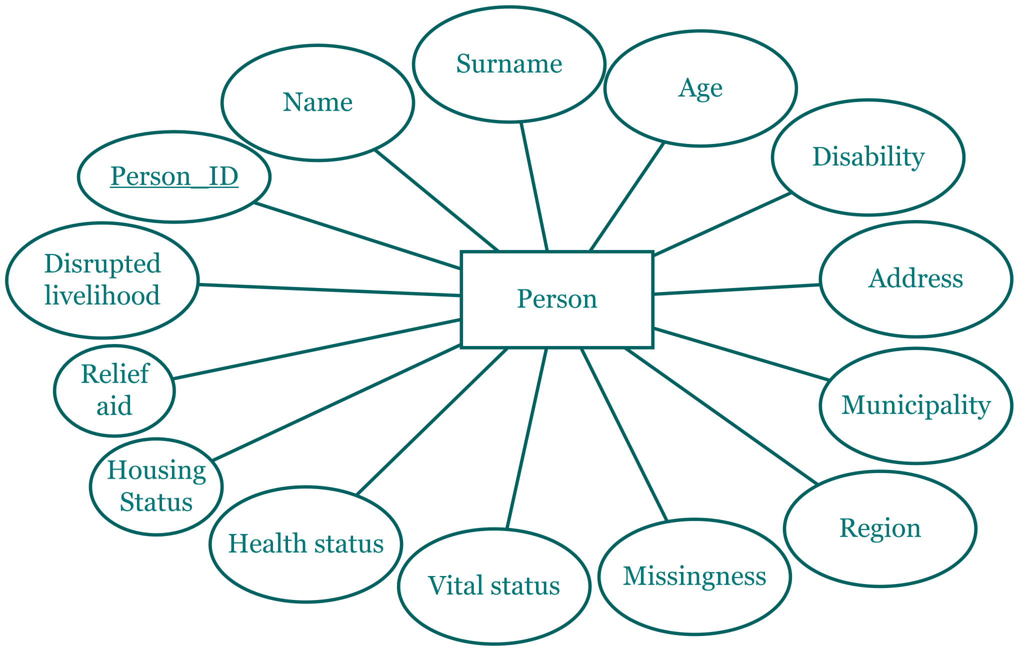

Figure 30 Person entity and its attributes

An additional relationship is present in the ERD on Figure 3, linking the **Person** entity with the **Housing_Unit** entity: Person resides in Housing Unit. This relationship is a "master-Slave" relationship, where the master entity is **Person**, and **Housing_Unit** is the slave one, based in the cardinalities set on the ERD.

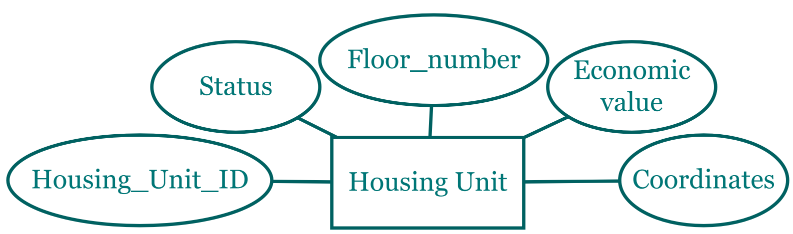

Figure 31 Housing Unit entity and its attributes

The **Housing_Unit** entity to which the **Person** and **Event** entities are related shown in Figure 31, collects data for the calculation of **indicators C5 and C6** and consequently **indicators B4 and B5**. It considers the following attributes:

- **Housing_Unit_ID**: This is the key attribute. It is automatically generated by the database management system in consistence with the order in which different housing units are inserted.
- **Status:** Inputs the status of the housing unit as either damaged, destroyed or no damaged.
- **Floor_number**: Inputs the floor number on which the housing unit is. If there is more than one housing unit in the same floor, an extra number must be added that controls this.
- **Economic_value**: Inputs the value for rehabilitation or reconstruction of the affected housing unit.
- **Coordinates**: Inputs the coordinates of the housing unit.

Now that the ERD has been entirely described, the relational model is presented in the following subchapter where further detail on the relationships and the key attributes is done.

3.2 Relational model

The relational model represents the database as a collection of relations among entities. It is centered on the idea of organizing data into collections of two-dimensional tables called "relations" (Elmasri & Navathe, 2010). In order to support the calculation of the indicators to monitor the SFA global targets, the relations and the relational model were defined.

Generally, the relational model begins by naming the entity for which the relation table is being created. After this, there is a listing of every attribute corresponding to the entity. The key attribute is underscored to highlight it above the rest of the attributes. Some entities present other dashed underscored attributes which correspond to foreign keys, meaning a key attribute coming from a related entity, there might be more than one foreign key. This will allow the data from the two related entities to be reached in either way.

- **Event** (Event_ID, Type, Severity, Coordinates, Start_Date, Finish_Date, Country, Region, Municipality)
- **Direct_Physical_Damage** (Physical_ID, Event_ID, Assessment_Date)

- **Damaged_Object** (DObject_ID, Cultl_heritage_ID, Environmental_ID, Admin_Building_ID, Transp_Infr_ID, Private_Asset_ID)
- **Cultural_Heritage_Asset** (Cultl_heritage_ID, Name, Type, Level_of_affectation, Cost, Spatial_scale, Location)
- **Environmental_Unit** (Environmental_ID, Type, No_of_affected_hectares, Level_of_affectation, Economic_value, Spatial_scale, Location)
- **Pulic_and_Strategic_Building** (Admin_Building_ID, Name, Use, Address, Level_of_affectation, Size_of_facility, Economic_value, Spatial_scale, Location)
- **Transportation_Infrastructure_Asset** (Transp_Infr_ID, Road_ID, Bridge_ID, Railway_ID, Airport_ID, Port_ID)
- **Road** (Road_ID, Name, Type_of_road, Affected_length, Level_of_affectation, Economic_value, Spatial_scale, Location)
- **Bridge** (Bridge_ID, Name, Level_of_affectation, Economic_value, Spatial_scale, Location)
- **Railway** (Railway_ID, Name, Affected_length, Level_of_affectation, Economic_value, Spatial_scale, Location)
- **Airport** (Airport_ID, Name, Level_of_affectation, Economic_value, Spatial_scale, Location)
- **Port** (Port_ID, Name, Level_of_affectation, Economic_value, Spatial_scale, Location)
- **Private_asset** (Private_Asset_ID, Health_facility_ID, Educational_facility_ID, Industrial_facility_ID, Commercial_facility_ID, Transp_unit_ID, Agro_ID, Housing_Unit_ID)
- **Health_facility** (Health_facility_ID, Name, Level_of_affectation, Size_of_facility, Economic_value, Spatial_scale, Location)
- **Educational_facility** (Educ_facility_ID, Name, Level_of_affectation, Size_of_facility, Economic_value, Spatial_scale, Location)
- **Industrial_facility** (Ind_facility_ID, Name, Level_of_affectation, Size_of_facility, Economic_value, Spatial_scale, Location)
- **Commercial_facility** (Com_facility_ID, Name, Level_of_affectation, Size_of_facility, Economic_value, Spatial_scale, Location)
- **Vehicle** (Transp_unit_ID, Level_of_affectation, Vehicle_class, Economic_value, Spatial_scale, Location)

- **Agricultural_Asset** (Agro_ID, Name, Type_of_asset, Type_of_crop, No_of_Hectares_affected, Type_of_livestock, No_of_livestock_lost, Economic_value, Spatial_scale, Location)
- **Housing_Unit** (Housing_Unit_ID, Status, Floor_number, Coordinates, Economic_value)
- **Outage** (Outage_ID, Type_of_Service, Start_Date, Finish_Date, Cause, Economic_value, Spatial_scale, Location, Event_ID)
- **Person** (Person_ID, Name, Surname, Age, Disability, Address, Municipality, Region, Missingness, Vital_status, Health_status, Housing_status, Relief_aid, Disrupted_livelihood, Event_ID, Housing_Unit_ID)
- **Person_resides_in_Housing_Unit** (Person_ID, Housing_Unit_ID)
- **Event_affects_person** (Affectation_Date, Person_ID, Event_ID)
- **High_level_DA** (High_lev_ID)
- **Hlda_estimates_Damage** (Assessment_ID, Assesment_date, Spatial_scale, Location)
- **Human_Loss** (Human_loss_ID, No_of_deaths, No_of_missing)
- **Human_Affectation** (Human_Affect_ID, No_of_injured, No_of_evacuated, No_of_relocated, No_of_aided, No_of_disrupted)
- **Directly_Affected_Assets** (Damaged Asset_ID, No_affected_crop_Ha, No_livestock_lost, No_commercial_fac, No_industrial_fac, No_damaged_houses, No_destroyed_housed, No_admin_build, No_fixed_cult_her, No_mobile_cult_her, No_affected_forest_Ha, No_health_fac, No_educational_fac, No_ports, No_airports, No_bridges, No_km_roads, No_km_railways, No_times_bs_disruption, No_power_plants, Approx_Economic_Value)

3.3 Database querying

From the 33 indicators to monitor the SFA global targets, this database allows the calculation of 32, either by directly querying the recorded data or by combining indicators between them or even by using external indicators, i.e. GDP data, which are required for the calculation of the indicators as described on Chapter 2 .

On the Appendix A the proposed querying to compute each of the indicators using the previously presented database in a national level for the first four Global Targets of the SFA, is presented. The appendix is divided on four sub-appendixes, each presenting the queries of one of the four global targets that are analyzed in this document.

The database also allows to obtain spatially disaggregated values for the indicators. For the Global Targets A and B indicators, a disaggregation can be done by limiting the query only considering the attributes “Municipality” or “Region” in addition to the population of the correspondent administrative unit that is being considered.

The disaggregation on the Global Target C and D can be done by limiting the query to consider only the data that matches a “Location” and “Spatial scale” in its attributes. Additionally, the GDP of the administrative unit that is being queried must be inserted as an external variable as the query for indicator C1 shown in Appendix A.3.

Chapter 4

Case study: The June 2013 floods in Vall d'Aran and Pyrenees

The June 2013 floods in Vall d'Aran and Pyrenees is one of the case studies used for the, previously discussed, IDEA project. This chapter starts by describing the event and the affected areas of the case study. It then proceeds to depict the practices on damage data collection in Spain at its different levels. Finally, considering the damage data collection practices and the collected data for the case study, the database is employed to analyze the level of fulfillment of the same, and how can this be seen from the SFA point of view.

4.1 Description of the case study

The Spanish region of Catalunya is divided in 42 districts (comarques). On the Atlantic side of the Central Pyrenees bordering with France, the Aragon region and two more Catalonian districts is located the Vall d'Aran district, as seen in Figure 32. It is located in a 620 km2 mountainous region with about 30 % of its area above 2000 m.a.s.l. The Vall d'Aran is classified as a high flood risk area susceptible to suffering mountainous torrential flood events such as the documented 1875, 1897, 1907, 1937, 1963, 1982 and 2013 events (Victoriano, Marta, Furdada, & Bordonau, 2016).

On June 18th 2013 in Vall d'Aran a severe flash flood, considered to have been a 30-50-year medium-magnitude flood, along the Garona, Noguera Pallaresa, Noguera de Cardós, Noguera de Vallferrera rivers and some tributaries of the western Pyrenees, caused losses exceeding €20 million, particularly in the municipalities of Vielha, Arties and Salardù mainly caused by the fluvial erosion effect in the urbanized areas.

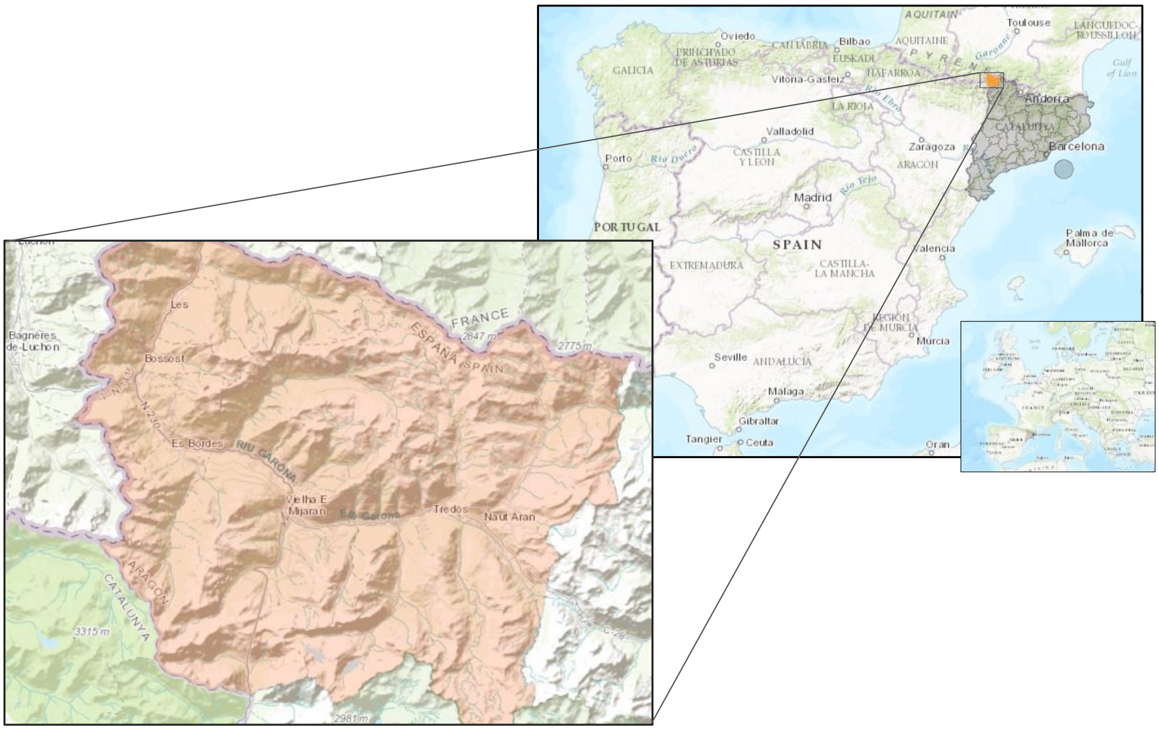

Figure 32 Location of Vall d'Aran

The flood event was driven by diverse climate factors according to a multidisciplinary analysis by (Generalitat de Catalunya & Servei Meteorologic de Catalunya, 2013). Climate factors such as the important snow accumulation during the 2012/2013 winter where the snow thickness reached levels considerably above the median value in some areas of the northern Pyrenees (0.5m to 2m above the median). In addition, the low temperatures on spring 2013 kept the snow from being thawed until a sudden rise of the temperature starting on June that year.

This factors summed to the intense rainfall during 17^{th} and 18^{th} June that reached 115 L/m2 in some areas, lead to water level and flow increments in the rivers sources and later along their courses (Protecció Civil Generalitat de Catalunya, 2013). Furthermore, the flood and erosion caused damages and losses in urbanized areas. The Figure 33 presents a map developed by the Institut Cartogràfic i

Geològic de Catalunya where the Vielha municipality is shown with its flooded and eroded areas. The Vielha municipality is the capital of the Vall d'Aran district.

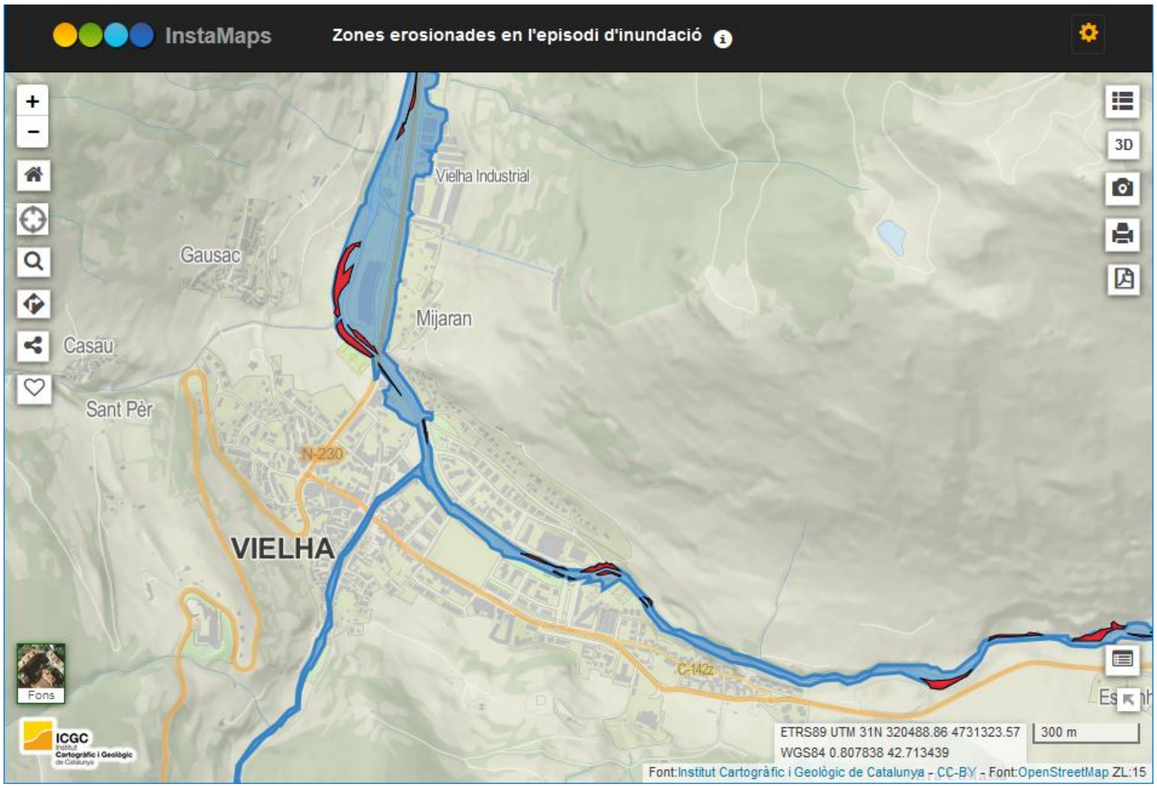

Figure 33 Map of the flooded and eroded areas in Vielha, Vall d'Aran

The following summary damages and losses accounting is adapted from a report on the emergency of 18th June 2013 in the Vall d'Aran done by (Protecció Civil Generalitat de Catalunya, 2013) to respond to the SFA Global Targets described in the previous chapters. Figure 34 corresponds to a photograph documenting a destroyed bridge over the Garona river in Salardù, Vall d'Aran.

- **Global Target A**
    - No mortality
    - No missing people
- **Global Target B**
    - 276 evacuated people
    - People with damaged houses
- **Global Target C**

- Agricultural losses
    - Damages on industrial facilities
    - Damaged on commercial facilities
    - Damaged houses
    - Damaged infrastructure
- **Global Target D**
    - Closure of 8 primary schools
    - Closure of 2 high schools
    - Affected road network
    - One affected bridge
    - School transportation services suspended
    - Water supply interruption
    - Gas supply interruption
    - ICT services interruption
    - 4 power outages affecting 4.000 people

Figure 34 Destroyed bridge over the Garona river in Salardù, Vall d'Aran [7]

[7] La Vanguardia. (23/06/2013). *El río Garona se lleva un puente en Salardù (Val d'Aran).* Retrieved from: http://www.lavanguardia.com/vida/20130623/54376209220/val-d-aran-comeinza-de-cero-tras-la-riada.html

4.2 Practices on damage data collection in Spain

Spain is divided administratively in 17 regions (comunidades autónomas in Spanish) each of which is divided into one or more provinces each of which is divided as well into municipalities (in the case of Catalunya, provinces are subdivided into districts and then into municipalities). This administrative division is reflected in the different official entities in charge of damage data collection in Spain.

In the case of the Vall d'Aran floods of 2013, the agencies and organizations that collected the damage data relevant to the computation of the SFA Global Targets A to D, are summarized in the Table 7 below.

Table 7 List of public and private stakeholders.

List of Public and Private Stakeholders		
Stakeholders	**Spanish / Catalan**	**English**
IDESCAT	Institut d'Estadística de Catalunya	Statistical Institute of Catalonia
Conselh Generau d'Aran	Consell General d'Aran	General Council of Aran
SEM	Sistema d'Emergències Mèdiques	Medic Emergencies System
IMLCFC	Institut de Medicina Legal i Ciències Forenses de Catalunya	Legal and Forensic Medicine Institute of Catalonia
DGPC	Direcció General de Contractació Pública	General directorate for public contracting
Municipalities	Ajuntament de Vielha e Mijaran	Vielha and Mijaran Town Hall
Red Cross	Cruz Roja Española	Spanish Red Cross
CCS	Consorcio de Compensación de Seguros	National Insurance System coverage for natural disasters
CME	Policia de la Generalitat - Mossos d'Esquadra	Catalonia Police Department
BG	Cos de Bombers de la Generalitat de Catalunya	Catalonian Fire Brigade
CECAT	Centre de Coordinació Operativa de Catalunya	Catalonian Civil Protection
ICGC	Institut Cartogràfic i Geològic de Catalunya	Catalan Cartographic and Geographic Institute
SMC	Servei Meteorològic de Catalunya	Meteorological Service of Catalonia

ACA	Agència Catalana de l'Aigua	Catalan Water Agency – Environmental Department of Catalan Government)
ARC	Agència de Residus de Catalunya	
CHE	Confederación Hidrográfica del Ebro	Ebro Hydrographical Confederation –Environmental Ministry of Spanish Government
ENDESA	Empresa Nacional de Electricidad, S.A.	National electric utility company
Gas Natural	Gas Natural Fenosa	Spanish natural gas utilities company (private)
DGTSI	Direcció General de Telecomunicacions i Societat de la Informació	General directorate for telecommunications and information
SCT	Servei Català de Trànsit	Catalan Transit Service
DCG	Dirección General de Carreteras	Roads General Directorate
Ministerio de Fomento	Ministerio de Fomento	Ministry of Public Works and Transport
MAPAMA	Ministerio de Agricultura y Pesca, Alimentación y Medio Ambiente	Ministry of Agriculture, Fisheries, Food and Environment
MECD	Ministerio de Educación, Cultura y Deporte	Ministry of Education, Culture and Sports
Departament de Justícia	Departament de Justícia (Oficina d'atenció a víctimes)	Catalonian Department of Justice (Victims office)
Departament d'Empresa i Ocupació	Departament d'Empresa i Ocupació	Catalonian Department of Employment
Departament d'Ensenyament	Departament d'Ensenyament	Catalonian Department of Education
Departaments De Benestar i Família	Departaments de Benestar i Família	Catalonian Department of Welfare and Family
CAR	Departament d'Agricultura, Ramaderia, Pesca i Medi Natural	Catalonian Department of Agriculture, Livestock, Fisheries and the Environment
Departament De Cultura	Departament De Cultura (Direcció General D'arxius, Biblioteques, Museus I Patrimoni)	Catalonian Department of Culture (General Directorate for archives, libraries, museums and patrimony)

The table above depicts the different administrative levels in which the data for the Vall d'Aran case study was acquired (municipal, district, regional and national). The data collected by these entities and described in the previous sub-chapter, was stored into GIS or commercial databases with no standards/shared protocols among the different authorities. Moreover, data are often stored in paper form or scan copies of paper documents (Protecció Civil Generalitat de Catalunya & IDEA Project, 2015a).

Identifying and mapping these entities that collect data is crucial in order to feed a database that will allow comparable results of queries for a variety of purposes, especially accounting. This is why the Table 8 below, presents a recommendation on which entity's collected data use to fill the designed database of Chapter 3 This recommendation is based on the spatial impact of the 2013 disaster, and on each of the entities overseen territories within Spain.

Table 8 Recommended data sources for the database relevant data organized by sectors.

Sector	Data	Source
People	Exposed people (e.g. census data)	CECAT
	Number of death	SEM
	Number of injured	
	Number of affected people	Conselh Generau d'Aran
	Number of evacuee	
	Mitigation actions (before and during the event)	
Lifelines (roads, railways, electric lines, water supply, sewage, telecom)	Lifelines location/vulnerability (e.g. length, classification, functional and systemic vulnerability)	Ministerio de Fomento, DCG, SCT, DGTSI, Gas Natural, ENDESA, CHE, ARC, ACA
	Direct damage (lines and installation)	
	Direct damage (lines and installation) - economic value	
	Mitigation actions (before and during the event)	
Public items (public buildings/public spaces)	Location/vulnerability (e.g. physical, functional, systemic)	Conselh Generau d'Aran
	Direct damage	
	Direct damage - economic value	CCS
	Mitigation actions (before and during the event)	Conselh Generau d'Aran
Strategic buildings (hospital, schools, headquarters, etc.)	Location/vulnerability (e.g. physical, functional, systemic)	
	Direct damage	
	Direct damage - economic value	CCS
	Mitigation actions (before and during the event)	Conselh Generau d'Aran
Economic activities	Location/vulnerability (e.g. physical vulnerability, economic sector, personnel)	

(commercial, industrial, agricultural)	Economic value (e.g. net capital value)	Departament d'Empresa i Ocupació
	Direct damage	
	Direct damage - economic value	CCS
	Mitigation actions (before and during the event)	Departament d'Empresa i Ocupació
Residential buildings	Market value	CCS
	Location/vulnerability (e.g. maintenance, typology)	Conselh Generau d'Aran
	Direct damage	
	Direct damage - economic value	CCS
	Mitigation actions (before and during the event)	Conselh Generau d'Aran
Environment	Location/vulnerability	CAR
	Direct damage	
	Mitigation actions (before and during the event)	
Cultural Heritage	Location/vulnerability	Departament De Cultura
	Direct damage	
	Mitigation actions (before and during the event)	

4.3 Employing the database

The database is employed for the Vall d'Aran case based in the IDEA project Deliverable A4 compiled by (Protecció Civil Generalitat de Catalunya & IDEA Project, 2015b) where the available data for the case is described in the Annex A.9: Table A.8. The collected data for the Vall d'Aran case can be categorized in 13 sectors:

1. Base maps
2. Physical event
3. Protective measures (e.g. for floods: dikes, walls, weir)
4. People
5. Lifelines (roads, railways, electric lines, water supply, sewage, telecom)
6. Public items (public buildings/public spaces)
7. Strategic buildings (hospital, schools, headquarters, etc.)
8. Economic activities (commercial, industrial, agricultural)
9. Residential buildings
10. Environment
11. Cultural heritage
12. Emergency management
13. Documents

Clearly, not all the sectors, in which the collected data was divided, can be matched to the SFA indicators to monitor the Global Targets A to D, only sectors 4 to 11. Organizing the data by sectors was a helpful tool for the following aggregation across sectors for the calculation of the SFA indicators. The following Table 9 Collected data from the Vall d'Aran case study presents the collected data for each sector and its connection to the SFA, if any, and the calculation of its indicators through the designed database presented on Chapter 3 .

Table 9 Collected data from the Vall d'Aran case study

Sector	Data	Global Target	Indicator	Entity	Attribute
People	Exposed people (e.g. census data)	A, B	A1, B1		
	Number of death	A	A2	People	Municipality, Region
	Number of injured	B	B2		
	Number of affected people		B1		
	Number of evacuee		B3a, B3b		
	Mitigation actions (before and during the event)		B6		Relief aid
Lifelines (roads, railways, electric lines, water supply, sewage, telecom)	Lifelines location/vulnerability (e.g. length, classification, functional and systemic vulnerability)	D	D4b, D4d, D1bis, D5	Road, Railway, Bridge, Outage	Name, Type of road, Affected length, Type of service, Cause, Start date, Finish date, Spatial scale, Location
	Direct damage (lines and installation)		D4b, D4d		Level of affectation
	Direct damage (lines and installation) - economic value		D4b, D4d, D1bis, D5		Economic value
	Mitigation actions (before and during the event)				

Public items (public buildings/public spaces)	Location/vulnerability (e.g. physical, functional, systemic)	C	C5b	Public and Strategic Building	Name, Use, Address, Size of facility, Spatial scale, Location
	Direct damage				Level of affectation
	Direct damage - economic value				Economic value
	Mitigation actions (before and during the event)				
Strategic buildings (hospital, schools, headquarters, etc.)	Location/vulnerability (e.g. physical, functional, systemic)	C, D	C5b, C7, D2, D3	Health facility, Educational facility	Name, Size of facility, Spatial scale, Location
	Direct damage				Level of affectation
	Direct damage - economic value		C7		Economic value
	Mitigation actions (before and during the event)				
Economic activities (commercial, industrial, agricultural)	Location/vulnerability (e.g. physical vulnerability, economic sector, personnel)	C	C2, C3, C4	Industrial facility, Commercial facility, Agricultural Asset	Name, Size of facility, Type of asset, Type of crop, Type of livestock, Spatial scale, Location
	Economic value (e.g. net capital value)				
	Direct damage				Level of affectation, No of Ha affected,

					No of livestock lost
	Direct damage - economic value				Economic Value
	Mitigation actions (before and during the event)				
Residential buildings	Market value				
	Location/vulnerability (e.g. maintenance, typology)	B, C	B4, B5, C5, C6	Housing Unit, Person	Address, Municipality, Region, Coordinates, Status, Floor number
	Direct damage				Status
	Direct damage - economic value				Economic value
	Mitigation actions (before and during the event)				
Environment	Location/vulnerability	C	C9	Environmental Unit	Type, Spatial scale, Location,
	Direct damage				No of affected Ha, Economic value
	Mitigation actions (before and during the event)				
Cultural Heritage	Location/vulnerability		C8	Cultural Heritage Asset	Name, Type, Spatial scale, Location
	Direct damage				Level of affectation, Cost
	Mitigation actions (before and during the event)				

The previous table links the collected data for the Vall d'Aran flood of June 2013, with the database, through the Entities and Attributes that would be filled by the collected data. However, Table 9 presents some flaws and voids in the collected data that will be listed next.

- The required disaggregation recommended by (UNISDR, 2016a) for the people (age, sex, disability, poverty level, geographic location) cannot be accomplished. The data on human losses is collected without considering this disaggregation. Therefore, the database proposes a person-by-person data collection, that will also help avoid double count when computing the indicators.
- The collected data for the case study, neglected the missing people, hence neglecting the indicator A3 and obstructing with calculation of indicator A1.
- The collected data for the case study neglected also the people whose livelihoods have been disrupted or destroyed, hence neglecting indicator B7 and obstructing with calculation of indicator B1.
- As is has been mentioned throughout the document, indicator C10 comes directly from the insurance companies' data, which in the case of the collected data for the Vall d'Aran case study is available.

Despite of the voids and flaws aforementioned, the collected data for the Vall d'Aran case managed to be enough for the calculation of 31 out of 33 indicators to monitor the SFA Global Targets A to D, which might sound, except for the fact that at least 10 indicators (indicators A and B) are computed without considering the minimum disaggregation proposed.

Therefore, when considering all the minimum requirements stablished, the collected data for the Vall d'Aran case fills 88 out of the 110 attributes proposed in the database on Chapter 3 . It is worth mentioning that 10 of the 22 attributes missing, correspond to data that does not exist in the Vall d'Aran (ports and airports) so there would only be missing the 12 indicators to fill.

Chapter 5

Conclusions and Recommendations

This chapter concludes this thesis by providing some conclusions and recommendations for future development in the field of damage data collection and recording after a hazardous event, while keeping in mind the necessities and requirements established in the Sendai Framework for Disaster Risk Reduction which the UN General Assembly endorsed. This chapter is mainly focused on addressing the challenges identified throughout the development of this document, regarding loss accounting as a mean to reduce global disaster damages and losses.

- Not all the indicators can be calculated or calculated completely with the proposed database. It is the case of the poverty level as data to be collected in the aftermath of a hazardous event, which might present difficulties. It is why it is recommended to keep the practices that have been active so far used to calculate the affected economy group by a hazardous event, as the document by (CRED et al., 2016) did.

- As the Sendai Framework for Disaster Risk Reduction proposes the calculation of a baseline to compare the global targets against, the quality of the data from the Hyogo decade must be acceptable. For the case study of the Vall d'Aran, the quality of the data was good enough to estimate most of the indicators, 31 out of 33, but this might not be the case for every other event as depicted in the introduction of the present document. Therefore, this research recommends the calculation of the indicators for every event on the Sendai decade through a database system similar to the presented, so a trend can be projected and the comparison against the Hyogo decade can be evaluated from this trend.

- The concepts of spatial scale and location introduced in the attributes of the presented database, represent an opportunity to consider the different detailing levels of data collection and to ease the aggregation when necessary. These attributes correspond to the administrative division of the country to which the data belongs (spatial scale), and its respective name (location). This is based in the evidence that different public assets can be part of different levels of a country's administrative division while considering the same typology of the asset. For example, the road assets present this spatial particularity, where they can be attributed to different administrative units in terms of construction or reparation. The same case can be made for environmental or agricultural assets, that can possess a transboundary location, challenging the usual location by the smallest administrative unit that is present in most loss databases.

- Considering the Vall d'Aran case study and its optimal collected data, it must be highlighted the necessity of the implementation of the first level damage assessment in other detailed databases that might be done in the future that would like to be used for the computation of the SFA indicators, as suggested in the present document.

- The database must be adapted to the final version of the OIEWG 3rd Session of the Working Group that took place on 15-18 November 2016, where the indicators to monitor the progress of the Global Targets were updated once again.

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Appendix A

Appendix A.1

This appendix presents the queries required to compute all the indicators to monitor **Global Target A** on a national scale, based on the designed database. Indicator A1 is last presented because it requires the results of the other indicators to be computed.

Indicator	**A2: "Number of deaths/deceased due to hazardous events"**
SELECT	
	COUNT(Person.Vital_status) **AS 'Number of dead/deceased people'**
FROM	
	Person
WHERE	
	(Person.Vital_status = 'dead')

Indicator	**A3: "Number of missing/presumed dead due to hazardous events"**
SELECT	
	COUNT (Person.Missingness) AS **'Number of missing/presumed dead people'**
FROM	
	Person
WHERE	
	(Person.Missingness = 'yes')

Indicator	**A1: "Number of deaths/deceased and missing/presumed dead due to hazardous events per 100,000"**
SELECT	

```
(COUNT(Person.Vital_status) AS 'Number of dead/deceased
people',
FROM
            Person
WHERE
            (Person.Vital_status = 'dead') +
COUNT (Person.Missingness) AS 'Number of missing/presumed
dead people',
FROM
            Person
WHERE
            (Person.Missingness = 'yes')) *100.000 / Population[8]
FROM
    Person
```

[8] The ***Population*** constant, depends on each country's population

Appendix A.2

This appendix presents the queries required to compute all the indicators to monitor **Global Target B** on a national scale, based on the designed database. Indicator B1 is last presented because it requires the results of the other indicators to be computed as denoted in the equation (2).

Indicator	**B2: "Number of injured or ill people due to hazardous events"**
SELECT	
	COUNT (Person. Health_status) **AS 'Number of injured or ill people'**
FROM	
	Person
WHERE	
	(Person. Health_status = 'injured') **OR** (Person. Health_status = 'ill)

Indicator	**B3a: "Number of evacuated people due to hazardous events"**
SELECT	**COUNT** (Person. Housing_status) AS **'Number of evacuated people'**
FROM	Person
WHERE	(Person. Housing_status = 'evacuated')

Indicator	**B3b: "Number of relocated people due to hazardous events."**
SELECT	**COUNT** (Person. Housing_status) AS **'Number of relocated people'**
FROM	Person
WHERE	(Person. Housing_status = 'relocated')

Indicator	**B4: "Number of people whose houses were damaged due to hazardous events"**
SELECT	**COUNT** (Person. Person_ID) **AS 'Number of people with damaged house'**
FROM	Person, Housing_Unit
WHERE	(Person. Housing_Unit_ID = Housing_Unit. Housing_Unit_ID) **AND** (Housing_Unit. Status = 'damaged')

Indicator	**B5: "Number of people whose houses were destroyed due to hazardous events.**
SELECT	**COUNT** (Person. Person_ID) **AS 'Number of people with destroyed house'**
FROM	Person, Housing_Unit
WHERE	(Person. Housing_Unit_ID = Housing_Unit. Housing_Unit_ID) **AND** (Housing_Unit. Status = 'destroyed')

Indicator	**B6: "Number of people who received aid including food and non-food aid due to hazardous events"**
SELECT	**COUNT** (Person. Person_ID) **AS 'Number of people who received aid'**
FROM	Person,
WHERE	(Person.relief_aid = 'yes')

Indicator	**B1: "Number of affected people [by hazardous event] per 100,000"**
SELECT	**((COUNT** (Person. Health_status) **AS 'Number of injured or ill people'**

```
        FROM
                Person
        WHERE
                (Person. Health_status = 'injured') OR (Person. Health_status =
                'ill')) +
        (COUNT (Person. Housing_status) AS 'Number of evacuated people'
        FROM
                Person
        WHERE
                (Person. Housing_status = 'evacuated')) +
        (COUNT (Person. Housing_status) AS 'Number of relocated people'
        FROM
                Person
        WHERE
                (Person. Housing_status = 'relocated')) +
        (COUNT (Person. Person_ID) AS 'Number of people with damaged
        house'
        FROM
                Person,
                Housing_Unit
        WHERE
                (Person. Housing_Unit_ID = Housing_Unit. Housing_Unit_ID)
                AND
                (Housing_Unit. Status = 'damaged')) +
        (COUNT (Person. Person_ID) AS 'Number of people with destroyed
        house'
        FROM
                Person,
                Housing_Unit
        WHERE
                (Person. Housing_Unit_ID = Housing_Unit. Housing_Unit_ID)
                AND
                (Housing_Unit. Status = 'destroyed')) +
        (COUNT (Person. Person_ID) AS 'Number of people who received
        aid'
        FROM
                Person,
        WHERE
                (Person.relief_aid = 'yes'))) *100.000/Population
FROM
        Person,
        Housing_Unit
```

Appendix A.3

This appendix presents the queries required to compute all the indicators to monitor **Global Target C** on a national scale, based on the designed database. Indicator C1 is last presented because it requires the results of the other indicators to be computed as denoted in the equation (5). Indicator C10 is neglected as mentioned in Chapter 2

Indicator	**C2: "Direct agricultural loss due to hazardous events"**
SELECT	
	SUM (Agricultural_Asset. Economic_value) **AS 'Agricultural loss'**
FROM	
	Agricultural_Asset

Indicator	**C3: "Direct economic loss due to industrial facilities damaged or destroyed by hazardous events"**
SELECT	
	SUM (Industrial_facility. Economic_value) **AS 'Industrial facility loss'**
FROM	
	Industrial_facility

Indicator	**C4: "Direct economic loss due to commercial facilities damaged or destroyed by hazardous events"**
SELECT	
	SUM (Commercial_facility. Economic_value) **AS 'Commercial facility loss'**
FROM	
	Commercial_facility

Indicator	**C5: "Direct economic loss due to houses damaged by hazardous events"**
SELECT	
	SUM (Housing_Unit. Economic_value) **AS 'Fixing costs'**

FROM

Housing_Unit

WHERE

(Housing_Unit. Status = 'damaged')

Indicator	**C5b: "Damage and loss of administrative buildings"**
SELECT	
	SUM (Public_and_Strategic_Building. Economic_value) **AS 'Fixing costs'**
FROM	
	Public_and_Strategic_Building

Indicator	**C6: "Direct economic loss due to houses destroyed by hazardous events"**
SELECT	
	SUM (Housing_Unit. Economic_value) **AS 'Rebuilding costs'**
FROM	
	Agricultural_Asset
WHERE	
	(Housing_Unit. Status = 'destroyed')

Indicator	**C7: "Direct economic loss due to damage to critical infrastructure/public infrastructure caused by hazardous events"**
SELECT	
	(**SUM** (Health_facility. Economic_value) +**SUM** (Educational_facility. Economic_value) +**SUM** (Road. Economic_value) **AS 'Economic loss due to critical infrastructure'**
FROM	
	Health_facility, Educational_facilty, Road

Indicator	**C8: "Direct economic loss due to cultural heritage damaged or destroyed by hazardous events"**
SELECT	
	SUM (Cultural_Heritage_Asset. Economic_value) **AS 'Cultural Heritage loss'**
FROM	
	Cultural_Heritage_Asset

Indicator	C9: "Direct economic loss due to environment degraded by hazardous events"
SELECT	
	SUM (Environmenta_Unit. Economic_value) **AS 'Environmental loss'**
FROM	
	Environmenta_Unit

Indicator	C1: "Direct economic loss due to hazardous events in relation to global gross domestic product"
SELECT	
	(SUM (Agricultural_Asset. Economic_value) + **SUM** (Industrial_facility. Economic_value) **+** **SUM** (Commercial_facility. Economic_value)) + **(SUM** (Housing_Unit. Economic_value) **FROM** Housing_Unit **WHERE** (Housing_Unit. Status = 'damaged')) + **SUM** (Public_and_Strategic_Building.Economic_value) **+** **(SUM** (Housing_Unit. Economic_value) **FROM** Housing_Unit **WHERE** (Housing_Unit. Status = 'destroyed') (**SUM** (Health_facility. Economic_value) +**SUM** (Educational_facility. Economic_value) +**SUM** (Road. Economic_value) **+** **SUM** (Cultural_Heritage_Asset. Cost) **+** **SUM** (Environmental_Unit. Economic_value)**) /** ***GDP***
FROM	
	Agricultural_Asset Industrial_facility Commercial_facility Housing_Unit Public_and_Strategic_Building Health_facility, Educational_facilty, Road Cultural_Heritage_Asset Environmental Unit

Appendix A.4

This appendix presents the queries required to compute all the indicators to monitor **Global Target D** on a national scale, based on the designed database. Indicator D1 is last presented because it requires the results of the other indicators to be computed. It is worth mentioning that indicator **D4** is rather the generalization of its sub indicators which as seen in Chapter 2 are impossible to be summed up.

Indicator	**D2: "Number of health facilities destroyed or damaged by hazardous events"**
SELECT	
	COUNT (Health_facility_ID. Health_facility) **AS 'Number of affected health facilities'**
FROM	
	Health_facility
WHERE	
	(Health_facility. Economic_value > 0)

Indicator	**D3: "Number of educational facilities destroyed or damaged by hazardous events"**
SELECT	
	COUNT (Educ_facility_ID. Educational_facility) **AS 'Number of affected educational facilities'**
FROM	
	Educational_facility
WHERE	
	(Educational_facility. Economic_value > 0)

Indicator	**D4b: "Kilometers of road destroyed or damaged per hazardous event"**
SELECT	
	SUM (Road. Affected_length) **AS 'Affected road length '**

FROM

Road

Indicator	D4c: "Number of bridges destroyed/damaged by hazardous event"

SELECT

COUNT (Bridge. Bridge_ID) **AS 'Number of affected bridges'**

FROM

Bridge

WHERE

(Bridge. Economic_value > 0)

Indicator	D4d: "Kilometres of railway destroyed / damaged by hazardous event"

SELECT

SUM (Railway. Affected_length) **AS 'Affected railway length '**

FROM

Railway

Indicator	D4k: "Number of airports destroyed / damaged by hazardous event"

SELECT

COUNT (Airport. Airport_ID) **AS 'Number of affected airports'**

FROM

Airport

WHERE

(Airport. Economic_value > 0)

Indicator	D4l: "Number of ports destroyed / damaged by hazardous event"

SELECT

COUNT (Port. Port_ID) **AS 'Number of affected ports'**

FROM

Port

WHERE

(Port. Economic_value > 0)

Indicator	D1bis: "Number of electricity plants / transmission lines destroyed or damaged by hazardous events"
SELECT	**COUNT**(**DISTINCT** Outage. Outage_ID) **AS 'Number of electric plants / transmission lines have been affected'**
FROM	Outage
WHERE	(Outage.Basic_Service = "Energy/Power system")

Indicator	D5: "Number of times basic services have been disrupted due to hazardous events."
SELECT	**COUNT** (Outage. Outage_ID) **AS 'Number of times basic services have been disrupted'**
FROM	Outage

Indicator	D1: "Damage to critical infrastructure due to hazardous events"
SELECT	(**SUM** (Health_facility.Economic_value) + **SUM** (Educational_facility.Economic_value) + **SUM** (Road.Economic_value) + **SUM** (Bridge.Economic_value) + **SUM** (Railway.Economic_value) + **SUM** (Airport.Economic_value) + **SUM** (Port.Economic_value) + **SUM** (Outage.Economic_value))
FROM	Health_facility, Educational_facilty, Road Bridge Railway Airport Port Outage