Shelter

Sustainable Historic Environments holistic reconstruction through Technological Enhancement & community-based Resilience

D.1.4. Multiscale Multisource Data Model

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Disclaimer:

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Definition, Acronyms and Abbreviations

Acronym	Full name
ADE	Application Domain Extensions
ANSI	American National Standards Institute
CCA	Climate Change Adaptation
CDM	Conceptual Data Model
CH	Cultural Heritage
CHM	Cultural Heritage Management
CNH	Cultural and Natural Heritage
CRED	Centre for Research on the Epidemiology of Disasters
CRM	Conceptual Reference Model
DBMS	Database Management System
DDP	Data-Driven Platform
DG-ECHO	Directorate General for European Civil Protection and Humanitarian Aid Operations
DMF	Data Mapping Form
DRM	Disaster Risk Management
DRR	Disaster Risk Reduction
DSS	Decision Support System
DTM	Digital Terrain Models
EID	European Interoperable Database
EO	Earth Observation
GIS	Geograghic Information System
GPS	Global Positioning System
HA	Historic Area
ICCROM	International Centre for the Study of the Preservation and Restoration of Cultural Property
ICOMOS	International Council on Monuments and Sites
IMGeo	Information Model Geography
INS	Inertial Navigation System
INSPIRE	Infrastructure for Spatial Information in the European Community
IUCN	International Union for the Conservation of Nature
JDBC	Java Database Connectivity
KCHDM	Korean Cultural Heritage Data Model
KPI	Key Performance Indicators
LoD	Levels of Detail
MMDM	Multiscale Multisource Data Model
ODBC	Open DataBase Connectivity
OKF	Operational Knowledge Framework
OL	Open Lab
PSI	Public Sector Information
RD	Resilience Dashboard
REST	Representational State Transfer
SDI	Spatial Data Infrastructure
SLD	Styled Layer Descriptor
SNH	Scottish Natural Heritage
SQL	Structured Query Language
T	Task

Acronym	Full name
VPN	Virtual Private Network
WCS	Web Coverage Service
WFS	Web Feature Service
WMC	Web Map Context Documents
WMS	Web Map Service
WMTS	Web Map Tile Service
WP	Work Package
WPS	Web Processing Service
UNESCO	United Nations Educational, Scientific and Cultural Organization

1 Executive summary

This report presents the results of the Task 1.4 - "Multiscale Multisource Data Model" within Work Package (WP) 1 of the SHELTER Project. The objective of this task is to design a multiscale multisource data model to store the geospatial and semantic data provided by the external sources, e.g. the Open Labs, in order to facilitate its management and understanding.

The main objective is to 1) integrate complex and heterogeneous data, in a 2) unique data model to allow the 3) later visualization of the information at 4) different scales from building to cross-region and 5) to enable the creation of a 3D multiscale data model that will 6) define constructive elements of the urban/region environment with a level of detail accurate enough to visualize, in a friendly way, relevant Cultural Heritage and climate change information.

As first step, the main requirements that the data model in SHELTER should achieve have been identified. Those requirements for the SHELTER data model can be divided into three main categories: general requirements, geometric requirements and application specific requirements.

Then, a review of the existing reference data models related to resilience (and vulnerability) assessment on Historic Areas and Cultural Heritage has been identified, which include: INSPIRE Natural Risk Zone, INSPIRE Protected site, CityGML or ResCult, among others.

Next, the approach followed to identify which information needs to be included in the Multiscale Multisource Data Model has been described. This includes data from ontologies (for compatibility with the concepts within the specific identified ontologies), data related to the Open Labs data mapping form (where, as a result, tables in *Appendix II – Combination of entities* have been created) or data from macrocategories, which are building, urban and natural.

Next, in the design of the Multiscale Multisource Data Model, a number of base reference data models have been selected. These are the ResCult EID and the CityGML standard. Then, the main entities that the Multiscale Multisource Data Model must include have been identified. These are HistoricArea, ProtectedSite, HazardArea, RiskZone, ObservedEvent, ExposedElement and CityObjects (Building, Vegetation, WaterBody, Transportation, CityFurniture). A detailed description of each of these entities is provided too. In addition to that, the required data related to Resilience ID, Resilience Index, the SHELTER indicators and data related to the macrocategories has been identified and matched with the already defined entities (see section *6.2.4.2* for more details). As a result, the tables in *Appendix II – Combination of entities* and *Appendix III – Parameters association Macrocategories* have been created.

After the design of the Multiscale Multisource Data Model, its implementation has been performed using as basis the ResCult EID database structure and a CityGML implementation for relational databases called 3DCityDB. This has been extended with

SHELTER required data and relationships (SHELTER extension). As a result, a database model (tables and relationships) has been created to implement the SHELTER Multiscale Multisource Data Model.

2 Introduction

This section includes the aims and the objectives of the document, it analyses the relationships with other tasks/WPs and details the report of every partner of the SHELTER project.

2.1 Aims and objectives

As mentioned in the previous section, the main objective of this task is to design a Multiscale Multisource Data Model (MMDM) for the storage of the geometric and semantic data in order to facilitate management and understanding of the complex information handled by the different actors involved in Historic Areas (HA) and in specific actions for an active safeguarding of Cultural and Natural Heritage (CNH) against hazards.

The particularity of this data model is mainly that it is multiscale as well as it refers to the specificities of the CNH. These specifications require taking into account different categories and standards, adopting a holistic, cultural and natural approach to heritage.

Other secondary objectives are:

- To define a MMDM considering the main European standards and programs facilitating the interoperability with models and tools in common use.
- To design the MMDM considering the particularities of the information regarding the different spatial scales and their connections within HA.
- To design the MMDM considering the particularities of the different heterogeneous information provided by multiple sources of data.
- To design the MMDM considering the incorporation of the concepts identified in the ontologies and best practices described in T1.2 – "Codification of existing knowledge".
- To design the MMDM considering the incorporation of the concepts identified in the CHN categories and combine it with the different SHELTER scales described in T2.3 – "Anatomy of HA: collective characterisation of CH assets".
- To design the MMDM considering the incorporation of Resilience related data, which includes Resilience ID, Resilience Index and SHELTER indicators.
- To design the MMDM in a clear way in order to be created and made accessible for each OL, later in WPs 5 and 7.
- The implementation of the MMDM in a geospatial database.

2.2 Relations with other activities in the project

The SHELTER project has been structured in 9 WPs to ensure fertilisation among the different steps and partners. The main objective of WP1 (Knowledge base: operationalising existing data and knowledge) is to identify and operationalise existing

data, information and knowledge sources defining the data and knowledge structures where all the data collected and generated during the project will be organised and exploited (see *Figure 1*):

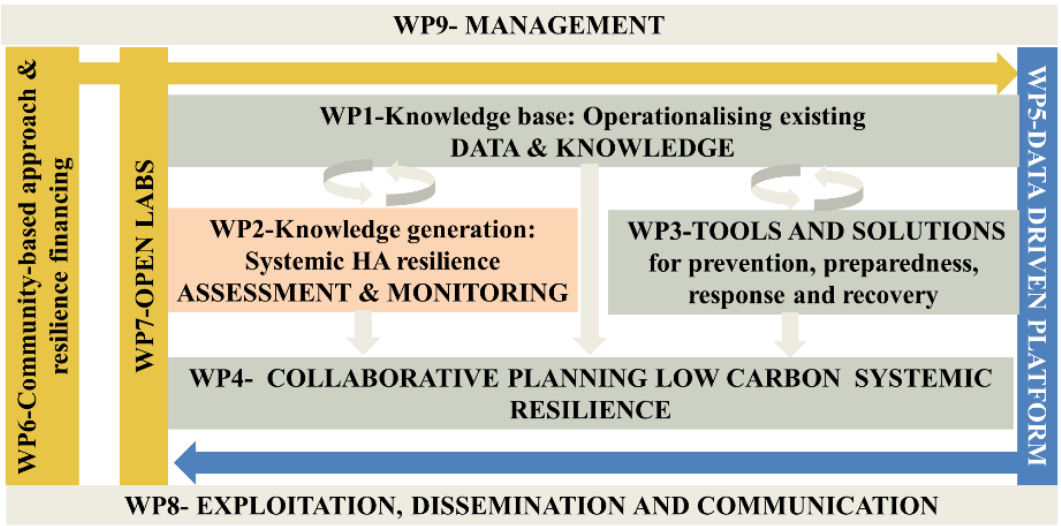


Figure 1 – PERT chart of SHELTER

Within WP1, the aim of T1.4 – "Multiscale Multisource Data Model" is the definition, the design and the implementation of the multiscale data model that will serve as a basis for storing the geoinformation and metadata collected in SHELTER project.

This task has a strong relation with other WPs in SHELTER, since it establishes the basis for the results of the project. The main relationships are the following:

WP1: Knowledge base: operationalising existing data and knowledge

- In T1.1 the identification, classification and evolution of useful data sources have been performed. The information collected in the Data Mapping Form (DMF) has been considered in order to define the MMDM structure.
- In addition to that, when designing the data model, the concepts identified in the ontologies and the best practices collected in T1.2 – "Codification of existing knowledge" have been also incorporated.
- In T1.3 a DataLake model will be defined to store the knowledge collected and generated during the project activities, from which MMDM will retrieve the data.

WP2: Knowledge generation: Systemic Historic Area (HA) resilience assessment and monitoring

- The list of indicators identified in T2.2 – "HA Systemic resilience assessment and monitoring framework" has been also considered for MMDM. For each of the indicators, a matching with one of the defined entities in the MMDM has been performed.

- Also, data from T2.3 – "Anatomy of HA: collective characterisation of CH assets" have been included in the MMDM, which is related with the macrocategories building, natural and urban.
- The resilience index and the definition of the Key Performance Indicators (KPIs) for resilience monitoring are being identified in T2.7, where a set of indicators will be defined. The aim of the indicators will be to quantify the links between multiple dimensions of HA resilience, the connections between different spatial scales and the changes across temporal scales. These tools will be based on information from the data model and other external sources for the assessment of resilience through the methodology and indicators that will be defined in T2.7 – "Development the SHELTER cross-scale HA systemic resilience assessment methodology".

WP4: Collaborative planning for building low carbon systemic resilience

- T4.1 will define in detail the incremental strategy for the implementation of the Resilience ID, the workflow to generate it using the Data-Driven Platform (DDP), the structure of the information and the visualisation in the multiscale data model.

WP5: Data Driven Platform

- WP1 outputs represent one of the main inputs for the DDP of WP5 and the T5.3 – "Historic Areas Resilience Dashboard". Indeed, datasets, existing knowledge, the data lake and the MMDM are all fundamental pillars to the design, development and implementation of the DDP.

WP6: Community-based approach and resilience financing

- T6.1 identified the GLOCAL user requirements for SHELTER project. User requirements related with the data have been used to define the general requirements of the MMDM.

WP7: Open Labs

- The relation between T1.4 and the OLs is crucial. For each of the OLs the MMDM defined in T1.4 needs to be created and completed with geometric and semantic data.

2.3 Report structure

The document is structured as follows:

- **Section 2** establishes the purpose of the deliverable and the links with other WPs and tasks of SHELTER project.
- **Section 3** identifies the requirements that the MMDM must meet.
- **Section 4** describes the state of the art regarding the existing data models for the resilience management of historic environments.

- **Section 5** describes the approach followed to identify which information needs to be included in the MMDM, such as ontologies, DMF or macrocategories.
- **Section 6** describes the design of the MMDM, defining which are the base data models, their integration and the proposed extension for SHELTER.
- **Section 7** describes the implementation of the MMDM.
- **Section 8** details the conclusions of the deliverable.
- **Section 9** contains the references used in this document.
- **Appendices** include tables with different information in relation to the deliverable.

2.4 Contribution of partners

The following table (*Table 1*) details the contribution of each partner to the writing of the present deliverable:

Partner	Contribution
EGIS	Responsible for the coordination of the task and deliverable. Drafting of section 1, 2, 3, 5, 6, 7 and 8. Responsible for sections 3 General requirements, 5.2 Identification of available data sources and 7 Implementation of data model. Contributions to the rest of sections. Review of the entire deliverable.
TEC	Responsible for sections 4 State of the art, 5 Data model approach and 6 Design of the MMDM. Contribution to section 1, 2 and 3 General requirements. Review of the entire deliverable.
POLITO	Constributions to sections 5 Connection with macrocategories and 6 Associaction of data sources with entities. Review of the entire deliverable.
UNIBO	Contributions to section 3 General requirements.
LINKS	Review of the entire deliverable.
SIST	Continuous update of the DMF, used as input for the analisys of available data sources (section 5.2 and section 10.1) and association of indicators with MMDM (section 10.2). Review of the entire deliverable.
RED	Contributions to section 3 General requirements and 5 Data model approach.

Table 1 – Contribution of partners

3 Requirements for the SHELTER Multiscale Multisource Data Model

SHELTER project is going to integrate local knowledge and existing data of different sources and different nature for the implementation of a DDP. These data are provided at different scales and are created using different tools, formats and approaches by different stakeholders, for different purposes and uses. The huge amount of existing data and its heterogeneity makes it crucial to have a proper information management strategy for informed decision-making for the resilience (and vulnerability) assessment on HAs and CNH. This strategy should link the information on the matter of CNH at different scales (building, district, city, region and cross-region) with different natural hazards (earthquakes, storms, floods, heatwaves, wildfires and subsidence) and human-induced hazards (see *T6.1* – "GLOCAL user requirements" [15]) from different domains (environmental, climatological, social, emergency management and others). Therefore, it will be necessary to design a MMDM to structure the relevant information gathered within a complete model which can support the decision making and tools that will be developed.

The first step for the definition of the data model is to identify the main requirements that the data model should achieve. Those requirements for the SHELTER data model can be divided into three main categories:

- General Requirements
- Geometric Requirements
- Application Specific Requirements

In the following sections, these requirements are divided into these three categories. Each requirement has a unique identifier and it also includes whether the requirement is mandatory or optional.

These requirements have been obtained from the analysis carried out in T6.1 in which user's requirements related to the data have been identified and from the experience of the authors in the development and implementation of geospatial models.

3.1 General Requirements

The following table (*Table 2*) represents the main general requirements for SHELTER MMDM, taking into account SHELTER project conceptualisations on the matter of CNH holistic approach and categorisation, spatial scales, standards, local user requirements or macrocategories, among others:

ID	REQUIREMENT	MANDATORY OPTIONAL
REQ_GEN_1	SHELTER data model must support information at different scales, from building to cross-regional	**Mandatory**
REQ_GEN_2	SHELTER data model must include geographic, 2D and 3D as well as semantic information (attributes/ properties/ values)	**Mandatory**
REQ_GEN_3	SHELTER data model must include information on the	**Mandatory**

ID	REQUIREMENT	MANDATORY OPTIONAL
	different hazards to be analysed	
REQ_GEN_4	SHELTER data model must be based on standards in order to facilitate interoperability	**Mandatory**
REQ_GEN_5	SHELTER data model must include the information regarding Resilience ID	**Mandatory**
REQ_GEN_6	SHELTER data model and all the elements included must be correctly georeferenced on a universal coordinate system in latitude, longitude and elevation	**Mandatory**
REQ_GEN_7	SHELTER data model should be easily extensible in both, spatial extension of the model (increasing the extension of HA) and regarding CNH categories and related attributes (adding new properties)	**Mandatory**
REQ_GEN_8	Geometric and semantic information of the SHELTER data model must be represented in different layers, to reduce coupling and promote its reuse	**Optional**
REQ_GEN_9	SHELTER data model should be able to include information from at least the five OLs: Ravenna, Seferihisar, Dordrecht, Baixa Limia-Serra Do Xurés and Sava River Basin	**Mandatory**
REQ_GEN_10	SHELTER data model must allow system administrators to easily update relevant content (e.g. update areas affected by hazards or disaster events)	**Mandatory**
REQ_GEN_11	SHELTER data model should contain information on CNH elements and their status in the HA	**Optional**
REQ_GEN_12	It must be assured that information processed and stored in SHELTER data model is secure	**Mandatory**
REQ_GEN_13	SHELTER data model shall support the organization of the information collected to enable an effective consultation and analysis	**Optional**
REQ_GEN_14	SHELTER data model should include an Index or conceptual scheme of the information stored to facilitate data/information retrieving	**Mandatory**
REQ_GEN_15	It should be allowed to modify accessibility permissions of users at any moment	**Mandatory**
REQ_GEN_16	SHELTER data model should include the possibility to search for information/data by different parameters (e.g., keywords, synonym of keywords, multiple filters)	**Mandatory**
REQ_GEN_17	SHELTER data model should be linked historical information of CNH and past events of the different hazards to be analysed	**Mandatory**
REQ_GEN_18	Administrators of SHELTER data model should be able to audit past and present activity carried out by the direct users.	**Optional**
REQ_GEN_19	Semantic information should be based on defined ontologies, standards, normative, directives or guidelines recognized by international experts	**Mandatory**
REQ_GEN_20	Semantic information must be linked to the corresponding geometric element	**Mandatory**

Table 2 – General requirements

3.2 Geometric Requirements

The following table (*Table 3*) represents the main requirements for the geometric information for SHELTER MMDM:

ID	REQUIREMENT	MANDATORY OPTIONAL
REQ_GEO_1	SHELTER data model must allow representation of geometric information with different levels of detail	**Mandatory**
REQ_GEO_2	The language or file format for the representation of geometric information should allow modelling and storing geographic information	**Mandatory**
REQ_GEO_3	SHELTER data model must store information representative of the study areas	**Mandatory**
REQ_GEO_4	SHELTER data model must be able to represent different natural elements as well as elements in human settlements of differents scales such as buildings, public spaces, green areas or water bodies	**Optional**
REQ_GEO_5	SHELTER data model must store information of the geometry of natural and urban elements	**Mandatory**
REQ_GEO_6	The geometry of building, natural and urban elements must be correctly referenced in altitude with respect to the elevation model	**Mandatory**
REQ_GEO_7	Spatial information can be represented in vector or raster formats	**Mandatory**
REQ_GEO_8	The geometric information in vector format can be represented by points, lines or polygons	**Mandatory**
REQ_GEO_9	Linear geometry of a layer must not overlap with lines of the same entity	**Mandatory**
REQ_GEO_10	The linear geometry must not overlap with itself	**Mandatory**
REQ_GEO_11	The linear geometry of an entity must be a single part avoiding multipart features	**Mandatory**
REQ_GEO_12	The interior of a polygon in a layer must not overlap. They can simply share edges or vertices	**Mandatory**
REQ_GEO_13	The geometric elements must have the same coordinate system, if not, they must be projected in the same system to be referenced equally positionally	**Mandatory**
REQ_GEO_14	For raster elements, the spatial resolution (pixel size) must be appropriately defined taking into account the display scale	**Opcional**
REQ_GEO_15	The geometric elements must have an adequate numerical precision for an exact cartographic and analytical representation	**Opcional**

Table 3 – Geometric requirements

3.3 Application Specific Requirements*

The following table (*Table 4*) represents the application specific requirements for SHELTER MMDM:

ID	REQUIREMENT	MANDATORY OPTIONAL
REQ_APP_1	It should be able to authenticate with the external Authentication server with AA server	**Optional**
REQ_APP_2	It should be able to hold information from the Resilience Index (Resilience ID)	**Optional**
REQ_APP_3	It should be able to show aggregated information from Social Media Module	**Optional**
REQ_APP_4	It should be able to display aggregate IoT information	**Optional**
REQ_APP_5	SHELTER data model must allow easy integration of new data/information sources (e.g. addition in case studies of new tools and/or sensors)	**Optional**
REQ_APP_6	SHELTER data model should allow direct stakeholders to set automatic notifications/alert when new relevant information/data or specific parameters are processed by the system	**Optional**
REQ_APP_7	SHELTER data model should record all direct stakeholder's actions, processing and decisions (Who, What, Where, When - and in some cases Why) This can be seen in an audit log file	**Optional**

Table 4 – Application specific requirements

*At this time, the scope of these requirements can not be completed as the Resilience Dashboard (RD) and the tools and utilities of the Shelter system are not defined yet. The application specific requirements table will be completed before the end of the SHELTER Project. If the update is necessary, the correponding annexes to the document will be added, reflecting it in the T5.3 or in the tasks that generate inputs for the final definition of the model.

4 State of the art on existing georeferenced data models for resilience management of historic areas

The Multiscale Multisource Data Model defines the representation and storage of data describing a HA. To facilitate subsequent processing of these data is important to comply with standard or international directives. The use of standards is the key to ensuring the long-term impact of the proposed solutions. Some international references to be considered for data modeling solutions are listed below:

4.1 Generic overview

There are multiple directives, policies and initiatives related with the representation, storage and management of information about CNH and HA. Some of them are described below:

The Public Sector Information (PSI) directive (2003/98/CE- modified April 15, 2013) sets the legal framework for the reuse of PSI by the private sector with commercial and noncommercial purposes. It establishes the right to re-use public documents and recognizes the value of publishing open data, not just economic but also social, as the main factor to promote transparency.

IMGeo (Information Model Geography) is the Dutch standard for the exchange of large scale geographic information. This standard includes the documentation of elements such as roads, tunnels, water bodies, land use and others. IMGeo intended to be a representation system for scale-independent objects that provides uniform national coverage. IMGeo 2.0 has legal status in the Netherlands. IMGeo is 2D, but extensible to 2.5D and finally to 3D. IMGeo is based on CityGML and also recognizes different levels of detail (LoD). The Netherlands is the first country that has made a national standard based on the CityGML standard for the representation of geospatial information.

A review that attempts to describe the use of Geographic Information System (GIS) in CH has been performed by the Urban Engineering and Regional Development Department of the Urban Technical University of Civil Engineering of Bucharest. The main objective of the work is to facilitate the exchange of information between the actors involved in the implementation of such systems in different countries [1].

Another approach is the one presented in: *A data model for Cultural Heritage within INSPIRE* [2]. In that document the authors present a technical guideline in order to develop an Infrastructure for Spatial Information in the European Community (INSPIRE) Conceptual Data Model (CDM) for CNH [3].

Another point of view is the design of a semantic data infrastructure for heterogeneous CNH data, which aims to provide the possibility of a semantic link between heterogeneous datasets. In order to do that, they propose a structure of metadata schemas to incorporate resources from heterogeneous databases that already have

their own metadata schemas. They propose as a result the Korean Cultural Heritage Data Model (KCHDM) [4].

Using ontologies is another approach in order to perform CNH data management. In this work, a summary of the present potentials and challenges for using CIDOC Conceptual Reference Model (CRM) for solving the CNH data management and integration puzzle is presented [5].

Another initiative is offered by the Copernicus program, which can contribute to the preservation and management of both tangible and intangible CNH. Earth Observation (EO) data is becoming increasingly instrumental, with numerous projects and applications aimed at providing products tailored to the needs of CNH [Link1].

Finally, initiatives such as the Scottish Natural Heritage (SNH) will support projects that encourage visitors to experience more of the unique nature and culture of the Highlands & Islands [Link2].

4.2 Reference Data Models

To carry out the data model, different existing models have been taken as a reference. The study of each model is detailed below.

4.2.1 CityGML

CityGML [Link3] is an open data model based on Extensible Markup Language (XML) format for storage and exchange of virtual models of 3D city defined by the Open Geospatial Consortium (OGC) [Link4]. The aim of the development of CityGML was to reach a common definition and understanding of the basic entities, attributes, and relations within a 3D city model [7]. This is especially important since it allows the reuse of the same data in different fields of application. The extension of the 3D model with semantic information is the main feature of the CityGML data model. CityGML extends the geometric information with additional information on the use and function of objects through an ontology defined in this data model. The aim of this approach is to ensure the integrity and validity of the model city to be useful for administrative use. CityGML is based on Geography Markup Language (GML).

Each component in CityGML is a CityObject. Subclasses of CityObject represent different thematic modules of the city model. CityGML defines modules for the terrain, buildings, bridges, tunnels, coverage by land use objects, water bodies, vegetation, generic city objects, city furniture objects, city object groups and transportation.

Each thematic module includes features. Features represent real-world entities such as buildings, walls, windows, rooms, railway, road, square, etc. Spatial properties of CityGML features are represented by geometry models. The geometry model in CityGML is based on the standard GML3. Generally, most of the features have the attributes class (classification), function (aimed functionality) and usage (current usage). Specific attributes are also defined for each feature and additional attributes

can be included for each of them. The CityObjectGroup module provides a grouping concept for CityGML. Arbitrary city objects may be aggregated in groups according to user-defined criteria to represent and transfer these aggregations as part of the city model.

The main characteristics of CityGML Data Model are:

Modularity: CityGML data model is broken down into a core module and thematic extension modules. The main module covers the basic concepts and components of the CityGML data model and, therefore, must be executed by any system. Based on the core module, each extension covers a specific topic within the virtual 3D city model. The CityGML data model includes the geometry and thematic information of the different city elements such as digital terrain model, buildings, vegetation, water bodies, transportation facilities and urban furniture. Other objects, which are not explicitly modelled, can be represented using the concept of generic objects and attributes. Extensions can be made in the CityGML data model using the ADE.

Multi-scale Modelling: CityGML supports different LoD. The LoD are necessary to adjust the level of detail of the information to the requirements of each application. Moreover, LoD facilitates visualization and analysis of data. CityGML represents the same object with different LoD simultaneously. This allows analyzing and displaying the same object with different degrees of resolution (see *Figure 2*). LoDs defined in CityGML are:

- LoD0: The digital terrain model in two and a half dimensions. A map or aerial image can be represented by this level.
- LoD1: The block model including buildings represented as simple blocks with flat roofs.
- LoD2: Differentiates between the surfaces of façades and roof, as well as the type of the roof. Vegetation objects can also be represented.
- LoD3: Details architectural models with walls, roofs, openings (windows and doors). High resolution textures can be applied to these structures. In addition, detailed vegetation and transportation objects can be represented at this level.
- LoD4: Completes LoD3 adding interior structures. For example, buildings are composed of rooms, doors, stairs and furniture.

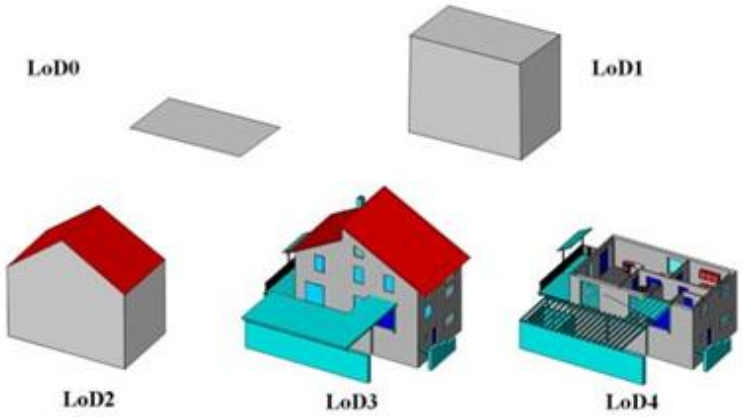


Figure 2 – LoDs in CITYGML [8]

Coherence between semantics and geometry: CityGML represents the graphical appearance of city models and also semantic and thematic properties, taxonomies and aggregations. One of the most important design principles of CityGML is the coherent modeling of the semantic and geometrical properties. At the semantic level, real-world entities are represented by features such as buildings, walls, windows or rooms. The description also includes the attributes, relationships and hierarchies of aggregation between features. Thus, part of the relations between features can be obtained from the semantic level without geometry. However, in spatial dimension, geometric objects are assigned to the features representing their spatial location and extension. The model consists of two hierarchies: semantics and geometric objects which are linked by relationships. *Figure 3* shows the coherence between semantics and geometry in CityGML.

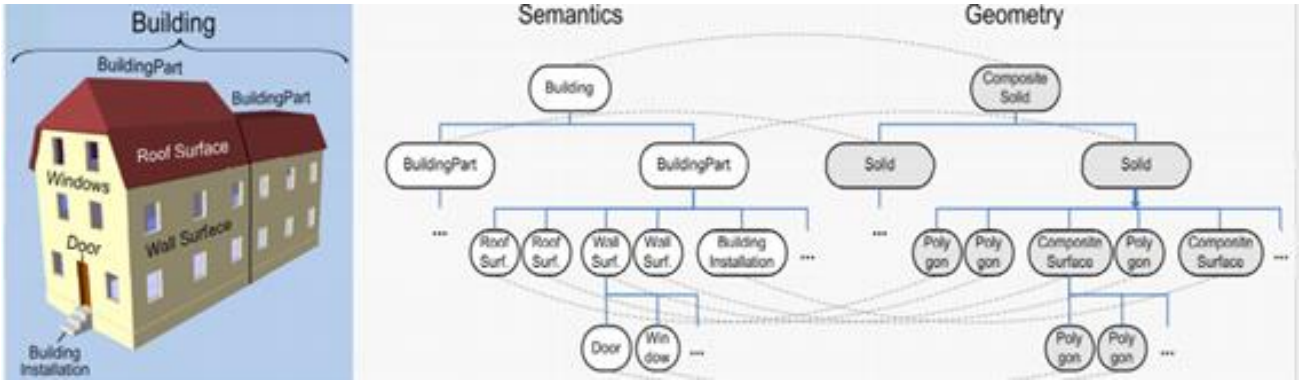


Figure 3 – Coherence between semantics and geometry in citygml [8]

Extensibility: CityGML has been designed as a universal model of topographic information that defines the most general types of objects and attributes that are included in the applications at urban scale. However, in real applications of the model, objects or attributes that are not explicitly defined in CityGML can be necessary. This is covered by the extension of CityGML. CityGML provides two different ways for the extensibility of the model:

- Generic objects and attributes: This concept allows the extension of CityGML applications without modifying the schema. Any object can be extended by additional attributes, whose names, data types and values can be provided by an application without any change to the CityGML schema. Similarly, the features that are not represented in the CityGML predefined themes can be modeled using generic objects defined in CityGML.
- Application Domain Extension: The ADE extensions specify the additions to the CityGML data model required for a specific domain. Such additions include the introduction of new features to existing classes of CityGML. For example, the number of inhabitants of a building or the definition of new object types. The difference between ADEs and generic objects and attributes is that an ADE has

to be defined in a new file that defines the XML schema with its own namespace. This file has to import explicitly the XML schema definition of the extended CityGML modules. The advantage of this approach is that the extension is formally specified. Extended documents can be validated against the schema of CityGML and ADE.

4.2.2 INSPIRE

The INSPIRE directive [6] establishes general rules for spatial information in the European Union. This directive requires data harmonization and interoperability of the system and its goal is to create a legal framework to establish an infrastructure for spatial information in Europe. INSPIRE will allow having more quantitative and reliable spatial data and will make existing data available to all (administrations, companies and citizens). One objective of this directive is to use and optimize the operation of currently existing spatial data. This requires that the data are properly documented and make information accessible through services thus achieving greater interoperability and data accessibility.

4.2.2.1 *Data specification on Natural Risk Zones*

INSPIRE includes a data specification related to vulnerable areas called Natural Risk Zones. It is focused on atmospheric, hydrological and seismic risks, volcanic phenomenon or natural fires, among others, that, due to their location, severity or frequency, may negatively affect the population. Some examples are floods, landslides and subsidence, avalanches, forest fires, earthquakes or volcanic eruptions.

One of the peculiarities of natural hazard zones data specification is that they are zones where natural hazard areas intersect with densely populated areas which possess a number of environmental, cultural or economic peculiarities.

In order to be able to define or pre-estimate a risk, some parameters need to be identified, such as:

- Potential hazard.
- Probability of its occurrence.
- Vulnerability of the exposed populations.
- Environmental assets.
- Cultural assets.
- Economic assets.

INSPIRE Natural Risk Zone has defined a classification of natural hazard, which are: geological, hydro-meteorological or biological. In addition to that, each hazard has certain attributes: magnitude or intensity, frequency, duration, area of extent, speed of onset, spatial dispersion and temporal spacing.

Different hazard types have been defined in the data specification:

- Floods (calculation of flood impact, reporting and flood hazard/risk mapping).
- Risk Management Scenario (an example from a national perspective).
- Landslides (hazard mapping, vulnerability assessment and risk assessment).
- Forest fires (danger, vulnerability and risk mapping).
- Earthquake insurance.

To facilitate semantic interoperability, this data specification includes a classification with two code lists that provide the type of natural hazards and the type of exposed item categorizations. These code lists are not intended to be exhaustive but they can be expanded with new terms by the Member States. Also, data providers can add a more specific classification for both concepts.

It is important that all potential users of information on natural hazard areas know what hazard is causing a particular area to be considered a risk area. It is essential for risk mitigation and management. For that reason, any provider must identify what type of natural hazard their data is related to and, for vulnerability data suppliers, what type of exposed item is at risk.

In *Figure 4*, a summary of the main concepts included in the INSPIRE Natural Risk Zones specification is presented.

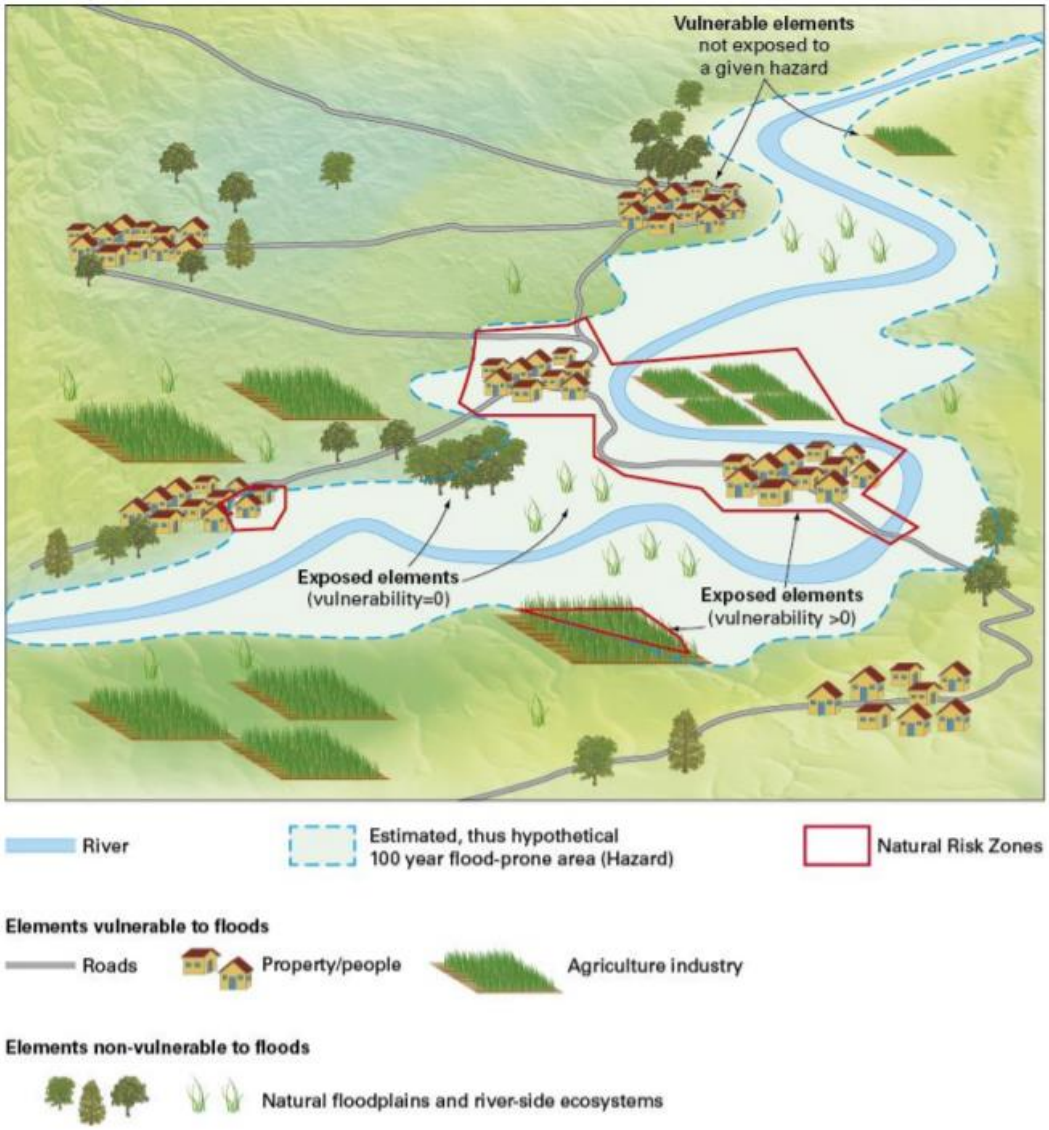


Figure 4 – INSPIRE Natural Risk Zones [16]

The model includes measured past events and modelled future events. It does not deal with real-time data or events as they are happening. This is the domain of monitoring and emergency response which is largely out of the domain of Natural Risk Zones.

The concepts included in the model are abstract and can be related to real HA or case studies using either vector or coverage spatial representation. This is done in order to create a framework which enables exchange of data that are either vector or coverage, considering that any of the spatial objects can be modelled in either way.

There are 4 key spatial object types that are modelled:

- Hazard area
- Observed event
- Risk zone
- Exposed element

The main entities included in risk zone specification are presented in *Figure 5*.

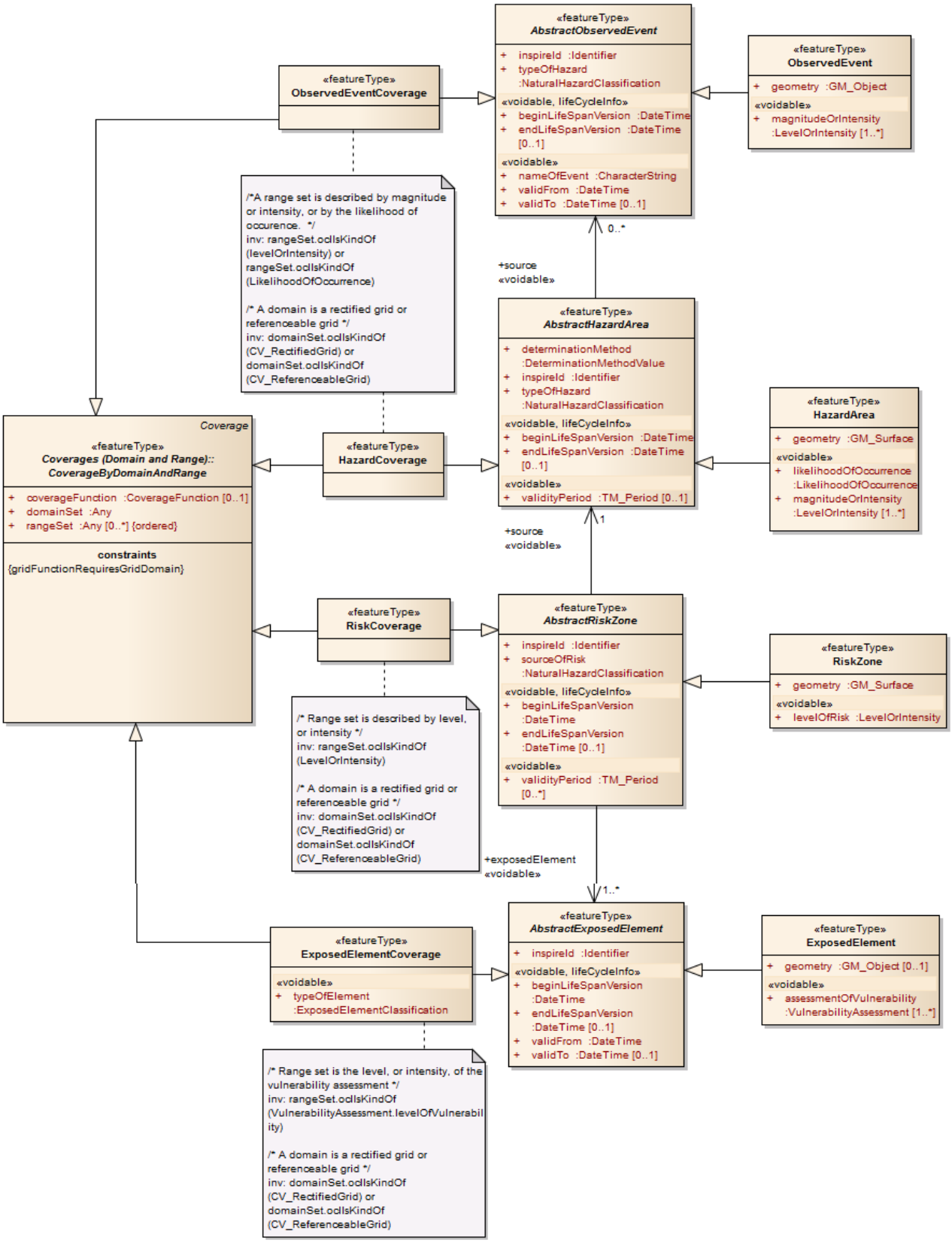


Figure 5 – Risk zone entities relationship model [Link11]

4.2.2.2 *Data specification on Protected Sites*

The INSPIRE Directive includes a data specification related to Protected Sites, defined as an "Area designated or managed within a framework of international, Community and Member States' legislation to achieve specific conservation objectives" [Directive 2007/2/EC].

According to the International Union for the Conservation of Nature (IUCN), the protected sites are the areas of land and / or sea especially dedicated to the protection and maintenance of biological diversity and natural and associated cultural resources, and managed through legal proceedings or other means.

Within the INSPIRE context, Protected Sites may be located in terrestrial, aquatic and/or marine environments, and may be under either public or private ownership.

Objectives for protection may include:

- The conservation of nature.
- The protection and maintenance of biological diversity and of natural resources.
- The protection of person-made objects including:
    - Buildings,
    - prehistoric and historic archaeological sites,
    - other cultural objects,
    - sites with specific geological, hydrogeological or geomorphological value.

Examples of legislation and policies that regulate protected sites are the Habitat Directive (1992) (Directive 92/43 / EEC), Birds Directive (Directive 79/409 / EEC), World Heritage, Ramsar Convention, Barcelona Convention, Helsinki Convention, OSPAR Convention, laws and other international sectoral policies.

The main entities included in protected site specifications are presented in *Figure 6*.

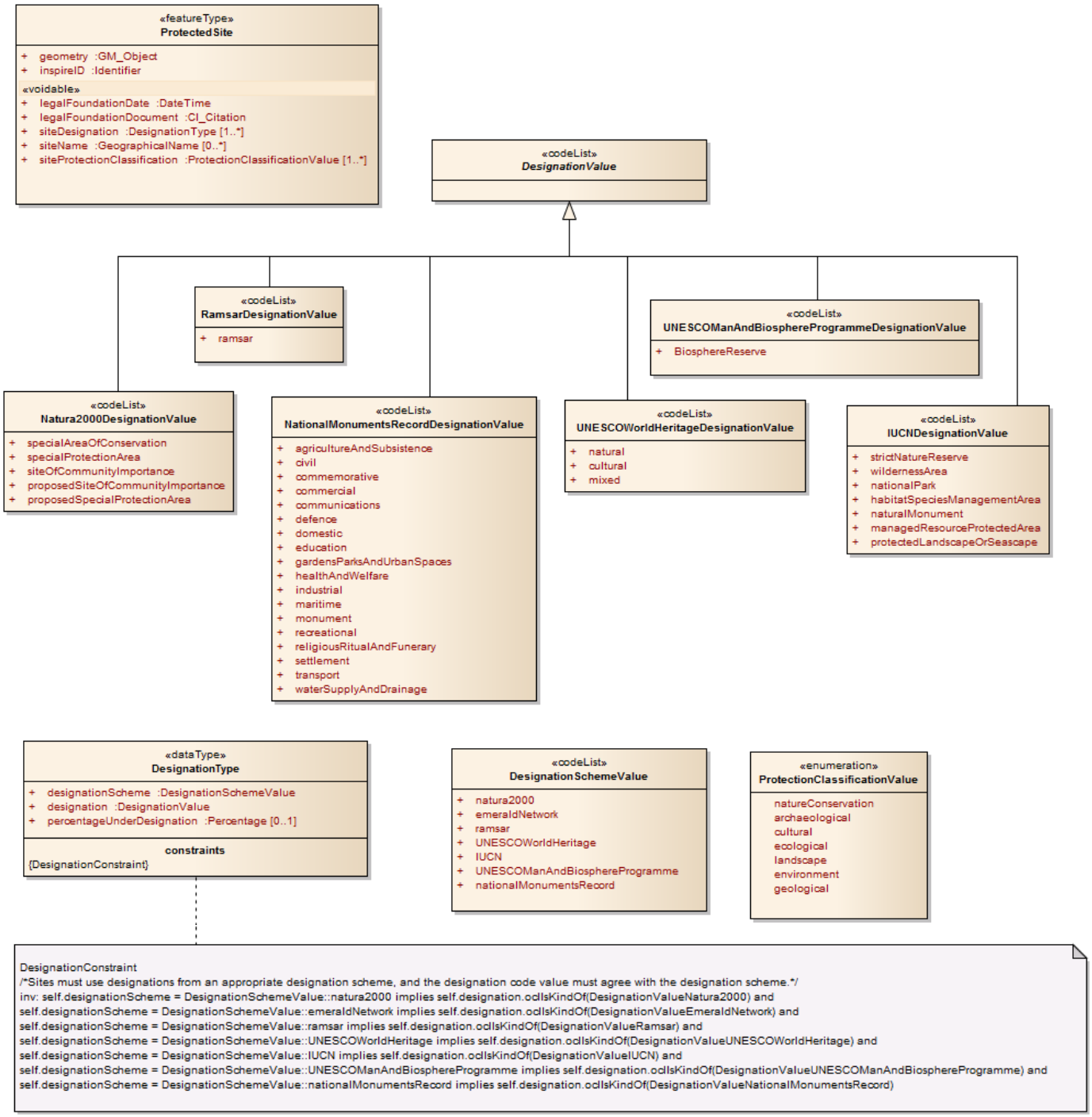


Figure 6 – Protected Sites entities relationship model [Link12]

4.2.2.3 *Data specification on Buildings*

INSPIRE includes a specification for the implementation of spatial data sets and services about buildings in the INSPIRE directive. This specification is focused mainly on buildings but it also includes other constructions of major interest for environmental applications.

The data specification on Buildings defines a data model that allows the multiple representations of buildings and constructions. They have defined four profiles with different LoD both in geometry and semantics (see *Figure 7*).

There are core profiles that contain the feature types 'building' and 'building part' and a limited number of attributes. Those core profiles are:

- Buildings2D, which includes various geometrical representations of buildings as 2D or 2.5D data.
- Buildings3D, which has some semantic as Building2D. Allows the 3D representation in four LoD.

The extended profiles contain recommendations that provide more detailed information. Also feature types 'other constructions', 'buildings' and 'installations' are defined.

- BuildingsExtended2D, a semantic extension of Building2D.
- BuildingsExtended3D, an extension of Building3D allowing rich 3D representations such as building boundaries, openings, interiors and textures.

	Basic semantic	Rich semantic
2D geometry	**Core 2D profile** *uses application schemas:* *- base* *- Buildings2D*	**Extended 2D profile** *uses application schemas:* *- base* *- Buildings2D* *- base extended* *- extended 2D*
3D geometry	**Core 3D profile** *uses application schemas:* *- base* *- Buildings3D*	**Extended 3D profile** *uses application schemas:* *- base* *- Buildings3D* *- base extended* *- extended 3D*

Figure 7 – 2D/3D Geometry [17]

- BuildingsBase: It is an abstract application schema that describes the feature types, data types and code lists that are common to all the four instantiable application schemas, namely 2D, 3D, extended2D and extended3D.
- Buildings2D: The buildings 2D application schema inherits of the semantics of BuildingsBase application schema and defines the geometric representation of buildings and buildings parts, using the data type BuildingGeometry2D, also defined in the BuildingBase application schema.
- Buildings3D: The buildings 3D schema is a normative profile offered to data producers of 3D building data, in order to enable to be INSPIRE conformant without having to flatten their data geometrically. The 3D representation has to be provided, using any of the LoD of CityGML.
- BuildingsExtendedBase: Buildings base extended is an abstract application schema describing the additional semantics that is common to instantiable

application schemas Building Extended2D and Buildings Extended3D. The features 'other constructions', 'installations' and 'building units' are added too.

- Buildings2DExtended: The aim is to be a recommendation for data providers willing to give more information than the basic one included in core 2D profile. This extended profile may be used as a whole or only partly. It's an extension of Buildings2D profile and BuildingsExtendedBase.
- Buildings3DExtended: The aim is to be a recommendation for data providers willing to give more information than the basic one included in core 3D profile. This extended profile may be used as a whole or only partly. It's an extension of Buildings3D profile and BuildingsExtendedBase. Moreover, the components of the building may also be semantically described by specific feature types:
    - In LoD2: Boundary surfaces (such as walls or roofs) and installations are added.
    - In LoD3: Openings (such as doors and windows) are added.
    - In LoD4: The interior of the building (building units, rooms, internal installations) is added.

Figure 8 summarizes the application schemas within the Data Specification on Buildings:

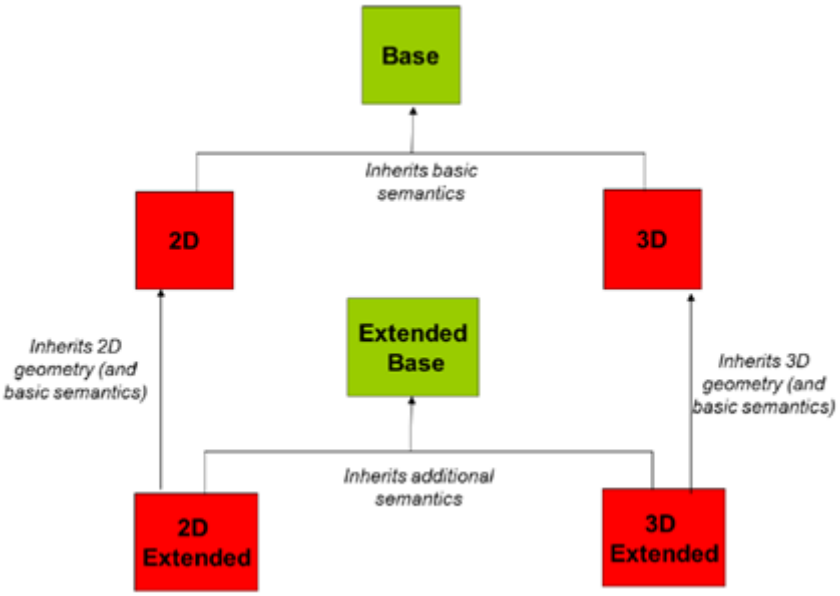


Figure 8 – Application Schema within Data Specification on Buildings [17]

The Core 3D profile and Extended 3D profile share many properties with CityGML, particularly the representation of the 3D geometry. There are different tools that allow the generation, storage, visualization and importation/exportation of CityGML files. However, these CityGML tools cannot be used directly for INSPIRE building data, because there are small differences between them.

In order to ease the importation/exportation between CityGML and INSPIRE building data a CityGML ADE (Application Domain Extensions) has been designed for the Core3D profile.

An ADE for the Extended 3D profile (application schema BuildingsExtended3D) is in preparation. In these ADEs, those properties which are shared by INSPIRE and CityGML are inherited from CityGML, while properties which are different or additional in INSPIRE are defined in the CityGML ADE for INSPIRE.

The main entities included in building specification are presented in *Figure 9*.

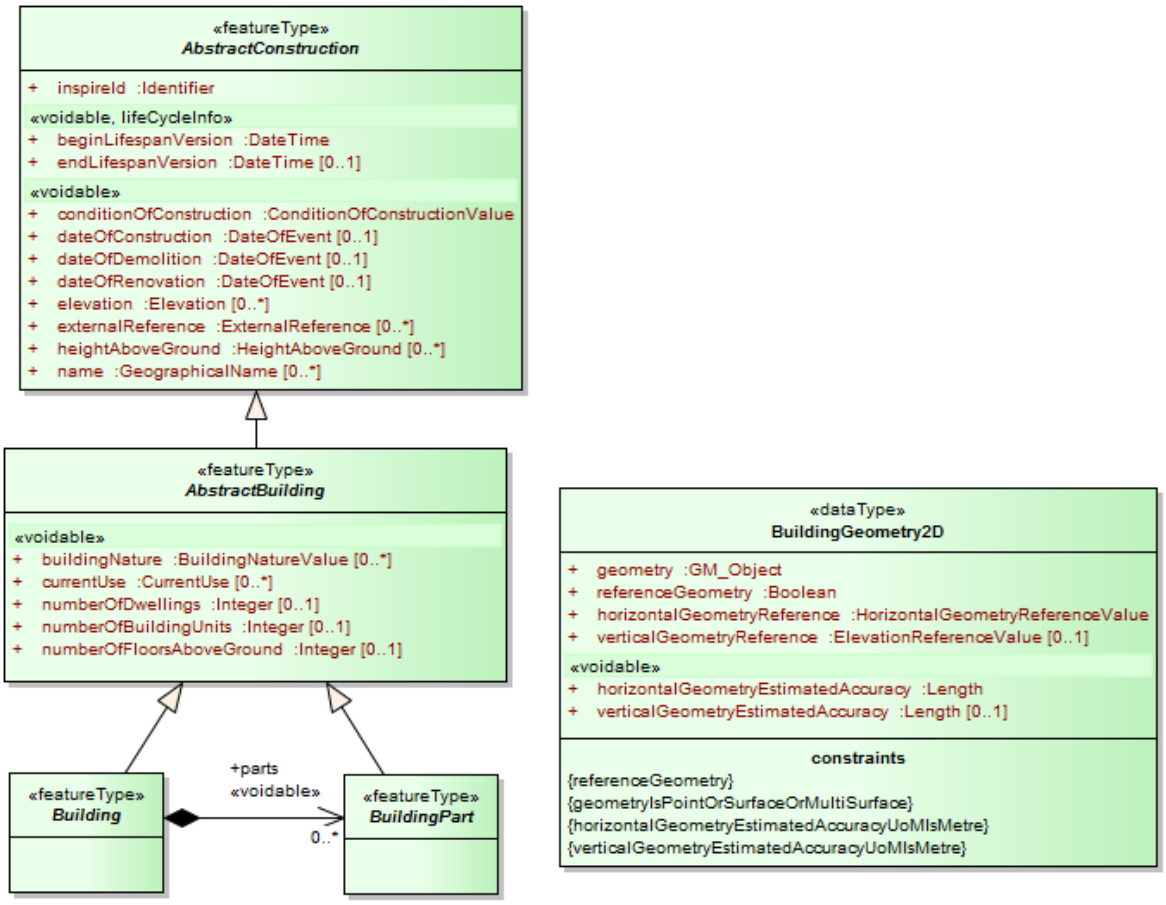


Figure 9 – Building entities relationship model [Link13]

4.2.3 ResCult EID

ResCult [Link6] is a project funded (2016-2018) by the European Commission with the European Union Humanitarian Aid and Civil Protection, in the Directorate General for European Civil Protection and Humanitarian Aid Operations (DG-ECHO) program, in order to enhance the capability to prevent the impact of disasters (natural or man-made) on CNH.

The European Interoperable Database (EID) is the key outcome of the ResCult project. It represents a composite tool designed to support emergency operators, authorities and decision-maker in protecting CNH against natural hazards.

The project aims at enhancing the capability of European Civil Protection to prevent disaster impacts on CNH by implementing an EID as a supporting decision tool. EID is intended to help stakeholders to understand the risk of damage to cultural assets, as well as possible impacts on cohesion, sustainable cultural tourism and engagement with local communities in the protecting environment.

As it is shown in *Figure 10*, EID is made by different components:

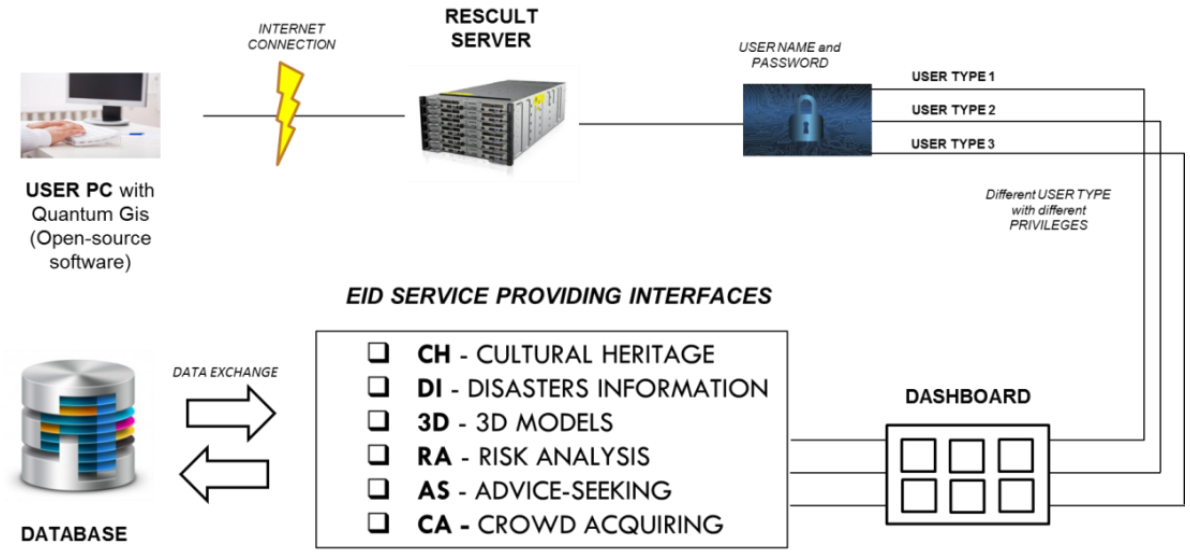


Figure 10 – ResCult EID components [Link10]

The core component is a database, designed and implemented to support emergency operators by providing six different interfaces:

1) Cultural Heritage.
2) Disaster information.
3) 3D models.
4) Risk analysis.
5) Advice-Seeking.
6) Crowd Acquiring.

The EID might offer a unique framework and a supporting decision tool to understand the risk of damage to CNH (included architectural heritage) as well as its impact on cohesion, sustainable cultural tourism and engagement with local communities in protecting the environment.

The EID manages a 3D European Heritage Map and helps in developing a Disaster Risk Reduction (DRR) strategy according to the Sendai Framework principles in order to improve both prevention and resilience capacities [9][10].

During the first phases of ResCult, the INSPIRE data model and CityGML were considered according to completeness, updating, extensibility and international acknowledgement. INSPIRE was taken into account as regards the harmonized spatial information as reference for the European Community. CityGML was chosen for its specific semantics about city objects representation. Moreover, CityGML includes the Level of Details (LoDs) concept, which foresees multiscale 2D and 3D representations of city and buildings. For further developments, the granularity of LoDs can be enhanced and further extended in order to represent more suitably the necessary architectural elements. Finally, some existing standards about classifying risks and hazards were considered analysing recent documents of UNESCO (UNESCO, ICCROM, ICOMOS-IUCN, 2010) and INSPIRE data model (CRED classification of Natural Disaster). The final ResCult classification of risks and hazards considers natural and man-made disasters.

The EID CDM (see *Figure 11*) was finally developed extending the INSPIRE data model, in order to operate in a unique and interoperable international framework. It deals in particular with three main parts of the INSPIRE data model: the first one is 'ProtectedSite' theme of the Annex I of the INSPIRE data model, for representing objects needing protection due to various reasons (ecological, biological, cultural) and legally acknowledged. This is the entity most useful to describe CNH, once it is suitably extended. Another part considered in the ResCult INSPIRE extension is the 'NaturalHazard' theme (INSPIRE Annex III), for connecting directly the object exposed to the risk and the description of the risk itself. Finally, the 'Building' theme (INSPIRE Annex III) is considered and extended, adding attributes and useful features to archive effective information for architectural heritage. The extension is described in more detail in [11]. However, further improvements are needed to specifically represent different types of built heritage with a very high level of detail in order to better describe the structural behaviour of single elements, which is important for preventing damages in case, for example, of earthquakes, as stated by the updates of the Italian Directive (Model A-DC).

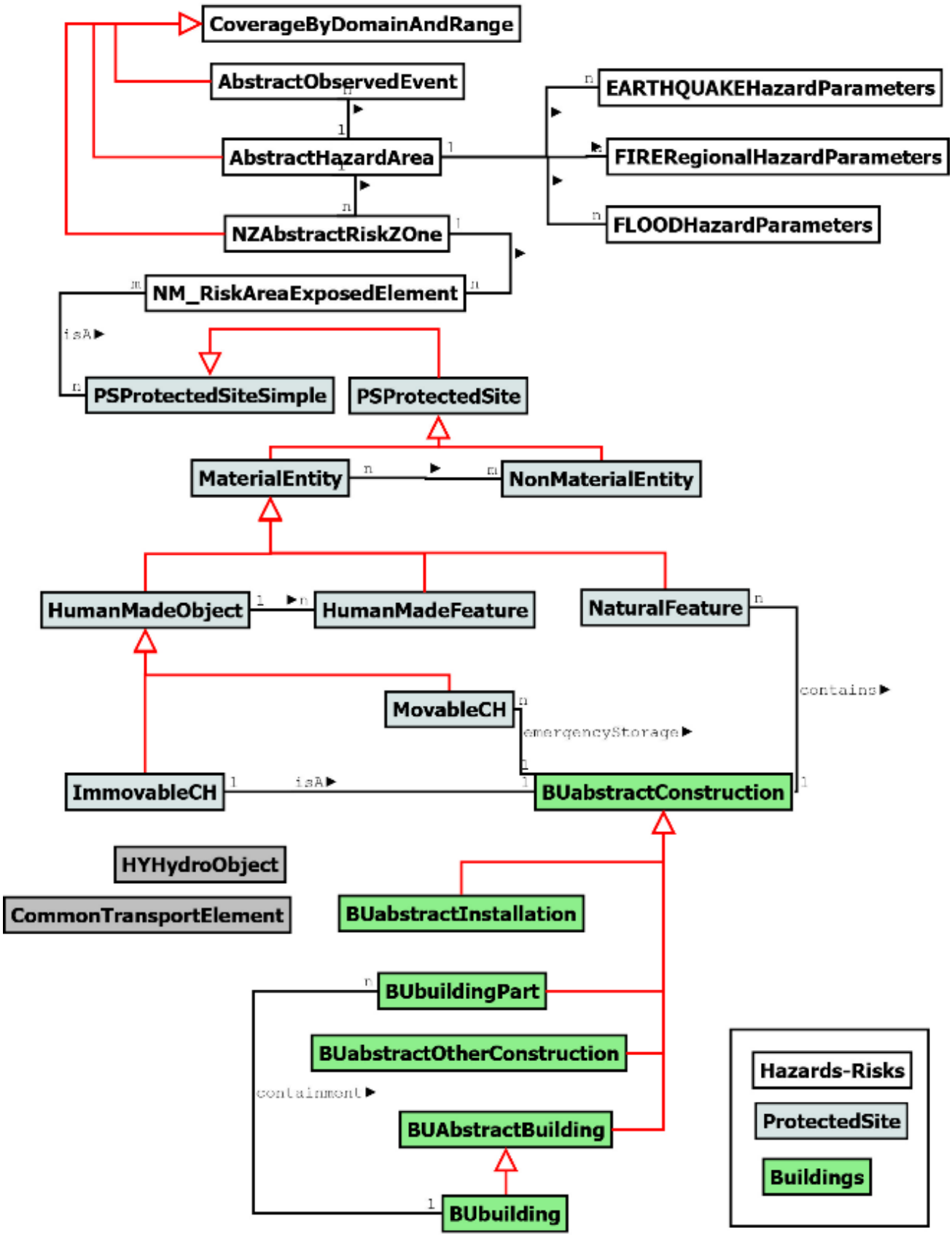


Figure 11 – EID CDM [Link6]

4.3 Geospatial Databases

Geospatial data is geographic data produced with the purpose of georeferencing any set of thematic information. It can be defined as a variable associated with a location in space.

Vector data is used to represent these real world data. Each vector spatial object has associated a class of attributes that consists of numerical or text information to describe the spatial objects. A spatial object can be represented with its own geometry. The geometry is made up of one or more interconnected vertices. A vertex describes a position in space using an X, Y, and optionally a Z axis (describes height or depth at each vertex, but not both). This geometry can be represented by three types: points, lines and polygons.

Another way to represent spatial data is through rasterization. A **raster** consists of a matrix of cells or pixels arranged in rows and columns in which each cell contains a value that represents information. For example, aerial photographs, satellite images, digital images, or even scanned maps.

Raster data can be divided into four main categories, as can be seen in *Table 5*:

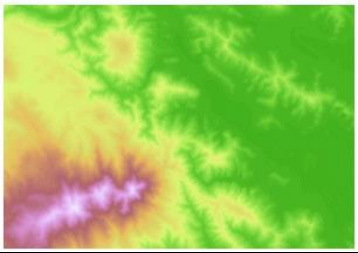
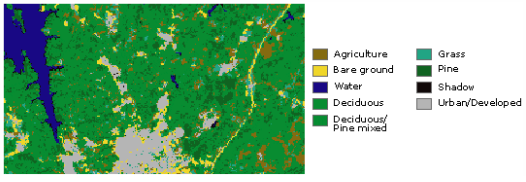
Category	Description	Example
BaseMap	Background display for other feature layers to ensure that map layers are spatially aligned. They can be satellite images, aerial orthophotos, etc.	
Surface map	Suitable for representing continuously changing data on a surface, such as temperature, precipitation, digital terrain model, etc.	
Thematic map	It groups multispectral data values into classes and assigns a categorical value from a satellite image.	
Entity's Attributes	Digital photographs or scans related to geographic data	

Table 5 – Raster data categories

Another known technique for displaying spatial data is Laser Imaging Detection Ranging (LIDAR). **LIDAR** is an active optical sensor that transmits laser beams towards a target as it moves through specific topography paths, whether land or air. The reflection of the laser from the target is detected and analyzed by the receivers in the lidar sensor. These receivers record the time from when the laser pulse left the system to when it returned to calculate the limit distance between the sensor and the target. Combined with positional information (GPS and INS), these distance measurements are transformed into measurements of three-dimensional points of the reflecting target. As a result, a dense point cloud is obtained that represents the objects in the real world classified by intensity value.

Spatial data from **3D Models** that represent a three-dimensional object can be also found using a collection of points in space within a 3D environment, connected by various geometric entities such as triangles, lines, curved surfaces, etc. Being a collection of data, 3D models can be made by hand, through algorithms or scanned. An example of these 3D Models can be CityGML model that represents urban objects in 3D.

Currently, the **web services** of the OGC are often used too. OGC was created to define open and interoperable standards within GIS. The most outstanding services are the following:

- Geography Markup Language (GML).
- Web Coverage Service (WCS).
- Web Feature Service (WFS).
- Web Map Context Documents (WMC).
- Styled Layer Descriptor (SLD).
- Web Map Service (WMS).

To manage these possible spatial data explained above, the spatial databases are used. These databases are defined as the administrator system that handles existing data in the space. It is essential to establish a reference table to define the location and relationship between objects, since the data processed in this type of database has a relative value, not an absolute value. The spatial reference system can be of two types: on the one hand, **georeferenced** which are those that are established on the earth's surface by means of localized coordinates and are the ones that are most used; on the other hand, **non-georeferenced**, which are the systems not referenced on the earth's surface.

The construction of a database involves a process of abstraction to go from the complexity of the real world to a simplified representation that can be processed by the language of today's computers. For designing a database properly, next steps must be followed:

- Determine the purpose of the database.
- Find and organize the necessary information: all types of information of interest must be collected in the database.

- Divide the information into tables: the information must be divided into main entities or topics. After each topic it is implemented in a table.
- Convert the information elements into columns: it must be decided what information must be stored in each table. Each item is converted to a field and displayed as a column in the table.
- Specify the primary keys: the primary key of the table must be chosen. This key is a column that is used to identify each row.
- Establish table relationships: the data in a table must be related with the data in other tables.
- Perfect the design.
- Apply the normalization rules: the objective is to see if the tables are structured correctly.

4.3.1 Geospatial DBMSs

Currently, there are different systems to manage databases. Some of them are listed below along with some software that exists to publish information:

- **SQL Server**: relational database management system (DBMS) developed by Microsoft. The development language used is Transact-SQL, an implementation of the American National Standards Institute (ANSI) of the Structured Query Language (SQL), used to manipulate and retrieve data, create tables and define relationships between them. The operating system where it can be deployed is Windows and Linux.

- **ORACLE**: object-relational DBMS developed by Oracle Corporation. It does not require a free license and it has been used widely in the business server market until competition from other free licensed systems has appeared in recent years.

- **DB2**: relational database that provides advanced analytics and data management capabilities for transactional workloads. It is designed to offer high performance, applicable knowledge, reliability and data availability. It is compatible with Linux, Unix and Windows operating systems. It is not available in a free version.

- **ArcGIS Server**: is a back-end server software component of ArcGIS Enterprise that makes geographic information available to others in an organization and, optionally, to anyone with an Internet connection. This is accomplished through Web Services that allow a powerful server computer to receive and process requests for information sent by other devices. Hardware, software, and data need to be prepared in order to start publishing services. It is not a free license system.

- **PostgreSQL**: relational and object-oriented database manager. Its license and development are open source, being maintained by a community of developers,

collaborators and commercial organizations. It is available for most operating systems. PostgreSQL is very complete and the following advantages stand out:

- Support for raster and vector GIS files.
- Provides analysis, transformation and spatial query functions.
- Processing speed thanks to spatial indexes.
- Tools for geocoding, 3D, topology, route calculation ...

In addition, there is a spatial extension for PostgreSQL called **PostGIS** that has the ability to store and work with geographic objects located in space. The module adds a huge package of functions to query, process, transform and analyze stored spatial information. Thanks to this extension, GIS analysis execution times are significantly shorter and more efficient than any other desktop GIS. This extension allows to:

- Create and edit geometries.
- Establish spatial relationships between geometric elements.
- Perform distance and routing analysis.
- Make topological corrections of elements.
- Analyse and combine different bands.
- Edit and reclassify pixels of raster layers.
- Carry out map algebra operations.
- Generate elevation models, etc.

- **3DCityDB**: It is a free geodatabase to store, represent and manage virtual 3D city models on top of a standard spatial relational database. The database schema implements the CityGML standard with semantically rich and multi-scale urban objects facilitating complex analysis tasks, far beyond visualization. 3DCityDB is in productive and commercial use for more than 14 years in many places around the world. It is also employed in numerous research projects related to 3D city models.

  The main functionalities are the followings:

  - Spatial relational database schema for semantic 3D city models.
  - All thematic modules from CityGML 2.0 included.
  - Five different LoDs.
  - Appearance data (e.g. textures, colors) in addition to flexible 3D geometries.
  - Supports generic and prototypical 3D objects.
  - Complex digital terrain models (DTMs).
  - Web Feature Service (WFS) interface.
  - Works with Oracle Spatial 10g, 11g, and 12c (Spatial and Locator), or PostGIS 2.0 or higher.
  - Docker containers available for quick setup.

5 SHELTER Data Model Approach

The SHELTER MMDM aims to organize relevant information to represent the Resilience ID of the HA and facilitate access to the information through the RD. The information of the multiscale model will be organized around a geospatial data model with information at different scales (from the city to the region) and three-dimensional representation (3D). The SHELTER data model will combine information provided by the OLs with information obtained from external sources.

The SHELTER data model development process is spread across different project WPs. The process is divided into three stages: Definition, Implementation and Access. The Definition stage is carried out within WP1, specifically it corresponds to T1.4 and is mainly the work described in this deliverable. In this stage the elements, relationships and metadata of the model are identified. After that, the selection of the standard data models on which the SHELTER data model is based is done. Then, the selected models are extended with the properties and parameters necessary for the scope of the project and under the umbrella of the domain ontology of the project. The second stage is the implementation of the data model and will be partially executed between work packages 1 and 7. In WP1, the database management system on which the model will be implemented, and the implementation of the data model will be carried out. In WP7, the data model information for each OL will be completed, performing the following tasks, among others: data transformation, data pre-processing and cleaning, and the generation of the multiscale model. Finally, the third stage will facilitate access to the information contained in the model through the development and deployment of web services for access to that information. It will require also the definition of roles and users to manage the access to information. This last stage will take place within WP5. The complete process is presented in the *Figure 12*.

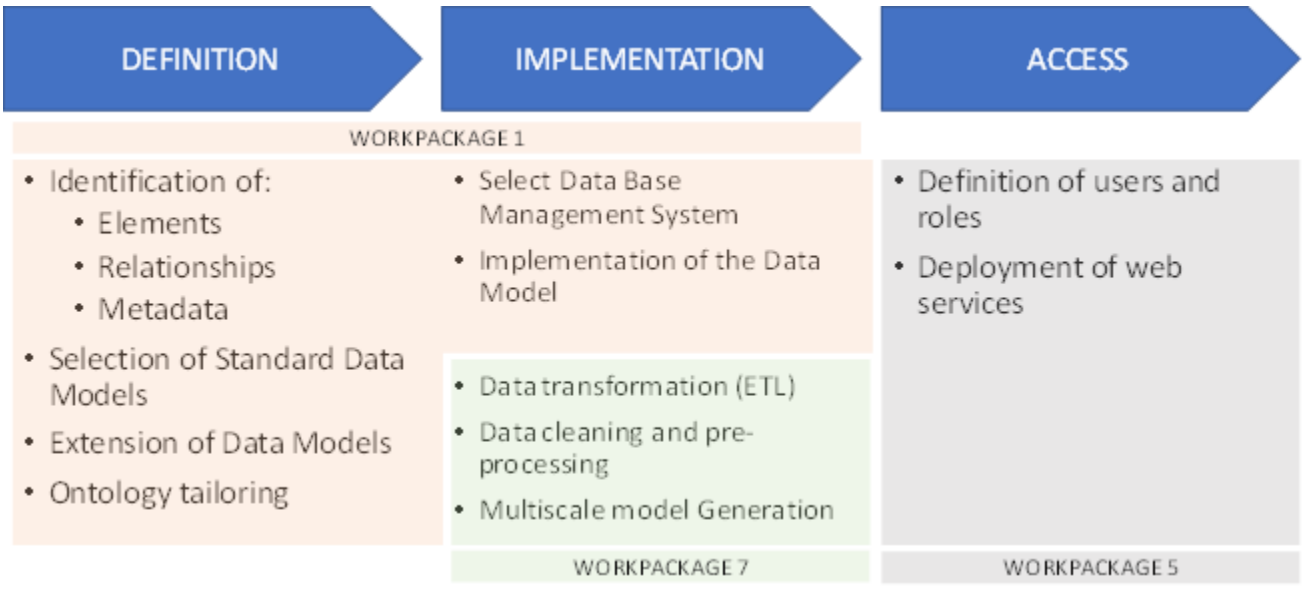


Figure 12 – Multiscale Data Model development process

5.1 Relation between Data Model and Ontologies

The ontology created for the SHELTER project [12] integrates some concepts from three different problem domains: Climate Change Adaptation (CCA), Disaster Risk Management (DRM) and Cultural Heritage Management (CHM), and extends them with elements related to the concept of Resilience (see *Figure 13*).

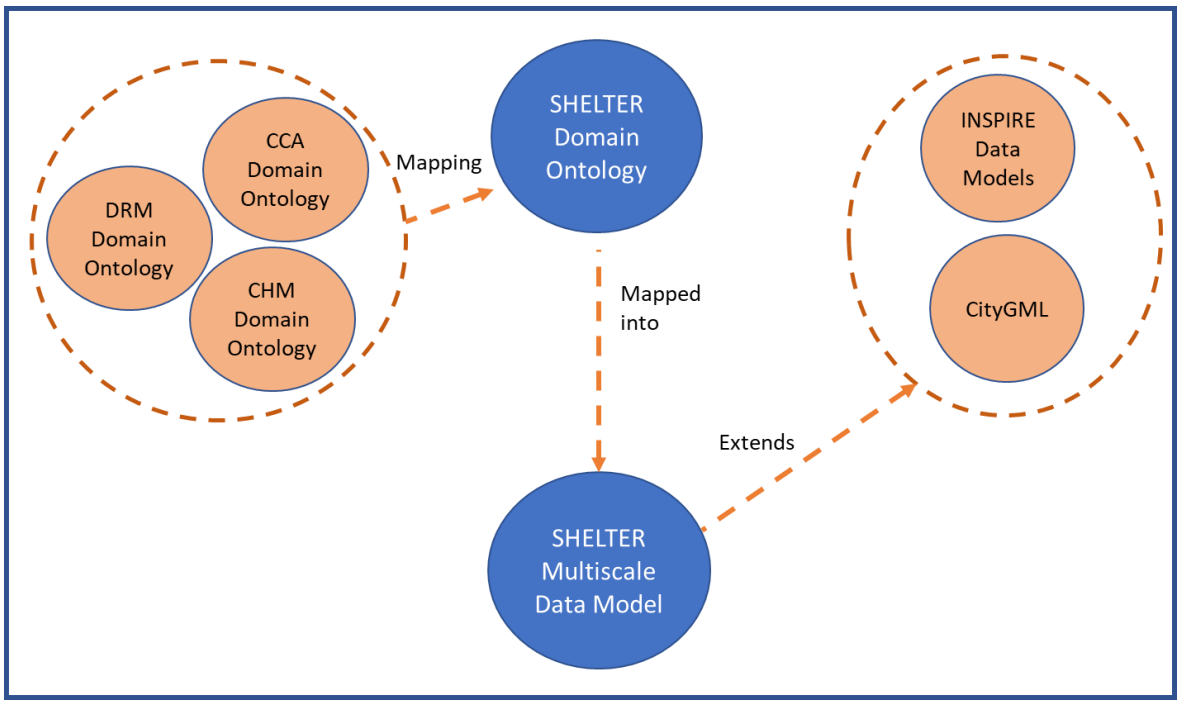


Figure 13 – Relation between Data Model and Ontologies

The ontology has been defined with different purposes. One of them is guiding the design of the MMDM as shown in the previous figure. There are some concepts in the ontology which are thus not intended to have a mapping into the MMDM, because they have been created to support other purposes of this ontology (e.g., facilitating the semantic annotation of documents in the project).

The SHELTER ontology has 11 root terms [13]. The following points explain how each of them must be related to the MMDM, or justify why it is not necessary to do so:

- **Disaster Risk Management Phase**: This concept is related to activities and actions required for the application of DRR policies and strategies. In the context of SHELTER, the MMDM would support those actions, but it is the Dashboard the part of the system that needs to track the different phases of DRM and offer the right views, data, and tools required in each of them.
- **Heritage Attribute**: This concept and its specializations (Tangible Heritage, Intangible Heritage etc.) refer to the heritage-related characteristics of the different elements in a HA. The MMDM will have to define an entity, or at least some attributes, that allows associating these characteristics to the elements in a HA, as they are crucial to have a proper description of those HAs.

- **Historic Area**: This is a key concept in the SHELTER project. The MMDM will have to define an entity for HAs, which is coherent with the definition of the ontology. This means that it needs to be a site, i.e., an entity with a location, typically an area, associated with different material, cultural and natural values, such as historic buildings, archaeological sites, landscapes and others.
- **Risk Component**: The ontology defines this concept as a way to facilitate the calculation of risks. Its specializations are Exposure, Vulnerability and Hazard. The MMDM will have to define entities and/or attributes that allow to store and query the necessary values for these elements.
- **Vulnerability Component**: This is a separated root concept because vulnerabilities have at least two separated, though related, parts: Sensitivity, i.e., how much a system is affected, positively or negatively, by certain stimuli, and Adaptation Capacity, i.e., how systems adjust to damage or respond to its consequences.

The other 6 root terms in the ontology are related to resilience:

- **Resilience**: This is defined in the ontology as the ability of a historic urban or territorial system to maintain or return to desired functions after a disturbance. The MMDM will have to provide a way to link HAs, or maybe to some of their components, to the properties required to know, estimate or take decisions about their resilience.
- **Resilience Activity**: These are typically long-term actions aimed at reducing disaster related risks. The MMDM will have to provide a way to link HAs with the Resilience Activities linked to them via the Resilience ID.
- **Resilience Approach**: This concept includes the different results, tools and artifacts which the SHELTER project will define and apply in order to improve the resilience of HAs. The MMDM will have to provide a way to link HAs with the Resilience Approaches followed in those HAs by the SHELTER project via the Resilience ID. It is interesting to point out that the Multiscale Strategy, which is a specialization of Resilience Approach in the ontology, is one of the foundations of the MMDM.
- **Resilience Capability**: These are related to local and traditional knowledge and skills that can be incorporated into existing resilience-related practices. Again, the MMDM will have to provide a place for data related to these capabilities to be associated with HAs or their components, via the Resilience ID.
- **Resilience Stakeholder**: This concept includes the people which are affected by hazards or can contribute to any DRM phase. Its specializations in the ontology are closely related to the SHELTER project: Case Study Coordinator, Core OpenLab Stakeholder Group and Extended OpenLab Stakeholder Group. The MMDM will have to provide a way to keep quantitative or qualitative information about potentially affected people to HAs and their components. The rest of the stakeholders will have direct access to the Dashboard and other SHELTER tools after the authentication process.

  Resilience Tool: This is a generic concept, and its specializations in the ontology are quite diverse. Any solution applicable to any problem in any phase

in SHELTER is a potential Resilience Tool, including for instance the RD. Given this, it is not necessary for the MMDM to model this concept explicitly.

5.2 Identification of available data sources

Among the objectives of T1.1 are the identification, classification and evolution of useful data sources. To collect this information in a structured way, a matrix has been designed, namely the DMF, which serves to record information and data descriptions, as well as an internal SHELTER tool to support communication and information exchange between partners.

The DMF satisfies the need of the technological partners to be continuously updated on the type of data available from the OLs, in order to adequately comply with the technical requirements of each tool that makes up the SHELTER project, including the MMDM. In turn, the MMDM, to be effective, had to include all the types of geospatial data described in the DMF.

In this perspective, all the information contained in the DMF and specifically related to the OLs has been exhaustively analyzed in order to see what information exists and whether or not it is useful as an output of the data model. The DMF is meant for example not only for describing geospatial data, but also for information knowledge not directly referring to a position in space and time, which are not usable in the data model. As a result of this analysis, a document has been obtained in which each data set is described, detailing its characteristics and specifications.

Information classified as unstructured in the DMF, that is, information lacking a predefined data model (for example books, journal, images, documents, metadata) has also been discarded directly from the analysis. For the data model, only structured data are required (for more information see section *10.1*).

5.2.1 Analysis – Datasets sources associated with indicators

The SHELTER methodology is based on a set of indicators that will quantify the links between multiple dimensions of HA resilience, the connections between different spatial scales and the changes across temporal scales. The indicators are a fundamental part to identify the set of data that can be exploited for SHELTER objectives. The calculation of these indicators requires certain information that can be found in the DMF. In this document, the information appears divided into five case studies (OLs) located in different areas of Europe. These case studies contain different geographical areas at a different scale, from local sites to large areas which include several countries, and each of them in turn is associated with a series of natural disasters: wildfires, floods, earthquakes, etc (see *Table 6*).

Area of Interest	Open Lab	Hazard
Local	Seferihisar (Turkey)	Earthquakes / Heatwaves
Regional	Baixa Limia-Serra (Spain)	Wildfires
Local	Dordrecht (The Netherlands)	Floods / Storms
Local	Ravenna (Italy)	Earthquakes / Subsidience
National	Sava River Basin (Croatia, Slovenia, Bosnia and Herzegovina, Serbia and Montenegro)	Floods

Table 6 – SHELTERs OLs

Table 7 shows the set of data sources more relevant to the OLs for the calculation of the indicators described in *Appendix II* – Combination of entities in order to perform analysis prior to the generation of the MMDM. The selection of this set of data sources has been made considering especially those classified as "MsMs Data Model" or "Importer & Mapper" in the "Module" column of the DMF.

Furthermore, in each OL column the corresponding identifier of the data source is indicated. In turn, a unique identifier ("*Dataset ID*") has been added to each data source to associate it with the most appropiate indicator in the indicators tables, taking into consideration the data required for each one.

Dataset ID	Dataset source	Format	Access Mode	Seferihisar	Baixa Limia	Dordrecht	Ravenna	Sava River Basin
01	Corine Land Cover (CLC) 2018 from the Copernicus Land Monitoring Service	Raster, vector, JSON, SOAP, WMS	Web Service	73003	75053			
02	European Digital Elevation Model (EU-DEM) v1.1 from the Copernicus Land Monitoring Service	Geotiff, JSON, SOAP, WMS	Web Service	73006	75056	74012	72048	76032
03	Water Occurrence from JRC Global Surface Water Explorer	.tif, .qml, WMS, API	WebMap Service, API			74015	72052	76035
04	Water Occurrence Change Intensity from JRC Global Surface Water Explorer	.tif, .qml, WMS, API	WebMap Service, API			74016	72053	76036
05	Water Seasonality from JRC Global Surface Water Explorer	.tif, .qml, WMS, API	WebMap Service, API			74017	72054	76037
06	Annual Water Recurrence from JRC Global Surface Water Explorer	.tif, .qml, WMS, API	WebMap Service, API			74018	72055	76038
07	Water Transitions from JRC Global Surface Water Explorer	.tif, .qml, WMS, API	WebMap Service, API			74019	72056	76039
08	Maximum Water Extent from JRC Global Surface Water Explorer	.tif, .qml, WMS, API	WebMap Service, API			74020	72057	76040
09	Copernicus Corine Land Cover Change (CHA) 2012 – 2018	Raster, Vector, SQLite, JSON, SOAP, WMS	WebService	73004	75054			
10	UERRA dataset - estimate of daily accumulated precipitation and six-hourly air temperature and relative humidity at 2 meters above the model topography	GRIB2, .NetCDF	WebService	73005				

Dataset ID	Dataset source	Format	Access Mode	Seferihisar	Baixa Limia	Dordrecht	Ravenna	Sava River Basin
11	Copernicus ERA5-Land hourly data from 1981 to present	GRIB2, NetCDF, API	API, GUI, C3S toolbox	73007				
12	Viewer maps tool	.shp	Open		75005			
13	Geographic information files such as covers, orthoimages, cartographic series, natural spaces, hydrography, administrative limits...	Depending on the data	-		75049			
14	Biodiversity and distribution of species	JSON, AMF, geoJSON, WMS	ArcGIS REST		75050			
15	Metadata download center	-	-		75051			
16	Paths to see general patrimony	.shp	-		75052			
17	Data on national monuments	Web Service	WMS, WFS, .shp, GML			74004		
18	Data on municipal monuments	CSV, .shp, geoJSON	Web applicati on			74006		
19	Precipitation - radar/gauge 24-hour accumulations over the Netherlands	.HDF5 3.5 WMS	API webinter face WMS			74010		
20	Climdex indices for understanding patterns in precipitation extremes	ASCII, .jpg, .NetCDF	Webinter face			74011	72032	76007
21	Subsidence velocity in vertical movements (isolines)	.shp, .csv, .xlsx	WFS				72001	
22	Precipitation forecast from ARPAE	html, grib	Http, Google drive				72003	
23	UNESCO Cultural Heritage catalogue (descriptions, maps, documents, galleries, videos)	.pdf, .jpg, RSS, xml, xls, kml	Webinter face				72004	76005

Dataset ID	Dataset source	Format	Access Mode	Seferihisar	Baixa Limia	Dordrecht	Ravenna	Sava River Basin
24	Flood Hazard Mapping	.shp	Direct to file				72013	
25	Meteorological data - monthly observation from ARPAE	json	Google drive				72039	
26	Regional Technical Map 1:5000 (from Emilia-Romagna geoportal)	WMS, geoTiff	WMS				72040	
27	AGEA RGB ortophoto (from Emilia-Romagna geoportal)	WMS	WMS, direct download				72041	
28	Database of municipalities areas (from Emilia-Romagna geoportal)	WMS, .shp	WMS, direct download				72042	
29	Administrative boundaries 2018 (from Emilia-Romagna geoportal)	WMS, .shp	WMS, direct download				72043	
30	Database of municipalities - points (from Emilia-Romagna geoportal)	WMS, .shp	WMS, direct download				72044	
31	Database of districts areas 2019 (from Emilia-Romagna geoportal)	WMS, .shp	WMS, direct download				72045	
32	Union of municipalities (from Emilia-Romagna geoportal)	WMS, .shp	WMS, direct download				72046	
33	Daily air quality analyses and forecasts for Europe from Copernicus CAMS	GRIB, NetCDF	Webinterface, API				72047	
34	Past flood events in Upper Sava River Basin - November 1990 (polygons)	.shp	http WMS, WFS					76043

Dataset ID	Dataset source	Format	Access Mode	Seferihisar	Baixa Limia	Dordrecht	Ravenna	Sava River Basin
35	Past flood events in Upper Sava River Basin and Kupa River - October/November 1998 (polygons)	.shp	http WMS, WFS					76044
36	Past flood events in Upper Sava River Basin - September 2007 (points)	.shp	http WMS, WFS					76045
37	Past flood events in Middle Sava River Basin - May/June 2010 (polygons)	.shp	http WMS, WFS					76046
38	Past flood events in Middle Sava River Basin - September 2010 (polygons)	.shp	http WMS, WFS					76047
39	Past flood events in Middle Sava River Basin - September 2010 (points)	.shp	http WMS, WFS					76048
40	Past flood events in Middle and Lower Sava River Basin (Una, Vrbs, Bosna, Drina, Bosut, Kolubara) - May 2014 (polygons)	.shp	http WMS, WFS					76049
41	Copernicus Emergency Management Service (EMS) - Flood Rapid Mapping Activations in Sava River Basin	.pdf, .jpeg, .tiff	http, GeoRSS feed					76050
42	Geodatabase of Cultural Heritage sites (Admin info, Asset, Conservation/Restauration, Damage info, Historic background, Risk assessment, Site info, Source relation, Status, Territory info)	.gdb	-					

Table 7 – Datasets sources associated to OLs

5.2.2 Analysis – Spatial dataset sources

Since the specific characteristic of the SHELTER data model is the organization of spatial data, it is important to identify those data sources with semantic information that contain a geometric extension, that is, that can be located in space. The spatial extension can be given in different formats, such as a shapefile, a csv file, a Web Map Service (WMS), etc.

In the *Table 8* these data sources with a geographic component have been identified, describing the information regarding the geometry in each one. For example, geodataset G023 called "Hydrologic and meteorological data, information and knowledge about water resources in the SavaRiver Basin" is a vector layer with a point type geometry georeferenced in space with thematic information about hydrological and meteorological stations, containing semantic information such as station names, country, measurement time, air temperature, water level, precipitation, water temperature, etc. As shown in the table, the information belongs to the Sava River Basin OL.

GeoDataset ID	Dataset source	Description	Seferihisar	Baixa Limia	Dordrecht	Ravenna	Sava River Basin
G01	Corine Land Cover (CLC) 2018 from the Copernicus Land Monitoring Service	EU database with information on land cover and use	73003	75053			
G02	European Digital Elevation Model (EU-DEM) v1.1 from the Copernicus Land Monitoring Service	Hypsometric information that represents the terrain relief	73006	75056	74012	72048	76032
G03	Data on national monuments	Monuments of the Netherlands represented as a point feature georeferenced on the ground			74004		
G04	Data on total risk of flood	Information on flood risks in the Netherlands represented in vector and raster formats			74005		

GeoDataset ID	Dataset source	Description	Seferihisar	Baixa Limia	Dordrecht	Ravenna	Sava River Basin
G05	Data on municipal monuments	Information on the monuments of Dordrecht represented by polygons			74006		
G06	Water Occurrence from JRC Global Surface Water Explorer	Water dataset containing a color map in raster format			74015		
G07	Water Occurrence Change Intensity from JRC Global Surface Water Explorer	Water dataset containing a color map in raster format			74016		
G08	Water Seasonality from JRC Global Surface Water Explorer	Water dataset containing a color map in raster format			74017		
G09	Annual Water Recurrence from JRC Global Surface Water Explorer	Water dataset containing a color map in raster format			74018		
G10	Water Transitions from JRC Global Surface Water Explorer	Water dataset containing a color map in raster format			74019		
G11	Maximum Water Extent from JRC Global Surface Water Explorer	Water dataset containing a color map in raster format			74020		
G12	Nature Network Brabant – Ecological Corridor zones	Geographic dataset that contains Ecological Corridor Zones as a line object with information about its realization			74027		
G13	SIOTUGA- Planning instruments- Regional and urban planning	Urban panning of Galicia which information with lineal and polygonal geometry		75002			
G14	Viewer maps tool	Cartographic information (transport networks, natural spaces, land occupation, hydrography,		75005			

GeoDataset ID	Dataset source	Description	Seferihisar	Baixa Limia	Dordrecht	Ravenna	Sava River Basin
		etc.) of Galicia represented with vector (points, lines and polygons) and raster elements					
G15	Data from European Forest Fire Information System (EFFIS) - Copernicus EMS	Fire danger forecast, active fires and burnt areas of Europe in raster format		75048			
G16	Meteorological stations network from Meteogalicia	Dataset of point features with information about meteorological stations		75065			
G17	Informacion Xeografica de Galicia: Land uses and cover 2000	Cartographic information land cover of Galicia represented with vector features (polygons) and raster elements		75066			
G18	Informacion Xeografica de Galicia: SIOSE 2014	Cartographic information land cover of Galicia represented with vector elements (polygons) and raster elements		75067			
G19	Informacion Xeografica de Galicia: Cadastral Mapping	Cadastral information of the region of Galicia (polygonal features)		75068			
G20	Informacion Xeografica de Galicia: Administrative boundaries - Municipalities	Administrative boundaries of the municipalities Galicia (line and polygon geometry)		75069			
G21	Informacion Xeografica de Galicia: Administrative boundaries - Counties	Administrative boundaries of the counties of Galicia (line and polygon geometry)		75070			

GeoDataset ID	Dataset source	Description	Seferihisar	Baixa Limia	Dordrecht	Ravenna	Sava River Basin
G22	Centro Nacional de Informacion Geografica: city blocks and house numbers	Postal addresses in Spain with punctual representation from different state, regional and local bodies		75071			
G23	Subsidence velocity in vertical movements (isolines)	Point and line features with information on the subsidence movements on the ground in Emilia-Romagna region				72001	
G24	Flood hazard and risk maps	Point and polygon features that represent areas of flood risk				72002	
G25	Flood Hazard Mapping	Point, line and polygon features that represent flood hazard in the Emilia-Romagna region				72013	
G26	Regional Technical Map 1:5000 (from Emilia-Romagna geoportal)	Cartographic representation of the contents of the Regional Topographic Database on a large scale, with symbology similar to the Regional Technical Chart at 1: 5000 scale.				72040	
G27	AGEA RGB ortophoto (from Emilia-Romagna geoportal)	Four-band orthophotography that can be viewed in RGB or infrared, with an average pixel of 50cm.				72041	
G28	Database of municipalities áreas (from Emilia-Romagna	Municipalities of the Emilia-Romagna region				72042	

GeoDataset ID	Dataset source	Description	Seferihisar	Baixa Limia	Dordrecht	Ravenna	Sava River Basin
	geoportal)	with a polygon-type geometry					
G30	Administrative boundaries 2018 (from Emilia-Romagna geoportal)	Administrative boundaries (lineal geometry) of the Emilia-Romagna region together with topographic maps and orthophotos				72043	
G32	Database of municipalities-points (from Emilia-Romagna geoportal)	Municipalities of the Emilia-Romagna region with a point-type geometry				72044	
G33	Database of district areas 2019 (from Emilia-Romagna geoportal)	Districts of the Emilia-Romagna region with a polygon-type geometry				72045	
G34	Union of municipalities (from Emilia-Romagna geoportal)	Union of municipalities of the Emilia-Romagna region with a polygon-type geometry				72046	
G35	Emilia-Romagna metereological stations – coordinates and altitude	Geographic coordinates of meteorological stations in Emilia-Romaña and associated information				72068	
G36	Administrative boundaries (member state boundaries) from Sava GIS geoportal (WMS layer: adminbound)	Information with administrative limits (lineal geometry)					76008
G37	PFRA (Preliminary Flood Risk Assessment) flood events (historical and possible in future) - Sava FRM plan - from Sava GIS geoportal (WMS layer:	Polygonal features with hydrological information (basins, rivers, monitoring points) and meteorological data on flood risks					76002

GeoDataset ID	Dataset source	Description	Seferihisar	Baixa Limia	Dordrecht	Ravenna	Sava River Basin
	PFRA_floodevent_a = polygons)						
G38	PFRA (Preliminary Flood Risk Assessment) flood events (historical and possible in future) - Sava FRM plan - from Sava GIS geoportal (WMS layer: PFRA_floodevent_p = points)	Point features with hydrological information (basins, rivers, monitoring points) and meteorological data on flood risks					76003
G39	Hydrologic and meteorological data, information and knowledge about water resources in the SavaRiver Basin	Point features of hydrological and meteorological stations with thematic information in real time					76004
G40	Locations of the Areas with Potential Significant Flood Risk (APSFR) as identified by the Framework Agreement on the Sava River Basin contracting Parties (WMS layer: APSFR_a = polygons)	Polygonal features that indicate the most sensitive areas to flood risk					76009
G41	Areas with mutual interest for flood protection from Sava GIS FRMP (WMS layer: APSFR_ami = polygons)	Polygonal features that represent areas with mutual interest for flood protection					76010
G42	Locations of the Areas with Potential Significant Flood Risk (APSFR) as identified by the Framework Agreement on the Sava River Basin contracting Parties (WMS layer: APSFR_l = lines)	Line features that indicate the most sensitive areas to risk of flood					76011

GeoDataset ID	Dataset source	Description	Seferihisar	Baixa Limia	Dordrecht	Ravenna	Sava River Basin
G43	Locations of the Areas with Potential Significant Flood Risk (APSFR) as identified by the contracting Parties to the Framework Agreement on the Sava River Basin (FASRB) - (WMS layer: APSFR_p = points)	Point features that indicate the most sensitive areas to flood risk					76012
G44	Cities from Sava GIS geoportal (WMS layer: city_p = points)	Point features with information referring to cities					76013
G45	Relief map from Sava GIS geoportal (WMS layer: elevation_3857)	Digital Elevation Model (raster) that describes the hypsometry					76016
G46	Flood Hazard scenario areas from Sava GIS geoportal (WMS layer: FHRM_hazard = polygons)	Polygonal features representing flood hazard scenario areas					76017
G47	Flood Protection structures retention and reservoirs from Sava GIS geoportal (WMS layer: FPR_retres_a = polygons)	Polygonal features representing flood protection structures and reservoirs					76018
G48	Groundwater bodies from Sava River Basin Management Plan - Sava GIS geoportal (WMS layer: gwb = polygons)	Polygonal features representing groundwater bodies					76019
G49	PFRA (Preliminary Flood Risk Assessment) flood events (historical and possible in future) - Sava FRM plan -	Line-geometry feature that represents historical flood events and possible flood risk in the future					76020

GeoDataset ID	Dataset source	Description	Seferihisar	Baixa Limia	Dordrecht	Ravenna	Sava River Basin
	from Sava GIS geoportal (WMS layer: PFRA_floodevent_l = lines)						
G50	Protected areas - Sava River Basin Management (RBM) Plan from Sava GIS geoportal (WMS layer: protectedarea_a = polygons)	Polygonal features that identify natural protection areas					76021
G51	Protected areas - Sava River Basin Management (RBM) Plan from Sava GIS geoportal (WMS layer: protectedarea_p = points)	Point features that identify protected areas					76022
G52	River Basin Districts - boundaries of the river basin district and sub-units within the national borders - Sava River Basin Management (RBM) Plan from Sava GIS geoportal (WMS layer: rbd_a = polygons)	Polygonal features representing the subdivision of the basin by countries					76023
G53	River Basin - Sava River Basin Management (RBM) Plan from Sava GIS geoportal (WMS layer: riverbasin = polygons)	Polygonal features representing the contour of the basin					76024
G54	Surface water network in the Sava River Basin from Sava GIS geoportal (WMS layer: rivers = lines)	Lineal features representing the existing rivers of the basin					76025
G55	River water body boundaries from Sava GIS geoportal (WMS layer: rwb_boundary =	Point features of river water body boundaries					76026

GeoDataset ID	Dataset source	Description	Seferihisar	Baixa Limia	Dordrecht	Ravenna	Sava River Basin
	points)						
G56	SavaHIS Real-Time Hydrological Stations	Point features of hydrological stations with thematic information in real time					76027
G57	SavaHIS Real-Time Meteorological Stations	Point features of meteorological stations with thematic information in real time					76028
G58	SubBasin from Sava River Basin Management (WMS layer: subbasin = polygons)	Polygonal features that represents the contour of the sub-basins					76029
G59	Waterways from Sava River Basin Management (WMS layer: waterway)	Line feature that represent the waterways in Sava River Basin					76031
G60	Past flood events in Upper Sava River Basin and Kupa River - October/November 1998 (polygons)	Polygonal features representing floods that have occurred in the past					76044
G61	Past flood events in Upper Sava River Basin - September 2007 (points)	Point features representing floods that have occurred in the past					76045
G62	Past flood events in Middle Sava River Basin - May/June 2010 (polygons)	Polygonal features representing floods that have occurred in the past					76046
G63	Past flood events in Middle Sava River Basin - September 2010 (polygons)	Polygonal features representing floods that have occurred in the past					76047
G64	Past flood events in Middle Sava River Basin - September 2010 (points)	Point features representing floods that have occurred in the past					76048

GeoDataset ID	Dataset source	Description	Seferihisar	Baixa Limia	Dordrecht	Ravenna	Sava River Basin
G65	Past flood events in Middle and Lower Sava River Basin (Una, Vrbs, Bosna, Drina, Bosut, Kolubara) - May 2014 (polygons)	Polygonal features representing floods that have occurred in the past					76049
G66	Copernicus Emergency Management Service (EMS) - Flood Rapid Mapping Activations in Sava River Basin	Polygonal features georeferenced with information on the areas affected by natural disasters					76050
G67	Geodatabase of Cultural Heritage sites	Administrative information, assets, damage info, historic background, sites information, status, territory information…					76056
G68	Urban Atlas 2018 from Copernicus Land Monitoring Service	European urban atlas that provides land cover data for 785 functional urban areas for the 2018 reference year.				72069	76059
G69	Urban Atlas change 2012-2018 from Copernicus Land Monitoring Service	European urban atlas that provides land cover data for 785 functional urban areas for the period 2012-2018.				72070	76060
G70	Street Tree layer 2018 from Copernicus Land Monitoring Service	Layer from the Urban Atlas LC/LU that includes contiguous rows of trees covering 500 m^2 or more over artificial surfaces.				72071	76061

Table 8 – Datasets sources useful for geometry

5.3 Connecting with Macrocategories of Cultural and Natural Heritage Assets

In the process of collective characterization of historical heritage assets that has been carried out in T2.3 - "Anatomy of Historic Areas: collective characterization of CH assets" [14], a methodology for categorizing cultural assets based on the SHELTER ontology has been developed. This methodology takes into account the most relevant factors for the resilience and vulnerability of HAs. When defining the SHELTER data model, special care must be taken in the compatibility and coherence among the data that define the model and the macrocategories and key concepts that are identified in the characterization of the CNH assets. *Figure 14* shows the reflection about the macrocategories carried out in T2.3.

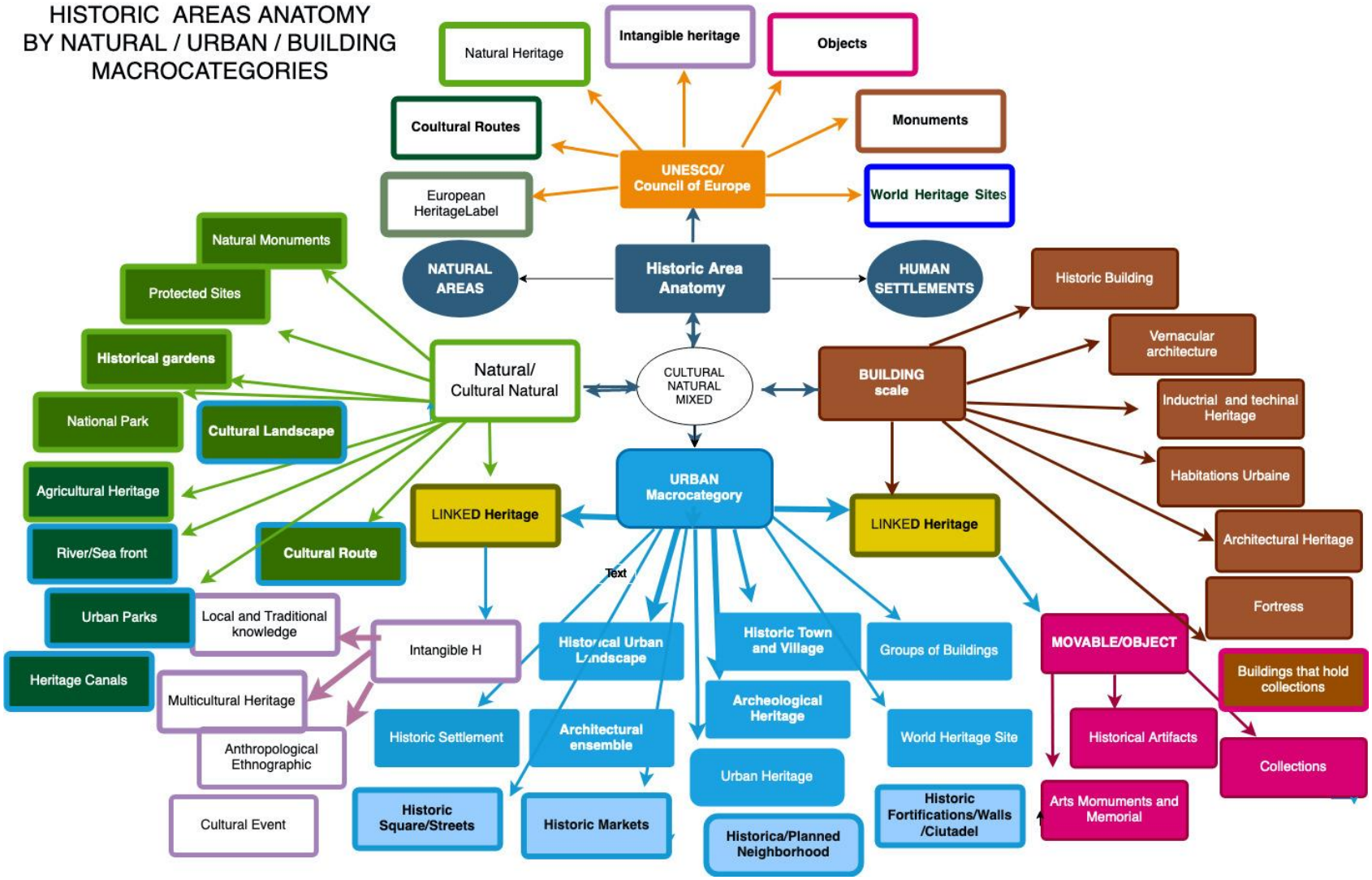


Figure 14 – HA anatomy by Macrocategories [14]

The final reflection of the macrocategory analysis has led to a structure of three macrocategories and a list of key contexts for all the macrocategories. The SHELTER data model must be defined with this structure in mind as well. The macrocategories identified are:

The **URBAN Macrocategory** refers to human settlements of different sizes. It refers both to historical cities and urban areas. It is understood as an aggregate of relevant information surveying HA in cities, its CNH categorization and characterization for risk informed thinking.

The **BUILDING Macrocategory** refers to any kind of monuments and historical buildings, both urban and rural, including complex buildings such as monasteries, industrial heritage, barracks and other buildings of cultural significance that are important for local cultural identities and collective memories, as well as architectural characterising elements such as infrastructure and institutional buildings. It also includes the movable CNH assets that are eventually stored in the buildings such as museums objects. Moreover, it includes related intangible heritage.

The **NATURAL Macrocategory** refers to natural heritage assets of different sizes and types. It also includes those CNH categories inclusive of human settlements and buildings sites where natural landscape component is a relevant priority of characterization of the site (e.g. cultural landscapes, cultural routes). It includes natural areas and trees in urban areas. The categorization is especially addressed to risks and resilience characterization of related inhabited and urbanized areas.

The SHELTER data model must be able to represent elements of each of the 3 macrocategories and allow the characterization of each of these elements from the main domain areas of the project (historical heritage and risk management). The macrocategories identified reflect the multiscale approach of the project and therefore of the data model (building vs. urban) and at the same time the capacity to represent elements of different nature (building vs. natural).

For each of the selected macrocategories, some key contexts are identified in order to group the parameters that characterize the elements of the data model. These key contexts are:

- **General Characteristics**: Including information on denomination, location and characterization. In general, these data characterize each of the elements of the model with special emphasis on the georeferencing of the element and its general properties (uses, dates, etc.).
- **Historical Information**: It includes all the cultural and historical information on the assets of all the macrocategories. In this context, special attention is paid to those parameters that define historical relevance and protection requirements, taking into account the potential risk.
- **Dimensions:** Mainly related to spatial dimensions of the assets of the different macrocategories.

- **Defining its Risk:** This context structures the information on risk exposure, as well as the resilience indicators defined in SHELTER.
- **Geographical and Environmental Context:** General description of the context of the element of both environmental aspects (such as weather, soil or water surface), including type of vegetation and variety of animals in the natural macrocategory, as well as geographical and physical and services infrastructure.
- **Governance / Policies and Planning Context:** It includes information corresponding to the owners and those which are responsible for the management and protection of the Cultural Natural Heritage (CNH) assets.
- **Socio-Economic Context:** It defines the information related to demographic, tourist and economic context of the environment.

There are other defined key contexts related to Resilience Tools and Resources for the different phases of SHELTER that do not require an explicit representation in the multiscale data model.

In order to address the challenge to make the model coherent with the key contexts identified above, the MMDM will have to define the entities and attributes to store information relative to the asset and its contexts. For such purpose, it will be based on the reference data model defined in ResCult project [Link6], which addresses some of the challenges identified here. This model is based on thematic modules of the European Spatial Data Infrastructure (SDI) represented in INSPIRE [Link7], specifically "Natural Risk Zones", "Protected Sites" and "Buildings". It will be necessary to extend the model to address some of the aspects not considered.

6 SHELTER Multiscale Multisource Data Model

In this section the design of the MMDM is documented. First, we describe the approach followed to represent the relevant information about resilience and the HAs. And then, the design of the MMDM, that combines the ResCult EID and CityGML, and extends them, is described.

6.1 General overview

In *Figure 15* the approach followed in T1.4 to create the MMDM is presented. One of the premises was trying to reuse some of the existing data model or standards, and then adapting or extending them to fulfill the SHELTER requirements.

After the state-of-the-art revision two data models were selected as basis for the SHELTER multiscale data model: ResCult EID and CityGML.

The ResCult EID data model includes three INSPIRE data specifications: Natural Risk Zone, Protected Site and Buildings. The SHELTER project needs to consider more city elements than ResCult, so the INSPIRE data specification of Buildings, included in the ResCult EID, is not enough. The CityGML data model is used instead, because it defines a greater variety of city objects. The scenario in section *6.1.1* provides examples of many of these elements.

After laying out the base of the data model, the SHELTER requirements, including the indicators, the ResilienceID, the relationship with T2.3 and the data available in the OLs have been analyzed to make sure that the data model can support them.

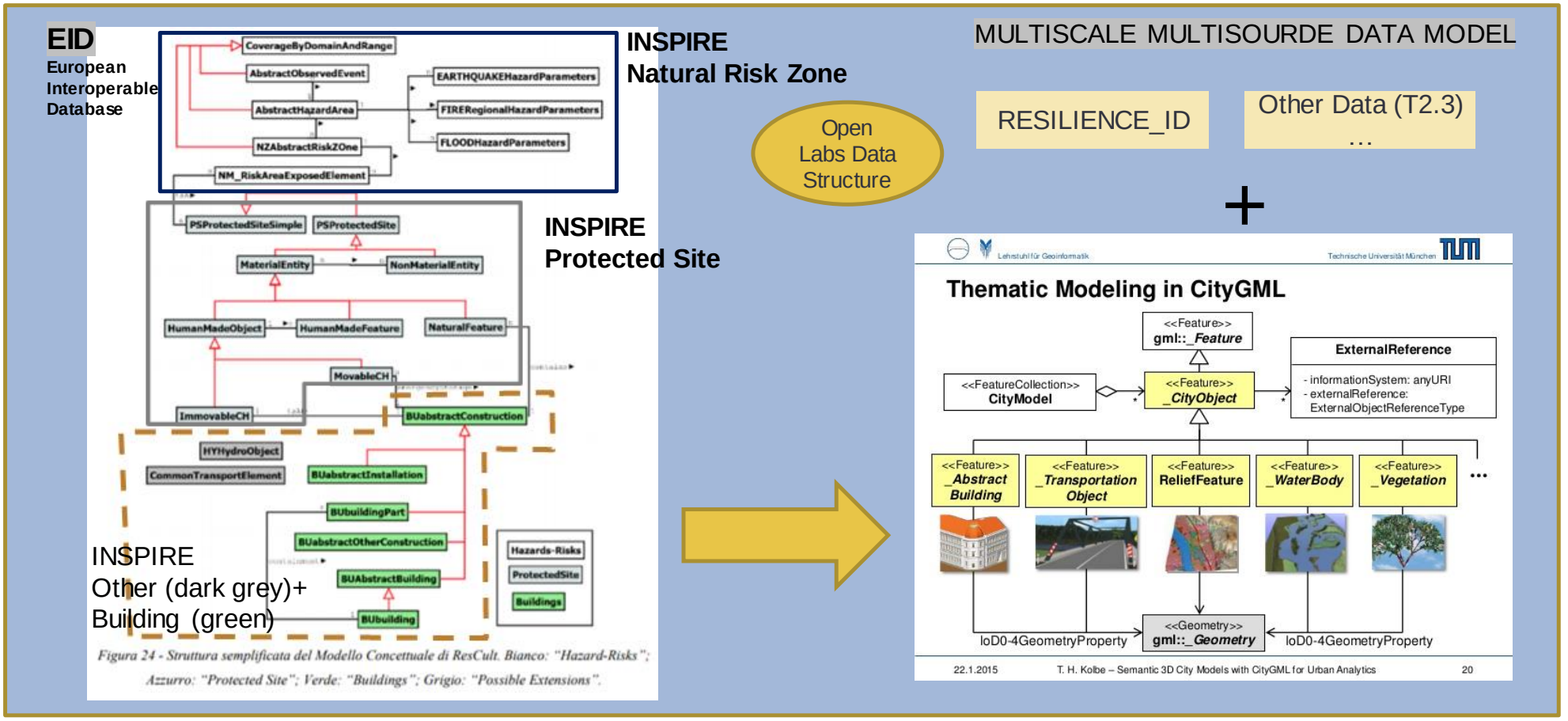


Figure 15 – MultiScale MultiSource Data Model schema

6.1.1 Example scenario

Figure 16 shows, at a glance, an example scenario where the main entities that will be included in the SHELTER MMDM are pointed out.

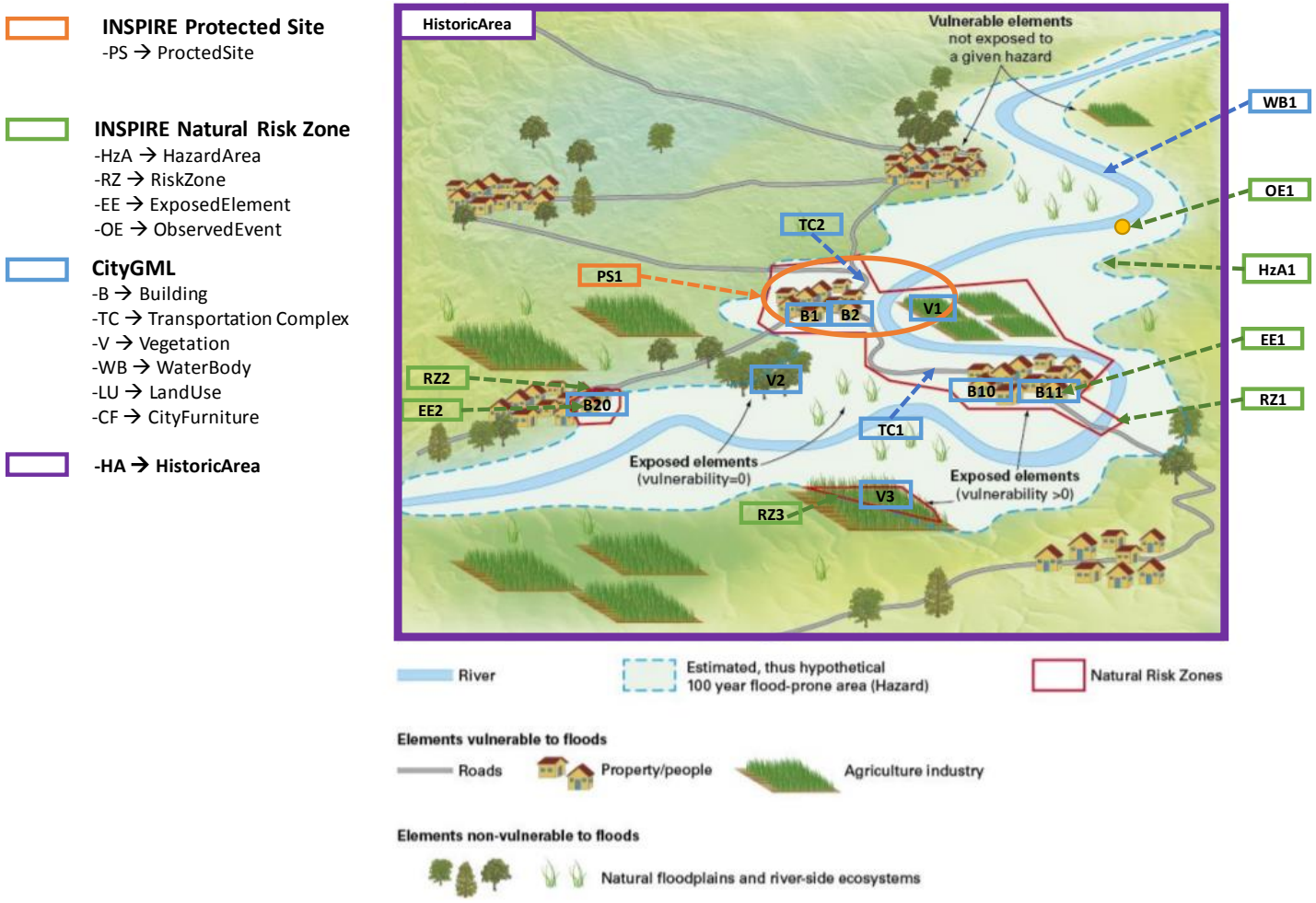


Figure 16 – Example Scenario

The feature that encompasses all the entities is the HistoricArea (HA). All the entities that are explained below are included within the HistoricArea.

The different features of interest for the SHELTER project are modeled using CityGML CityObjects. These are buildings (B), transportation complexes (TC), vegetation (V), water bodies (WB), city furniture (CF) and different land uses (LU).

A single hazard area (HzA) is defined in the figure. In this example, the hazard area represents the area where a flooding can occur. There are a number of features of interest within this HzA. The relationship among them and the HA itself will be made explicit in the data model.

Within the hazard area, 3 risk zones (RZ) are represented. The difference between a hazard area and a risk zone is that in a risk zone the vulnerability value is higher than 0. Each risk zone must be included within a hazard area, so a relationship will be made explicit in the data model. The relationship among all the features within the risk zone and that risk zone will also be made explicit.

An exposed element (EE) refers to the spatial representation of people, property, systems, or other elements present in hazard zones that are thereby subject to potential losses. In our model, every exposed element will be related to exactly one of the supported CityObjects.

Observed events (OE) are discrete spatial objects representing natural phenomena relevant to the study of natural hazards which occurred, or are currently occurring, and which have been observed.

In addition to that, another feature delimited by a polygon is the protected site (PS). A protected site is an area of land and/or sea especially dedicated to the protection and maintenance of biological diversity, and natural and associated cultural resources, and managed through legal or other effective means. All the features of interest within that polygon can be considered as protected entities and will be explicitly linked to it.

6.2 Design of the MMDM

The previous section has used an example to motivate and facilitate the understanding of the SHELTER MMDM, and has highlighted that it combines entities from several existing models. This section describes the MMDM, including more information about the foundational models of the MMDM and how they have been integrated and extended.

6.2.1 An overview

As shown in *Figure 17*, the SHELTER model combines INSPIRE Protected Sites and Natural Risk Zones (both included in ResCult), the CityGML standard, and an additional entity, Resilience, which is required for SHELTER.

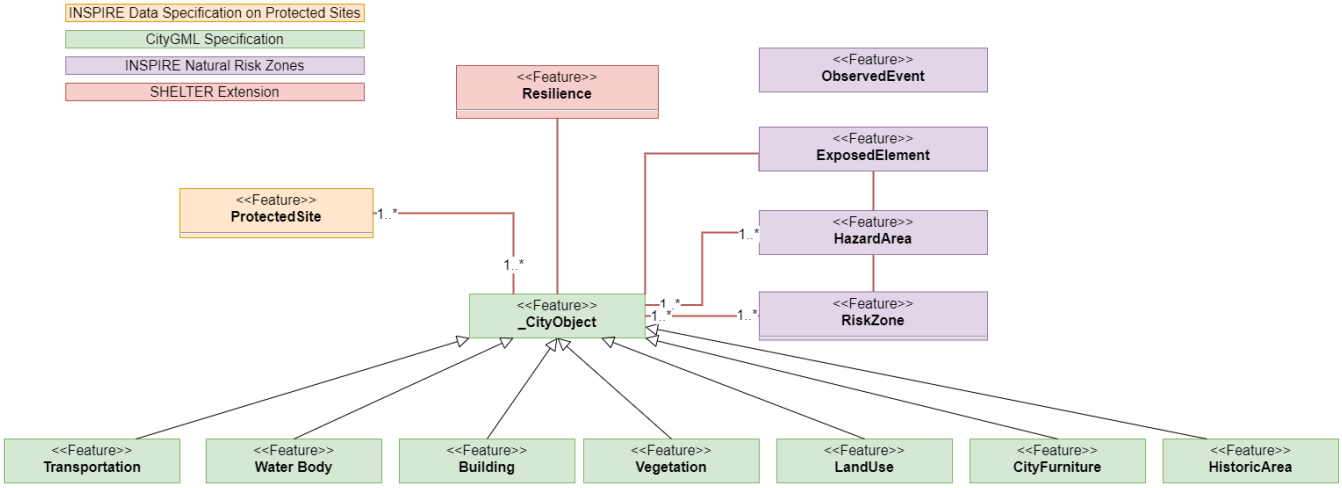


Figure 17 – UML Diagram **–** 1

The entity in orange (ProtectedSite) is taken from INSPIRE Protected Sites model.

The entities in purple (HazardArea, RiskZone, ExposedElement and ObservedEvent) are taken from INSPIRE Natural Risk Zones model.

The entities in green are taken from CityGML model, where the main element is the CityObject and the rest of the entities (HistoricArea, Building, Transportation, Water Body, Vegetation and LandUse) inherit from it.

The entities and relationships in red are the ones specifically created for SHELTER. The Resilience entity includes all the documentation strategy, which includes the relevant information to make it actionable when required. In addition to that, new relationships have been created between:

- ProtectedSite and CityObject. So it is possible to relate each CityObject with one or more ProtectedSites, and also, relate each ProtectedSite with one or more CityObjects.
- HazardArea and CityObject. So it is possible to relate each CityObject with one or more HazardAreas, and also, relate each HazardArea with one or more CityObjects.
- RiskZone and CityObject. So it is possible to relate each CityObject with one or more RiskZones, and also, relate each RiskZone with one or more CityObjects.
- ExposedElement and CityObject. So it is possible to know to which CityObject refers the ExposedElement.
- ExposedElement and HazardArea. So it is possible to know in which HazardArea is included the ExposedElement.
- HazardArea and RiskZone. So it is possible to know in which HazardArea is included the RiskZone.

6.2.2 RESCULT EID

The ResCult project was carried out to create a supporting decision tool for the safeguarding of cultural assets. The project aimed at enhancing the capability of European Civil Protection to prevent disaster impacts on CNH by implementing an EID as a supporting decision tool. EID is intended to help stakeholders to understand the risk of damage to cultural assets as well as possible impacts on cohesion, sustainable cultural tourism and engagement with local communities in the protecting environment. EID merges standards for interoperability, its representation of CNH, representation of hazards and risks, design and impact on the handling of CNH risks in Europe.

For more information about the ResCult project, see section *4.2.3*.

Natural Risk Zones

The ResCult EID is based on the INSPIRE Data Specification on Natural Risk Zones, which are vulnerable areas characterised according to natural hazards (all atmospheric, hydrologic, seismic, volcanic and wildfire phenomena that, because of their location, severity, and frequency, have the potential to seriously affect society), e.g. floods, landslides and subsidence, avalanches, forest fires, earthquakes, volcanic eruptions.

The database structure in ResCult EID is shown in *Figure 18*:

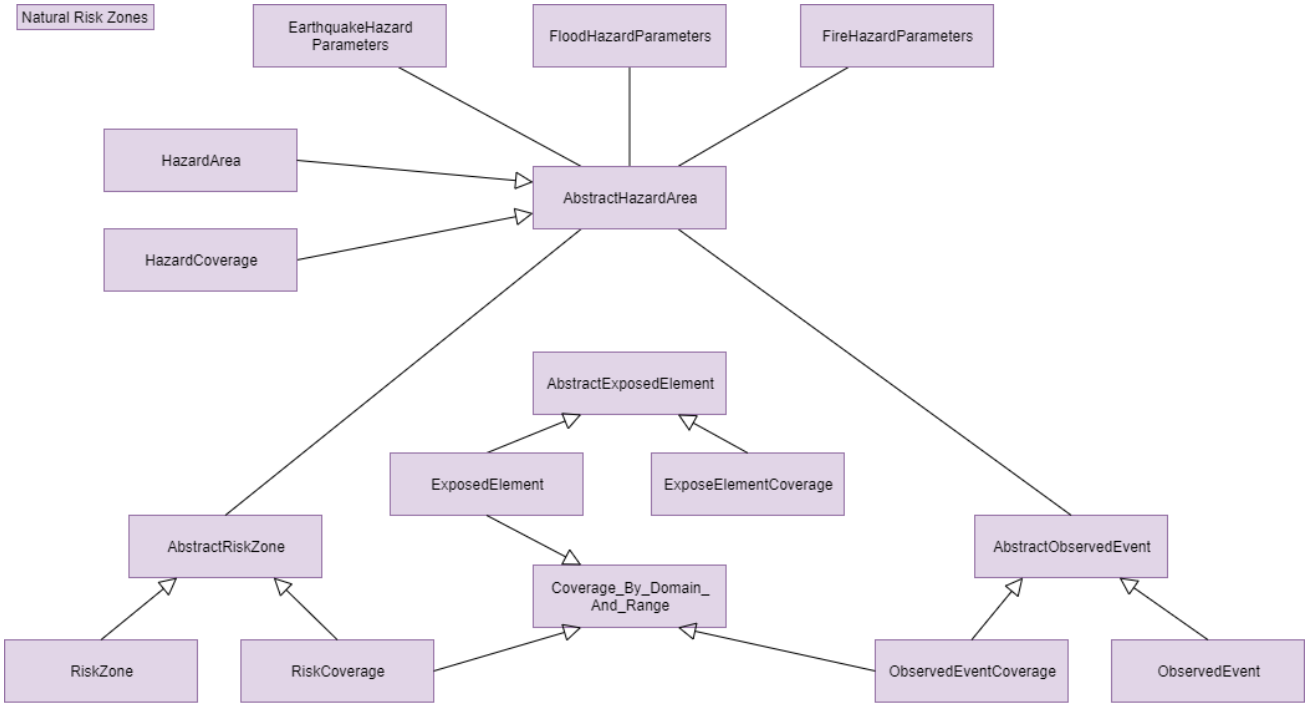


Figure 18 – UML Diagram **–** 2 Natural Risk Zones

Protected Site

The ResCult EID is based on the INSPIRE Data Specification on Protected Sites. This Specification details a Simple application schema of Protected Sites with a very limited set of fundamental attributes, including geometry, identifier, name and legal foundation date and document reference. Only current (non-historical) Protected Sites are included.

The database structure in ResCult EID is described in *Figure 19*:

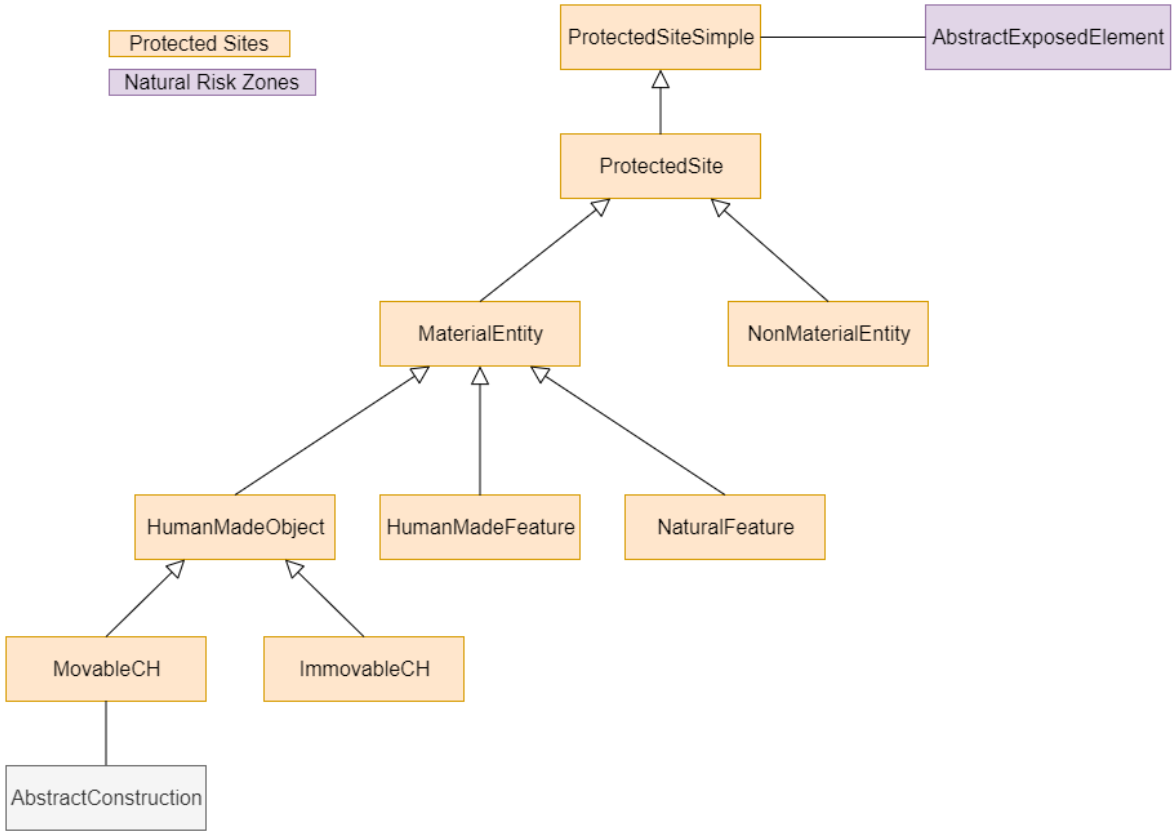


Figure 19 – UML Diagram **–** Protected Sites

Building

The ResCult EID is based on the INSPIRE Data Specification for the spatial data theme Buildings. However, in SHELTER the elements are not only buildings, other elements such as vegetations, transportation, water body or HA are defined and, in that sense, CityGML is broader than the INSPIRE Building specification. Because of that, CityGML is selected as the base data model, the building module available in CityGML core will be used instead of INSPIRE building specification.

6.2.3 CityGML thematic modules

In SHELTER MMDM, the building module available in CityGML core will be used, along with the water body module (see *Figure 20*).

The base class of all thematic classes within CityGML data model is the abstract class _CityObject. _CityObject provides a creation and a termination date for the management of histories of features as well as generic attributes and external references to corresponding objects in other data sets.

The subclasses of _CityObject comprise the different thematic fields of a city model, in the following covered by separate thematic models: building model (_AbstractBuilding), tunnel model (_AbstractTunnel), bridge model (_AbstractBridge),

city furniture model (CiyFurniture), digital terrain model (ReliefFeature), land use model (LandUse), transportation model (TransportationObject), vegetation model (_VegetationObject), water bodies model (WaterObject) and generic city object model (GenericCityObject).

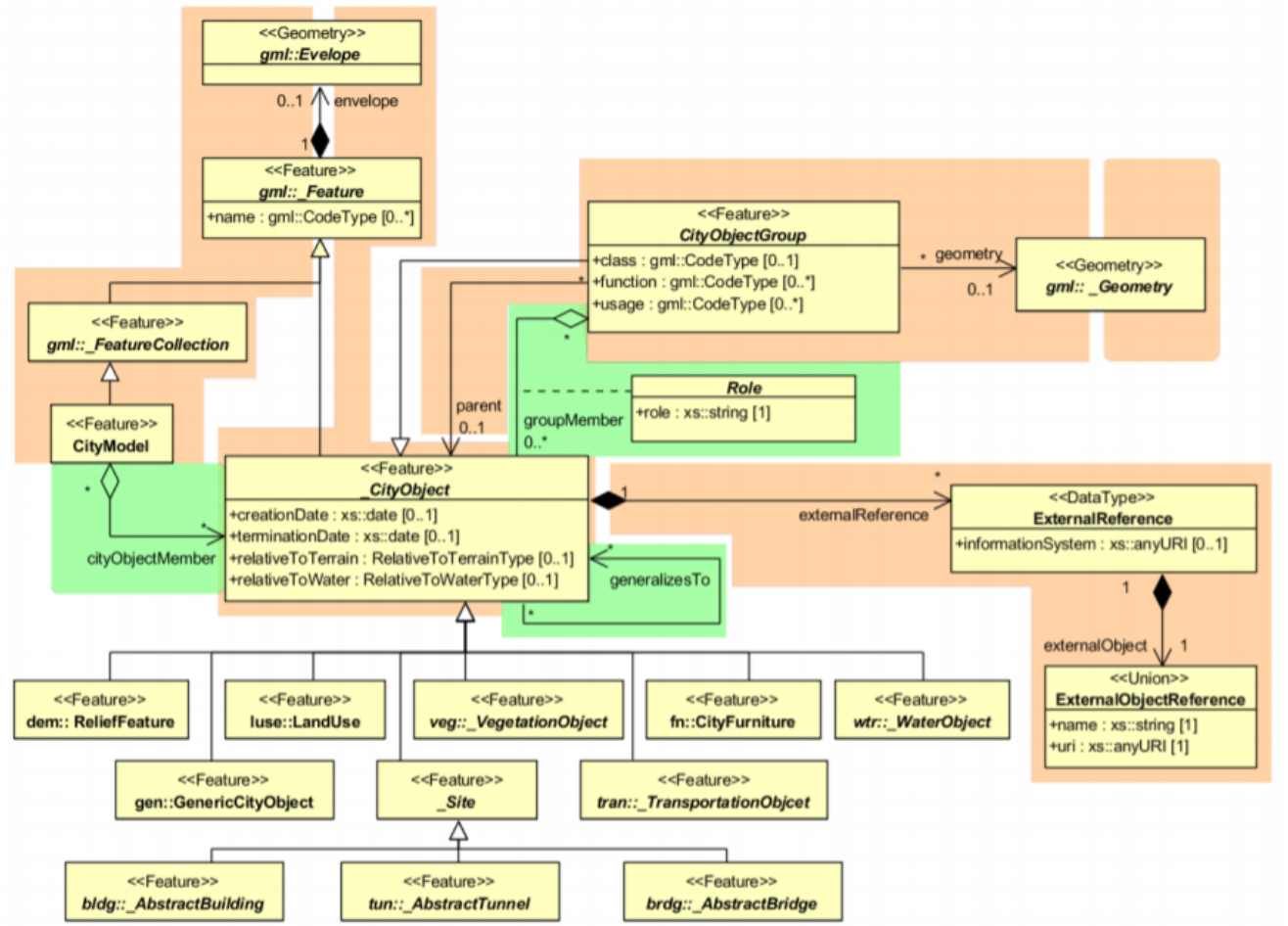


Figure 20 – CityGML Module

Figure 21 presents the main entities of the CityGML data model which are used in the SHELTER MMDM:

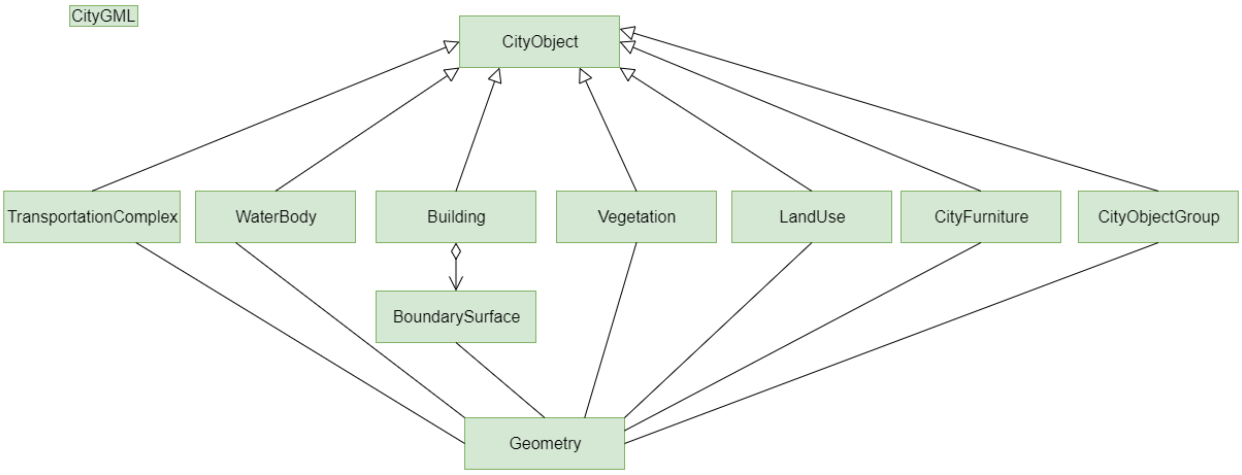


Figure 21 – Entities of CityGML in Shelter

6.2.4 Assembling the SHELTER MMDM

This section describes the SHELTER MMDM in more detail, with an emphasis on how this model integrates and extends the reference data models, namely ResCult EID and CityGML.

6.2.4.1 *Reference data models integration*

Regarding INSPIRE Protected Site specification, the main entity to be used is "ProtectedSite" (see *Figure 22*). In order to adapt it to SHELTER some changes have been done:

- A relationship between ProtectedSite and CityObject has been defined. It is multiple. In that way any city object can be included within a protected site and the same city object can be associated to several protected sites.
- The relationship between MovableCH and AbstractConstruction has been removed. The INSPIRE Building specification is not used in SHELTER, the CityGML standard is used instead. As first attempt, the idea was to perform a relationship between MovableCH and Building module in CityGML. However, the approach explained above fulfills all the requirements for all the different CityObjects.

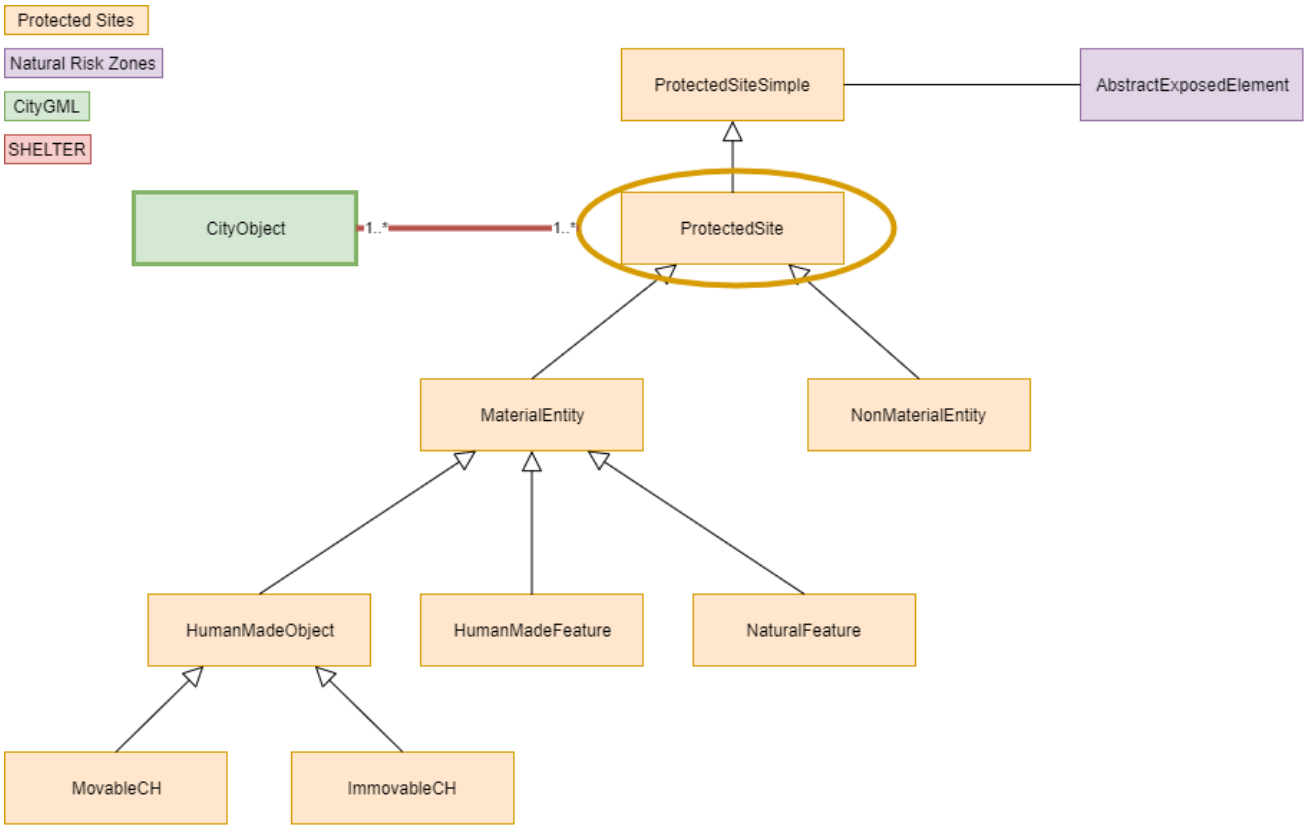


Figure 22 – Reference integration (CityGML-Protected Sites)

Regarding the INSPIRE Natural Risk Zone specification, the main entities used are "HazardArea", "RiskZone", "ExposedElement" and "ObservedEvent" (see *Figure 23*). In order to adapt it to SHELTER some changes have been done:

- A relationship has been defined between ExposedElement and CityObject. In that way it is possible to identify which city object is an exposed element.
- A relationship has been defined between ExposedElement and HazardArea. In that way it is possible to identify in which hazard area is located a specific exposed element.
- A relationship between HazardArea and CityObject has been defined. In order to allow multiple and bidirectional relationship. In that way any city object can be included within a hazard area. In this case, the same city object could be associated in multiple hazard areas.
- A relationship between RiskZone and CityObject has been defined. In order to allow multiple and bidirectional relationship. In that way, any city object can be included within a risk zone. In this case, the same city object could be associated in multiple risk zones.
- A relationship has been defined between RiskZone and HazardArea. In that way it is possible to identify in which hazard area is located a specific risk zone.
- New entities have been defined, which are: RainfallHazardParameters, TemperatureHazardParameters, HeatwaveHazardParameters, StormHazardParameters, WindHazardParameters, SubsidenceHazardParameters.

The role of these entities is similar to that of the already existing EarthquakeHazardParameters, FloodHazardParameters and FireHazardParameters. All of them model specific hazards related to an AbstractHazardArea. In that way, when the hazard is one of those types (rain, temperature, heat wave, storm, wind, subsidence), it is possible to complete the data with specific parameters.

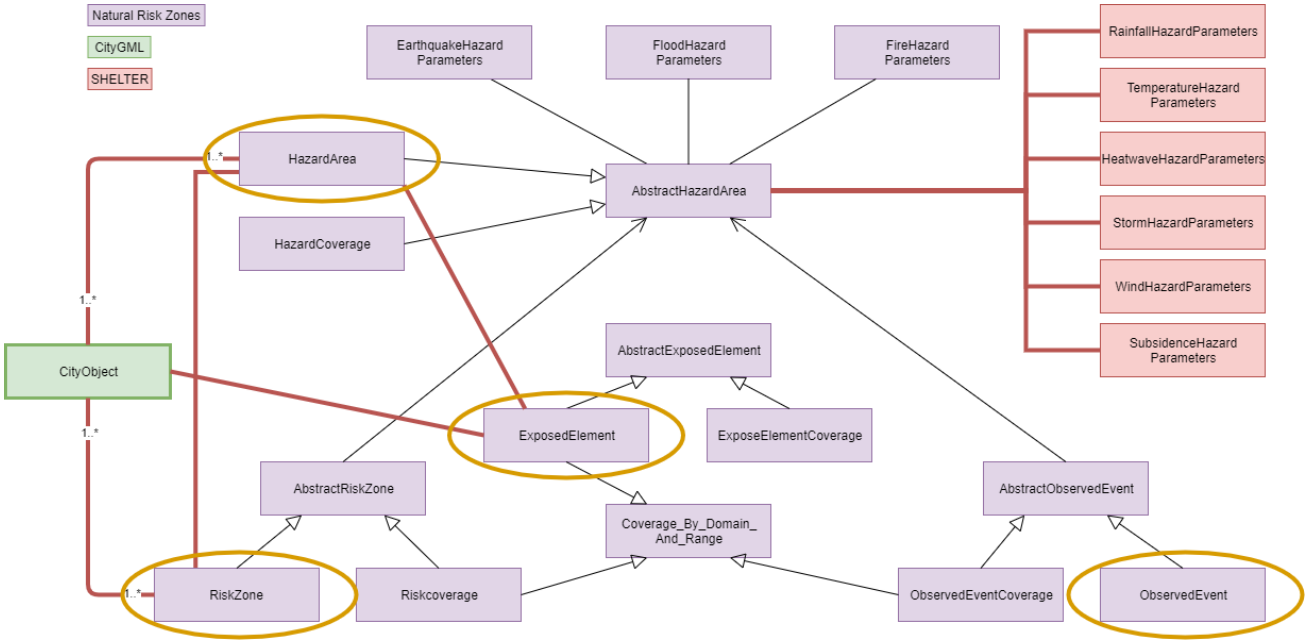


Figure 23 – Reference integration (new relationships)

Regarding OGC CityGML standard, the main entities to be used are "Building", "TransportationComplex", "WaterBody", "Vegetation", "LandUse", "CityFurniture" and "CityObjectGroup". They are shown in *Figure 24*.

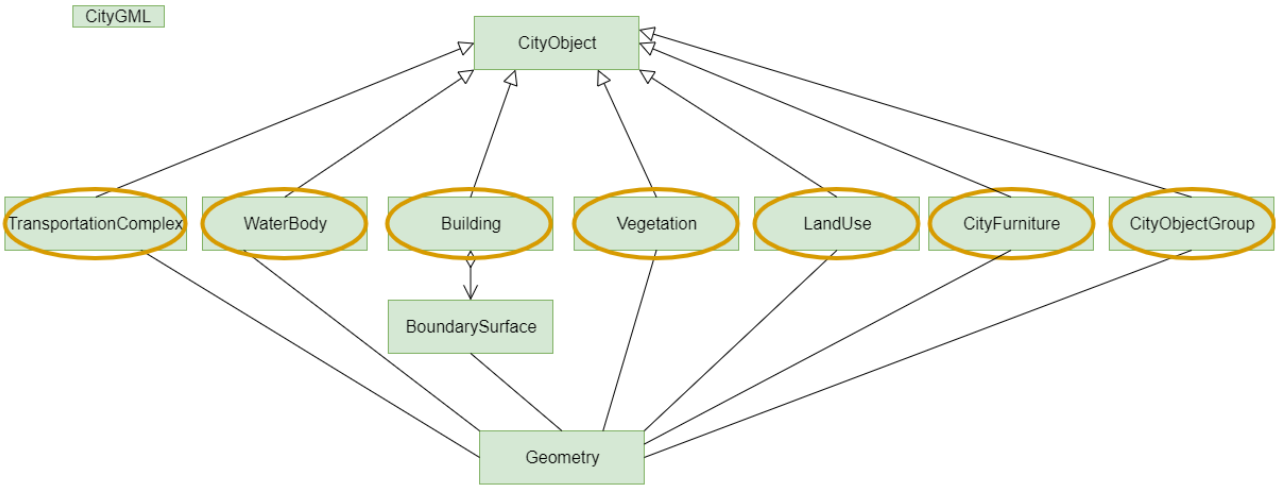


Figure 24 – Reference integration (CityGML main entities)

6.2.4.2 *Resilience extension*

To complete the design of the SHELTER MMDM, the Resilience must be incorporated to it. The resilience information in the data model is represented by three main components: 1) Resilience ID 2) Resilience Index and 3) SHELTER indicators.

1) Resilience ID

Adequate, georeferenced and easily accessible information is key for an effective DRM. Information on risk assessment, prevention measures, preparedness systems and plans and recovery planning decrease the impacts that hazards may cause and increase the speed of recovery and the effectiveness of the response. The "Resilience ID" is a multiscale and spatially explicit incremental documentation strategy intended to store in the MMDM all this relevant information to make it actionable when required. Besides this, the Resilience ID will structure and make accessible the results generated by the application of the Operational Knowledge Framework (OKF) of SHELTER, and could also support the monitoring of the resilience indicators. If any financing scheme is envisaged for particulars owners, it could be linked to specific buildings and actions. The Resilience ID will be implemented in an incremental and multiscale way:

- Multiscale approach: it will include information at the different scales of the model (mainly HA and building, but could include also at object level)
- Incremental approach: the strategy will start from the prioritised elements (either for their community value or for the result of the risk assessment) and generating a roadmap for the dynamic completion of all the information needed for the HA.

The information that will be included will address all the phases of the DRM:

- **PH-I-prevention phase:**
  - at HA level:
    - Resilience baseline and risk assessment.
    - Resilence index and indicators for effective monitoring.
    - Long term and short-term general HA adaptation roadmap.
  - at the building level:
    - Their specific long term and short-term adaptation plans and their role in the general HA adaptation roadmap.
    - Maintenance procedures and adaptation scheduler (to program all the planned maintenance and adaptation tasks).
    - Their vulnerability and risk level.
  - Adaptive governance structure at the prevention phase
- **PH-II- preparedness phase** (both building and HA level):
  - The risk management and contingency plans.
  - Early warning systems.
  - Adaptive governance structure at the preparedness phase.
  - Staff and occupancy training requirements (with a specific focus on vulnerable groups).
- **PH-III-response phase:**

  - at HA level:
    - Emergency procedures.
    - Protocols for short-term fast responses focused on CNH.
  - at building level:
    - Emergency procedures focused on the evacuation of CNH.
    - Stabilization measures and protocols.
- **PH-IV-recovery phase:**
  - at HA level:
    - Risk-based optimal design guidelines and standards for reconstruction interventions.
    - Prioritization strategy and roadmap.
    - Pre-planned early recovery roadmaps for cultural heritage-conscious reconstruction under the principle of building back better and safer.
  - at the building level:
    - Back up 3D models with different levels of details to preserve digital memory and support short and long-term reconstruction strategies.

T4.1 will define in detail the incremental strategy for the implementation of the Resilience ID, the workflow to generate it using the DDP, the structure of the information and the visualisation in the MMDM. The Resilience ID will be implemented in different scales and heritage types of the 5 OLs.

The following table (see

Table 9) describes the elements in Resilience ID, their associated elements in the model, the phase of the DRM when they are useful, the type of data and the source. Those elements are associated to the indicators defined in T2.2, which are also included in the MMDM.

The Resilience ID specification is still an ongoing process in WP4, so MMDM will be adapted to it in the future. As a first idea, the association with document, images or similar will be done with CityGML ExternalReference; while new identifiers, parameters or indicators will be included to specific tables if necessary.

Associated element in MMDM	Element	Phase	Source	Type of data
Historic Area	Resilience baseline	PH-I	Dashboard	Numerical indicator
	Results from risk assessment	PH-I	DSS	Numerical indicator
	Long term and short-term general HA adaptation roadmap (including financing schemes)	PH-I	DSS/ solutions portfolio	PDF/scheduled list of actions/link to solutions
	Adaptive governance scheme for each phase	PH-I-IV	D6.3	Image of organographs

Associated element in MMDM	Element	Phase	Source	Type of data
	Emergency procedures and protocols for short-term fast responses focused on CNH	PH-III	D4.2	PDF
	Risk-based optimal design guidelines and standards for reconstruction interventions	PH-IV	D4.2	PDF
	Prioritization strategy and roadmap	PH-IV	D4.2/DSS/ solutions portfolio	PDF/scheduled list of actions/link to solutions
	Pre-planned early recovery roadmaps for cultural heritage-conscious reconstruction under the principle of building back better and safer	PH-IV	D4.3	PDF
Building	Specific long term and short-term adaptation plans and their role in the general HA adaptation roadmap	PH-I	DSS/ solution portfolio	scheduled list of actions/link to solutions
	Maintenance procedures and adaptation scheduler (including financing schemes)	PH-I	Scheduler	scheduled list of actions/link to solutions
	Vulnerability level	PH-I	DSS	Numerical indicator
	Risk level	PH-I	DSS	Numerical indicator
	Contingency plans	PH-II	External source	PDF/list of actions
	EWS	PH-II	D3.1	PDF/list of actions
	Staff and occupancy training requirements	PH-II	External source	PDF
	Emergency procedures focused on the evacuation of CNH, stabilization measures and protocols	PH-III	External source	PDF
	Back up 3D models with different level of details to preserve digital memory and support short- and long-term reconstruction strategies.	PH-IV	WP7/ External source	3D model LoD 4, IFC, other formats
Vegetation	Vulnerability level	PH-I	DSS	Numerical indicator
	Risk level	PH-I	DSS	Numerical indicator
Water Body	Vulnerability level	PH-I	DSS	Numerical indicator
	Risk level	PH-I	DSS	Numerical indicator

Table 9 – Resilience ID elements and their associated elements in the MMDM

2) Resilience Index

The resilience index and the definition of the KPI's for resilience monitoring are being identified in T2.7, where a set of indicators will be defined. The aim of the indicators will be to quantify the links between the multiple dimensions of HA resilience, the connections between different spatial scales and the changes across temporal scales. It will collaborate with stakeholders to lead the development of action plans for enhancing resilience.

In addition to that, the resilience index will perform the required data analysis and the calculation of resilience index, while performing sensitivity and uncertainty analysis. To do that, it will combine different multidimensional resilience assessment results, such as building environment, cultural, social, governance and institutional resilience or economic and environmental resilience, among others.

In order to include resilience index related data in the MMDM, a Resilience Index entity will be associated with the CityGML CityObject entity.

3) SHELTER indicators

In this section, a review of the indicators identified in T2.2 is included. For each of the indicators, a matching with one of the defined entities for the MMDM has been done. As a first analysis, the subcategory has been mapped to the different entities, and then an individual analysis for each indicator has been performed. When necessary, a parameter has been created at the city object level (building, vegetation, transportation, etc.) and then the indicator that will store the aggregated value has been defined at a higher level entity (HistoricArea, HazardArea, RiskZone or ProtectedSite).

As a result, a number of tables that describe the parameters and indicators to be included in the MMDM have been created. They have been divided by entities, and they are described in section *10.2*.

Each table contains the following information:

- Subcategory: The subcategory defined in the indicators list which describes the scope of the indicator.
- Indicator: The name of the indicator.
- Parameter/Indicator: If the indicator is a parameter or an indicator in the MMDM.
- Reference Model: The base reference model for each indicator. The reference models are: ProtectedSite, NaturalRiskZone, CityGML and SHELTER.
- Entity: One of the entities of the MMDM.

- Core/Extension: If the indicator already exists in the reference model, 'Core' will be assigned, and `Extension' when a new indicator must be created.
- Table: The target table in the database.
- Parameter: The parameter name within the table.
- Data Type: The valid data types are String, Integer, Double, Date and Boolean.
- Enumeration: In case a list of values is predefined for the indicator, an enumeration can be created.
- Dataset ID: The unique identifier of the data sources described in *Table 7*.

6.2.5 MMDM in SHELTER context

Main entities

As a summary, this is the list of the entities used:

- Building
- Transportation
- Vegetation
- WaterBody
- HazardArea: there are some generic parameters at the HazardArea level and some specific parameters depending on the type of the hazard (earthquake, flooding, fire, rainfall, temperature, heatwave, storm or wind). For each type of hazard a list of specific parameters have been defined
- RiskZone
- HistoricArea

In addition to the main entities, a combination of entities can also happen. This means that a parameter is defined for one entity, and then, the indicator that aggregates all the values of the parameters is defined in the other entity. In SHELTER, the following combinations of entities have been identified:

- ExposedElementHistoricArea. Combines parameters at ExposedElement entity and indicators at HistoricArea entity.
- BuildingHistoricArea. Combines parameters at Building entity and indicators at HistoricArea entity.
- ProtectedSiteHistoricArea. Combines parameters at ProtectedSite entity and indicators at HistoricArea entity.
- VegetationHistoricArea. Combines parameters at Vegetation entity and indicators at HistoricArea entity.
- RiskZoneHistoricArea. Combines parameters at RiskZone entity and indicators at HistoricArea entity.
- HazardAreaHistoricArea. Combines parameters at HazardArea entity and indicators at HistoricArea entity.
- RiskZoneProtectedSite. Combines parameters and indicarors between RiskZone and ProtectedSite entity.

- WaterBodyHistoricArea. Combines parameters at WaterBody entity and indicators at HistoricArea entity.
- RiskZoneVegetation. Combines parameters at Vegetation entity and indicators at RiskZone entity.

Connection with macrocategories

The MMDM also includes data identified in T2.3, which is related with the macrocategories building, natural and urban, as explained in section *5.3*. In the same way done with the selected indicators, the parameters that must be in the MMDM related to the macrocategories have been identified. As a result, three tables (one per each macrocategory) that describe the parameters to be included in the MMDM have been created and are included in the section *10.3*. The table structure is similar as the ones in section *10.2*.

SHELTER tools

One of the aims of the MMDM is to facilitate access to information through the RD. For this purpose, the MMDM must keep updated information of the different SHELTER tools, whose results are shown in the Dashboard. The results to be displayed can be raw data of the tools or somehow processed or aggregated.

The tools to be developed in SHELTER and whose results will be connected to the Dashboard are different and provide results of different types. They can be grouped into three large categories depending on the relationship with the Dashboard:

- **Tools that calculate resilience indicators**. These tools are based on information from the data model and other external sources for the assessment of resilience through the methodology and indicators that will be defined in WP2 (T2.7 – "Development of the SHELTER cross-scale HA systemic resilience assessment methodology"). Examples of these tools are Early warning systems, Multihazard risk assessment and Strategic DSS. These indicators will be stored in the data model once defined. A structure has already been foreseen for them in the model (section *6.2.4.2*).
- **Tools that generate contextual information**. These tools are independent from the RD, have their own data input and output interfaces, but provide processed and aggregated data that complement the information from the resilience indicators. Examples of these tools are the Chatbot, Social media engine and IMMERSITE. Communication with these tools will be done through an API that provides access to the statistics and aggregated values that will be stored in the data model for their representation. The structure to contain this contextual information will be updated once the tools that generate this information have been defined.
- **Tools that generate unstructured data**. The unstructured data will be stored in the Data Lake. Some of this data will have geospatial representation and may

be required for its visualization in the RD. Examples of tools that generate these unstructured data are Rapid damage assessment and Prioritization matrix tools. Geospatial data will be served to the Dashboard through web map services (WMS) interfaces for visualization. These data will not have any type of representation in the MMDM.

Registered data

The ResCult EID also defines the ObservedEvent entity, which purpose is to define the spatial representation of a natural phenomenon relevant to the study of natural hazards which occurred, or is currently occurring, and which have been observed. The data stored in the ResCult EID data model includes: an identifier, the type of hazard, the name of the event, the likelihood of occurrence, information about the date of appearance of the event, information about the ending date of the event and the association to the ExposedElement.

The approach to include historical data in the MMDM will be by georeferencing past events with a point in the ObservedEvent entity, and then associating it with detailed and completed historical past events information that will be stored in the DataLake.

Governance

The ResCult EID data model already defines an Ownership entity, which may be used in SHELTER to identify the owner of the different city objects or the responsible for the protected sites. For each Ownership entity, the name, address, CF, e-mail and phone number are stored in the data model. In ResCult EID, the Ownership entity is linked to the ProtectedSite.

6.2.5.1 *Association of dataset sources with entities*

In order to analyze the relationship between data sources and entities, a table has been created showing the same dataset sources indicated in section *5.2.2* relating each one of them with the main entities of the MMDM. In addition to main entities, a new column called "Others" has been included in the table where it is identified the background cartography, such as orthophotos, digital terrain model, administrative boundaries, etc. This table can be seen in section *10.4*.

7 Implementation of SHELTER Data Model

This chapter describes the most important aspects regarding the implementation of the SHELTER MMDM. Section 7.1 explains the main technologies that support this implementation. Section *7.2* describes new entities and relationships created for the MMDM.

7.1 Information System Architecture

The SHELTER MMDM will be the core of an information system that provides support to different applications and activities of the SHELTER Project.

Figure 25 – System architecture shows a diagram with the architecture of this information system. The data tier is a PostGIS database where the SHELTER MMDM will be implemented. Data coming from different sources will be loaded to that database. There is a geographic application server (GeoServer) that provides a number of standardized OGC web service interfaces to client applications. The main client application is the Dashboard.

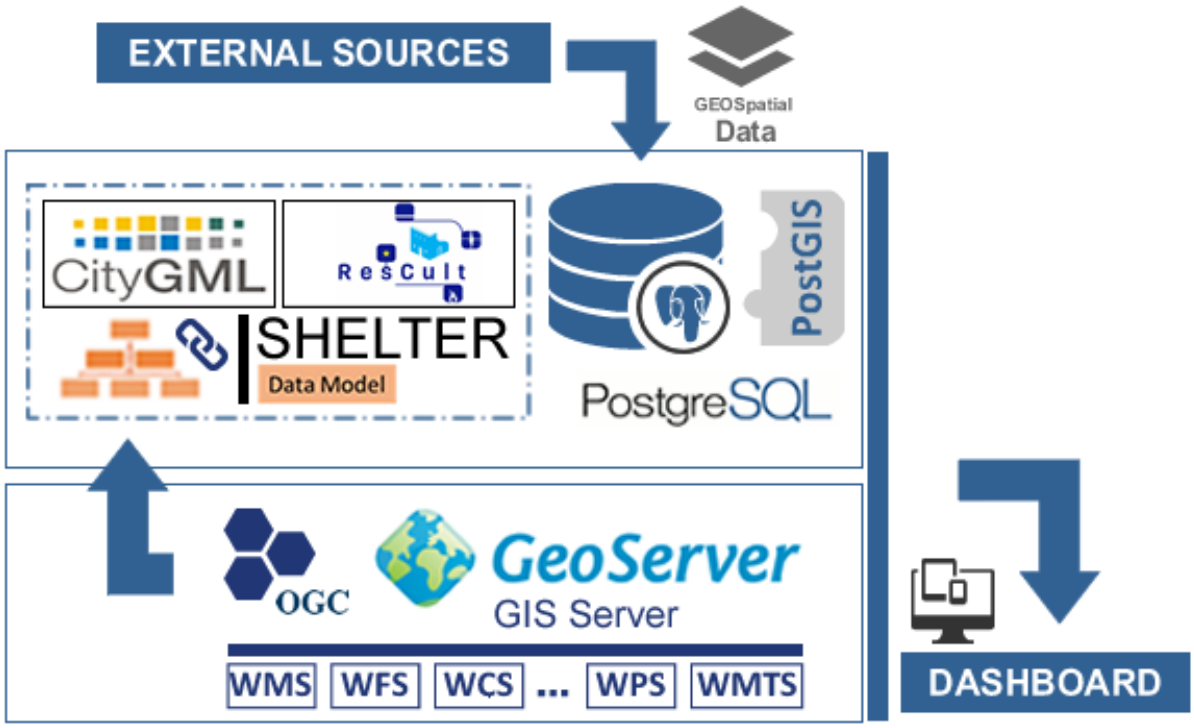


Figure 25 – System architecture

Figure 26 shows all architecture of the DDP as well as the tools and solutions that will be created in SHELTER project.

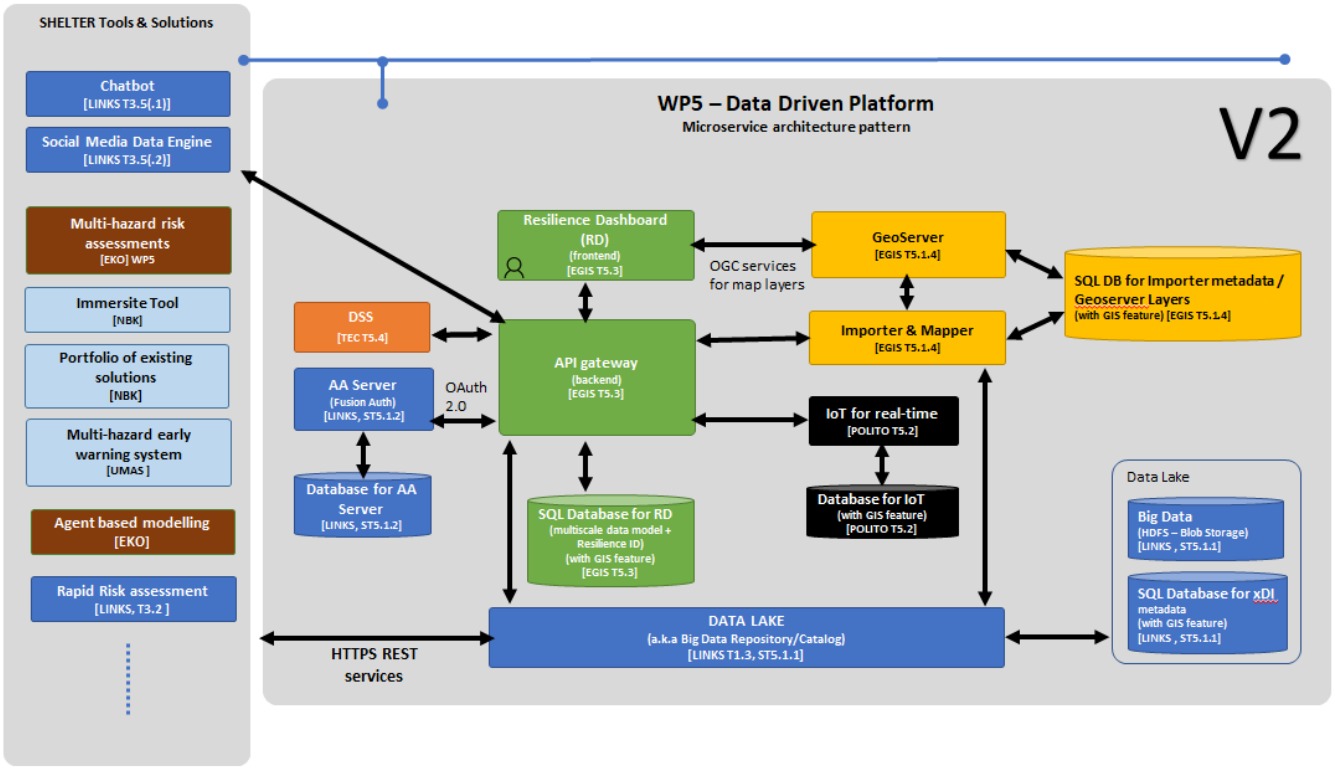


Figure 26 – Data Dive Platform Architecture

7.1.1 Technological environment

Repository of geographic data (Geodatabase): Corporative geodatabase

After having carried out a brief analysis of some of the existing (see section *4.3.1)*, **PostgreSQL**, with the PostGIS extension, has been chosen to implement the geodatabase, since it is the most powerful and robust available open source system with a spatial extension. PostgreSQL, also known as Postgres, is a free and open-source relational database management system (RDBMS). PostGIS is a spatial database extender for PostgreSQL object-relational database. It adds support for geographic objects allowing location queries to be run in SQL. In addition to that, PostGIS is compatible with OGC standards in order to facilitate the exchange of geographic information.

Besides this, the 3DCityDB will be used, since it allows storing CityGML models in a PostgreSQL + PostGIS database [Link5]. 3DCityDB offers database generation scripts and libraries that allow both importing to the database and exporting CityGML models from that database. It also contains the SQL scripts required to create an instance of 3DCityDB in PostgreSQL with PostGIS.

The database will be the place where all the geographic and alphanumeric information of the integral system is stored, prioritizing the use and reuse of stored procedures or functions for the processing of the data.

The corporative geodatabase allows multiuser access and editing. It is accessible by direct connection for data processing from GIS applications. Services with standard OGC interfaces and a specializaed REST API will be implemented on top of it to support different client application requirements.

Geographic data server

GeoServer is an open-source server for sharing geospatial data. Designed for interoperability, it publishes data from any major spatial data source using open standards. GeoServer implements industry standard OGC protocols such as WFS, WMS and WCS. Additional formats and publication options are available as extensions including WPS and WMTS. It will be deployed along with an Apache Tomcat 8.x/9.x web application server.

Resilience DASHBOARD

It will be the main control panel for information exploitation. The T5.3 is pending completion, so an update of the document will be necessary for the coming months to collect all the information related to the RD.

Its geographic visualization capabilities will be developed with libraries or frameworks that can use the capabilities supported by Geoserver. Web developments will be compatible with, and tested in, the main web browsers.Other modules: in the SHELTER Project there are other modules such us IoT Module, Data Lake, AA Server (User autenthication server), DSS, Importer & Mapper. These modules could interact with the Project Database.

Development Environment

There will be two different development environments:

- **Preproduction environment**: to develop and tests the system.
- **Production environment**: the final version of the system will be deployed here.

7.1.2 Model Management

7.1.2.1 *DB Roles, groups and users*

This section explains the types of user profiles / roles that will be created in the database:

Database Groups (group roles)

- Creator/superadmin (owner): total access to the data base.
- Read Only: edition and read access, but withouth the possibility to change the structure of the Data Model.
- Data Consumption from the apps:
    - Geoserver

- Dashboard
- Others

Database Users:

Example of Group roles: application roles.

DB User ID	Description	Group/Role
1	gisGeoserver	apps
2	gisDashboard	apps
3	gisIoT	apps
4	gisDataLake	apps
5	gisAAServer	apps
6	gisDSS	apps
7	gisSocialMedia	apps
8	gisOthers	apps
9	gisGeoserver	apps
11	gisOthers	apps

Table 10 – App users

The application roles in the database will be defined in the following months as the requirements for the different applications of the project are being defined.

7.2 Database Structure and Relationships

In this section the new database structures needed to create the SHELTER Project Database are detailed.

The base of the RESCULT EID and CityGML project will be uploaded to the Shelter Project Folder to have access to all the entities/attributes that are implemented in every origin project.

In addition, a *"SHELTER.CREATION.SCRIPT.SQL / BACKUP"* file will be added along with this document, where all the scripts necessary to create the DB appear.

The full Entity-Relationship Diagram is in section *10.6* and will be accessible in the Shelter Project folder (*"SHELTER_DATA_MODEL.pdf"*).

7.2.1 Entity-relationship diagram

This section defines the specific Shelter Entity-Relationship Diagram and includes the integration with the different entities of each Shelter DB Module (CityGML, Rescult, Shelter).

The complete Entity-Relationship Diagram is shown in the Appendix 10.6.

Figure 27 – Entity – Relationship Diagram (new entities and relationships (1)) includes entities with different colors: Rescult (**Protected Sites**, **Natural Risk Zones**), **CityGML** and **Shelter**.

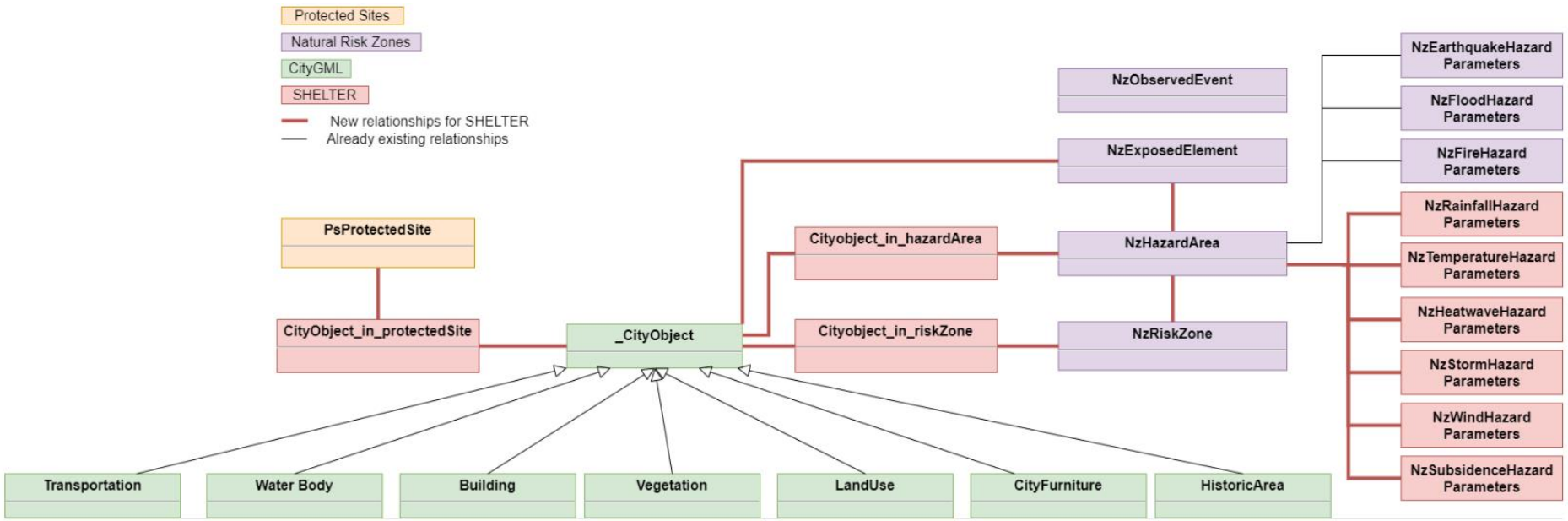


Figure 27 – Entity – Relationship Diagram (new entities and relationships (1))

7.2.2 Entities taken from other models

Based on Rescult DB

As these have been defined and documented elsewhere, and they are quite detailed, the entities and relationships from the RESCULT database are not repeated in this document.

This information is available in the Excel document uploaded to project folder and on the RESCULT project website [Link6].

Based on CityGML DB

As these have been defined and documented elsewhere, and they are quite detailed, the entities and relationships in the CityGML database (3DCityDB) are not repeated in this document.

This information is available in the Excel document uploaded to project folder and on the 3DCityDB project website [Link5].

7.2.3 New entitities and relationships

New entities, attributes and relationships have been created to integrate Rescult DB with CityGML. Also specific Shelter entities and relationships have been created to integrate all the indicators and information taken from DMF document.

In the following tables, some attributes added to the existing and new entities are marked in different colors. These colors are associated to the indicators that require those attributes. The indicators are described in section *10.2*, and these are the colors:

Attributes from **BuildingHistoricArea** (section *10.2*)
Attributes from **ExposedElementHistoricArea** (section *10.2*)
Attributes from **ProtectedSiteHistoricArea** (section *10.2*)
Attributes from **VegetationHistoricArea** (section *10.2*)
Attributes from **RiskZoneHistoricArea** (section *10.2*)
Attributes from **HazardAreaHistoricArea** (section *10.2*)
Attributes from **WaterBodyHistoricArea** (section *10.2*)
Attributes from **RiskZoneVegetation** (section *10.2*)

Attributes from **RiskZoneProtectedSite** (section *10.2*)

Attributes from **HazardAreaHistoricArea** (section *10.2*)

Attributes from **Building Macrocategory** (section *10.3*)

Attributes from **Urban Macrocategory** (section *10.3*)

Attributes from **Natural Macrocategory** (section *10.3*)

7.2.3.1 *New entities*

RainfallHazardParameters

New attributes:

column_name	data_type	udt_name	is_nullable
idrainfalhp	Integer	Integer	NO
dailyMaximumPrecipitation	Double	Double precision	YES
hourlyMaximumPrecipitation	Double	Double precision	YES
distributionRainfallIntensity	Double	Double precision	YES
torrentialityIndex	Integer	INTEGER	YES

Table 11 – RainfallHazard (new attributes)

Attributes from **RainfallHazard** (section *10.2*)

TemperatureHazardParameters

New table/attributes:

column_name	data_type	udt_name	is_nullable
idtemphp	Integer	Integer	NO
annualMeanTemperature	Double	Double precision	YES
meanDiurnalRange	Double	Double precision	YES
isoThermality	Double	Double precision	YES
temperatureSeasonality	Double	Double precision	YES
maxTemperatureWarmestMonth	Double	Double precision	YES
minTemperatureColdestMonth	Double	Double precision	YES
temperatureAnnualRange	Double	Double precision	YES
meanTemperatureWettestQuarter	Double	Double precision	YES
meanTemperatureDriestQuarter	Double	Double precision	YES
meanTemperatureWarmestQuarter	Double	Double precision	YES
meanTemperatureColdestQuarter	Double	Double precision	YES
dailyMeanTemperature	Double	Double precision	YES
thermalShock	Double	Double precision	YES
daysTmin0Tmax0Number	Integer	Double precision	YES

column_name	data_type	udt_name	is_nullable
landSurfaceTemperature	Double	Double precision	YES
annualMeanTemperature	Double	Double precision	YES
meanDiurnalRange	Double	Double precision	YES
isoThermality	Double	Double precision	YES
temperatureSeasonality	Double	Double precision	YES
maxTemperatureWarmestMonth	Double	Double precision	YES
Idrescultaha (FK)	character varing	Character varing (20)	NO

Table 12 – TemperatureHazard (new attributes)

Attributes from **TemperatureHazard** (section *10.2*)

HeatwaveHazardParameters

New table/attributes:

column_name	data_type	udt_name	is_nullable
Idheatwavehp	Integer	Integer	NO
dailySunHours	Integer	Integer	Yes
heatWaveIndicator	Double	Double precision	yes
Idrescultaha (FK)	character varing	Character varing (20)	NO

Table 13 – HeatwaveHazard (new attributes)

Attributes from **HeatwaveHazard** (section *10.2*)

StormHazardParameters

New table/attributes:

column_name	data_type	udt_name	is_nullable
Idstormhp	Integer	Integer	NO
windSpeed	Double	Double precision	YES
airPressure	Double	Double precision	YES
capeIndex	Double	Double precision	YES
liftedIndex	Integer	Integer	NO
heavyRain	Double	Double precision	YES
windPressure	Double	Double precision	YES
gustStrength	Integer	Integer	NO
stormDuration	Integer	Integer	NO
stormsPerMonthNumber	Integer	Integer	NO
windSpeedYearVariance	Integer	Integer	NO
gustSpeedsYearVariance	Integer	Integer	NO
Idrescultaha (FK)	character varing	Character varing (20)	NO

Table 14 – StormhazardHazard (new attributes)

Attributes from **StormHazard** (section *10.2*)

WindHazardParameters

New table/attributes:

column_name	data_type	udt_name	is_nullable
Idwindhp	Integer	Integer	NO
mainWindDirectionsColdest	String	Text	Yes
mainWindDirectionsWettest	String	Text	yes
Idrescultaha (FK)	character varing	Character varing (20)	NO

Table 15 – WindhazardHazard (new attributes)

Attributes from **WindHazard** (section *10.2*)

SubsidenceHazardParameters

New table/attributes:

column_name	data_type	udt_name	is_nullable
Idsubsidencehp	Integer	Integer	NO
subsidenceRate	Double	Double precision	Yes
deflectionRatio	String	Text	yes
Idrescultaha (FK)	character varing	Character varing (20)	NO

Table 16 – SubsidencehazardHazard (new attributes)

Attributes from **SubsidenceHazard** (section *10.2*)

HistoricArea

New attributes:

column_name	data_type	udt_name	is_nullable
Idhistoricarea (PK)	Integer	Integer	NO
cityobjectgroupid (FK)	Integer	Integer	NO
populationDensity	Integer	double precision	YES
streetNoiseAcousticPollution	Integer	double precision	YES
constructionMaterial	String	double precision	YES
numberOfParticipantsTrainingCourses	Integer	double precision	YES
populationAccessRiskInformationPercentage	Double	double precision	YES
populationBelow65Percentage	Double	double precision	YES
population17OrBelowPercentage	Double	double precision	YES

column_name	data_type	udt_name	is_nullable
populationWithoutDisabilityPercentage	Double	double precision	YES
femalePercentage	Double	double precision	YES
onePersonHouseholdPercentage	Double	double precision	YES
serviceCentresDistance	Double	double precision	YES
fireBrigadesDistance	Double	double precision	YES
populationWithTelephonePercentage	Double	double precision	YES
populationWithInternetServicePercentage	Double	double precision	YES
perCapitaIncome	Integer	double precision	YES
populationAbovePpovertyLinePercentage	Double	double precision	YES
infrastructureHousingInsurancePercentage	Double	double precision	YES
psychosocialSupportFacilitiesPer10kPersons	Double	double precision	YES
hospitalBedsPer10kPersons	Double	double precision	YES
hotelsMotelsPer10kPersons	Double	double precision	YES
residentialBuildingsPercentage	Double	double precision	YES
unemploymentRate	Double	double precision	YES
giniCoefficient	Double	double precision	YES
largeToSmallBusinessesRatio	Double	double precision	YES
firmsImplementingRiskStandardsPercentage	Double	double precision	YES
netInternationalMigration	Double	double precision	YES
civicOrganizationsPer10kPersons	Double	double precision	YES
redCrossVolunteersPer10kPersons	Double	double precision	YES
volunteerOrganizationsBudget	Integer	double precision	YES
registeredVolunteersNumber	Integer	Integer	YES
averagePerCapitaMitigationProjects	Integer	Integer	YES
populationCoveredMitigationPlanPercentage	Double	double precision	YES
streetPattern	String	text	YES
riskPerception	String	text	YES
peopleAccessEmergencyMedicalCare	Integer	Integer	YES
coordinationOtherGovernmentBodies	Integer	Integer	YES
mechanismsCommunitiesEngageGovernment	Integer	Integer	YES
traditionalCulturePresence	String	text	YES
measuresReduceDamageNumber	Integer	Integer	YES
predictionCapacity	Integer	Integer	YES
availableEquipmentLimitDamage	Integer	Integer	YES
oneFloorHousesNumber	Integer	Integer	YES
mediaObservationPublicPressure	Integer	Integer	YES
economicResilienceIndex	Integer	Integer	YES
gdi	Integer	Integer	YES
hazardMonitoringForecasting	Integer	Integer	YES
hazardAssessmentMapping	Integer	Integer	YES
vulnerabilityRiskAssessmentMapping	Integer	Integer	YES
publicInformationCommunityParticipation	Integer	Integer	YES

column_name	data_type	udt_name	is_nullable
landUseUrbanPlanningExtension	Integer	Integer	YES
reinforcementRetrofittingAssets	Integer	Integer	YES
organizationCoordinationEmergencyOperations	Integer	Integer	YES
hasWarningSystems	Integer	Integer	YES
equipmentToolsInfrastructureSupply	Integer	Integer	YES
interInstitutionalResponseCapability	Integer	Integer	YES
rehabilitationReconstructionPlanning	Integer	Integer	YES
decentralizedOrganizationalUnits	Integer	Integer	YES
resourcesInstitutionalStrengthening	Integer	Integer	YES
allocationMobilization Budget	Integer	Integer	YES
socialSafetyNetsFundsExistence	Integer	Integer	YES
insuranceLossTransferStrategies	Integer	Integer	YES
missionsNumberStormEvents	Integer	Integer	YES
newBuildingsRate	Double	double precision	YES
nonNativeFaunalSpeciesNumber	Integer	Integer	YES
speciesDiversityShannonDiversityIndex	Integer	Integer	YES
speciesNumberShannonEvennessIndex	Integer	Integer	YES
nativePollinatorSpeciesArea	Double	double precision	YES
naturalAreasProportion	Double	double precision	YES
prioritySpeciesConservationNumber	Integer	Integer	YES
nativeSpeciesNumber	Integer	Integer	YES
nativeBirdSpeciesNumber	Integer	Integer	YES
nativeSpeciesCompBaselineChange	Double	double precision	YES
professionalsCHPostDisasterRecoveryNumber	Integer	Integer	YES
infrastructuresBackUpSystemsPercentage	Double	double precision	YES
dailyTransportUsers	Integer	Integer	YES
vegetationWetlandsArea	Double	double precision	YES
existenceMechanismsIntegrationLocalKnowledge	Boolean	bool	YES
existencePlatformInformationSharing	Boolean	Bool	YES
newBusinessesRegisteredNumber	Integer	Integer	YES
renewableEnergyPercentage	Double	double precision	YES
siteAccessibility	String	text	YES
agriculturalOccupationRate	Double	double precision	YES
cattleHeadsNumber	Integer	Integer	YES
sheepHeadsNumber	Integer	Integer	YES
goatHeadsNumber	Integer	Integer	YES
poultryHeadsNumber	Integer	Integer	YES
swineHeadsNumber	Integer	Integer	YES
equineHeadsNumber	Integer	Integer	YES
landscapeHeterogeneity	Integer	Integer	YES
betaDiversity	Integer	Integer	YES
functionalDiversity	Double	double precision	YES

column_name	data_type	udt_name	is_nullable
totalPopulation	Integer	Integer	YES
illiteratePopulation	Integer	Integer	YES
habitatSuitabilityIndex	Integer	Integer	YES
carbonSequesteredCarbonSequestrationRate	Double	double precision	YES
buildingAlignmentRate	Double	Double precision	YES
drainageSystemPercentage	Double	Double precision	YES
basementFloodProneAreaPercentage	Double	Double precision	YES
openGroundFloorAboveMaxLevelPercentage	Double	Double precision	YES
structuralMaterialsWaterResistantPercentage	Double	Double precision	YES
facadeMaterialsWaterResistantPercentage	Double	Double precision	YES
blueGreenRoofsNumber	Integer	Integer	YES
hostingCollectionsStorageCapacityNumber	Integer	Integer	YES
enforcementSafetyConstructionCodesUpdating	Integer	Integer	YES
buildingTransformation	String	Text	YES
buildingWallsRotations	Integer	Integer	YES
hazardResistantStandardsPercentage	Double	double precision	YES
dailyHillsideRoofs	Double	Double precision	YES
dailyHillsideFacades	Double	Double precision	YES
skyViewFactor	Double	Double precision	YES
vibrationsCHTraffic	Double	Double precision	YES
areaShareProtectedLands	Double	Double precision	YES
cnhIntangibleValue	String	Text	YES
ShareEcologicalCorridors	Double	Double precision	YES
greenInfrastructureStructuralConnectivity	Double	Double precision	YES
greenInfrastructureFunctionalConnectivity	Double	Double precision	YES
nonNativeFloraSpeciesNumber	Integer	Integer	YES
veteranTreesNumber	Integer	Integer	YES
deadWoodQuantity	Integer	Integer	YES
habitatsRestoredArea	Double	Double precision	YES
habitatFunctionalComposition	Integer	Integer	YES
shannonIndex	Integer	Integer	YES
UrbanFreenSpaceArea	Double	Double precision	YES
plantRootDecayRate	Integer	Integer	YES
collapsedHeavyDamagedBuildingsNumber	Integer	Integer	YES
affectedCriticalFacilities	Integer	Integer	YES
stageDamageCurve	Integer	Integer	YES
recoveryRate	Integer	Integer	YES
slightModerateDamagedBuildings	Integer	Integer	YES
windthrow	Double	Double precision	YES
lossHabitatBiodiversity	String	Text	YES
durationInfrastructureOutage	Integer	Integer	YES
moderateDamagedMovableHeritage	Integer	Integer	YES
biologicalColonization	String	Text	YES

column_name	data_type	udt_name	is_nullable
burnSeverityIndex	String	text	YES
LandTakeArea	Double	Double precision	YES
buildingsNumber	Integer	Integer	YES
criticalFacilitiesNumber	Integer	Integer	YES
productiveActivitiesNumber	Integer	Integer	YES
majorAccidentRiskFactories	Integer	Integer	YES
managementRiverBasinsEnvironmentalProtection	Integer	Integer	YES
vegetationRecoveryRate	Double	Double precision	yes
primaryProductivity	Double	Double precision	Yes
climateType	String	Text	YES
humanSettlementSize	String	Text	YES
urbanHAScale	String	Text	YES
degreeOfUrbanization	String		

Table 17 – HistoricArea (new attributes)

7.2.3.2 *New attributes added to existing entities*

This information is added to the table name or is a new entity/table of the database.

ProtectedSite

New entity/attributes:

column_name	data_type	udt_name	is_nullable
areaShareProtectedLands	Double	Double precision	YES
cnhIntangibleValue	String	Text	YES
repairability	Double	Double precision	YES
economicLossCHDamagedDestroyed	Integer	Integer	YES
affectedIntangibleCH	String	Text	YES
heavyDamagedMovableHeritage	Integer	Integer	YES
lossAncestralNH	String	Text	YES
environmentalContext	String	Text	YES
naturalAreaType	String	Text	YES
chAssetDescription	String	Text	YES
chComponents	String	Text	YES
culturalAndNaturalValues	String	Text	YES

Table 18 – ProtectedSite (new attributes)

Attributes from **ProtectedSiteHistoricArea** (section *10.2*)

Attributes from **RiskZoneProtectedSite** (section *10.2*)

Attributes from **Natural Macrocategory** (section *10.3*)

Exposed Element

New entity/attributes:

column_name	data_type	udt_name	is_nullable
dailyHillsideRoofs	Double	Double precision	YES
dailyHillsideFacades	Double	Double precision	YES
skyViewFactor	Double	Double precision	YES
vibrationsCHTraffic	Double	Double precision	YES
registrationStatusConservationStatus	String	Text	YES
chAssetDescription	String	Text	YES
materialAndTechniquesDescription	String	Text	YES
function	String	Text	YES

Table 19 – Exposed Elements (new attributes)

Attributes from **ExposedElementHistoricArea** (section *10.2*)

Attributes from **Building Macrocategory** (section *10.3*)

Building

Existing attributes:

column_name	data_type	udt_name	is_nullable
idbuilding	integer	integer	NO
objectclass_id	integer	integer	NO
building_parent_id	integer	integer	YES
building_root_id	integer	integer	YES
class	character varying	varchar	YES
class_codespace	character varying	varchar	YES
function	character varying	varchar	YES
function_codespace	character varying	varchar	YES
usage	character varying	varchar	YES
usage_codespace	character varying	varchar	YES
year_of_construction	date	date	YES
year_of_demolition	date	date	YES
roof_type	character varying	varchar	YES
roof_type_codespace	character varying	varchar	YES
measured_height	double precision	double precision	YES
measured_height_unit	character varying	varchar	YES
storeys_above_ground	numeric	numeric	YES
storeys_below_ground	numeric	numeric	YES
storey_heights_above_ground	character varying	varchar	YES
storey_heights_ag_unit	character varying	varchar	YES
storey_heights_below_ground	character varying	varchar	YES

column_name	data_type	udt_name	is_nullable
storey_heights_bg_unit	character varying	varchar	YES

Table 20 – Building (existing attributes)

- *Comment: attributes associated with links/ geometry have not been included in this list (such as **lod1_terrain_intersection, lod2_multi_curve lod1_multi_surface_id**…), to simplify information. There can be found in the external excel file with the full information of CityGML entities/tables/attributes*

New attributes:

column_name	data_type	udt_name	is_nullable
stateOfConservation	String	text	YES
insulation	String	text	YES
protectionLevel	String	text	YES
structuralMaterial	String	text	YES
facadeMaterial	String	text	YES
accessibleWindows	Boolean	bool	YES
fireResistantPartitions	Boolean	Bool	YES
fireProtectionInstallations	Boolean	bool	YES
roofMaterial	String	text	YES
use	String	text	YES
typology	String	text	YES
hashazardresistantstandards	Boolean	bool	YES
isBuildingAligned	Boolean	Bool	YES
hasDdainageSystem	Boolean	Bool	YES
hasBasementFloodProneArea	Boolean	Bool	YES
hasOpenGroundFloorAboveMaxLevel	Boolean	Bool	YES
hasStructuralMaterialsWaterResistant	Boolean	Bool	YES
hasFacadeMaterialsWaterResistant	Boolean	Bool	YES
hasBlueGreenRoofs	Boolean	Bool	YES
hasHostingCollectionsStorageCapacity	Boolean	Bool	YES
enforcementSafetyConstructionCodesUpdating	Integer	Integer	YES
isTransformed	Boolean	Bool	YES
hasWallsRotations	Boolean	Bool	YES
hasHazardResistantStandards	Boolean	bool	YES
isBuildingAligned	Boolean	Bool	YES
hasDdainageSystem	Boolean	Bool	YES
hasBasementFloodProneArea	Boolean	Bool	YES
hasOpenGroundFloorAboveMaxLevel	Boolean	Bool	YES
hasStructuralMaterialsWaterResistant	Boolean	Bool	YES
hasFacadeMaterialsWaterResistant	Boolean	Bool	YES
hasBlueGreenRoofs	Boolean	Bool	YES
hasHostingCollectionsStorageCapacity	Boolean	bool	YES
enforcementSafetyConstructionCodesUpdating	Integer	Integer	YES
isTransformed	Boolean	Bool	YES
hasWallsRotations	Boolean	double precision	YES

column_name	data_type	udt_name	is_nullable
protectionType	String	Text	YES
function	Integer	Integer	YES
heritageCategory	String	Text	YES
facadeType	String	Text	YES
windowsType	String	Text	YES
restaurationDate	Date	Date	YES
restaurationType	String	Text	YES
mainOrientation	String	Text	YES

Table 21 – Building (new attributes)

Attributes from **Building** (section *10.2*)

Attributes from **BuildingHistoricArea** (section *10.2*)

Attributes from **Building Macrocategory** (section *10.3*)

Transportation

Existing attributes:

column_name	data_type	udt_name	is_nullable
id	integer	integer	NO
objectclass_id	integer	integer	NO
class	character varying	varchar	YES
class_codespace	character varying	varchar	YES
function	character varying	varchar	YES
function_codespace	character varying	varchar	YES
usage	character varying	varchar	YES
usage_codespace	character varying	varchar	YES

Table 22 – Transportation (existing attributes)

- *Comment: attributes associated with links/ geometry have not been included in this list to simplify information*

New attributes:

column_name	data_type	udt_name	is_nullable
roadTrafficDisturbance	Integer	Integer	YES
infrastructureRedundancy	String	Text	YES
roadLength	Double	double precision	YES

Table 23 – Transportation (new attributes)

Attributes from **Transportation** (section *10.2*)

Vegetation (solitary_vegetat_object)

Existing attributes:

column_name	data_type	udt_name	is_nullable
idvegetation	integer	integer	NO
objectclass_id	integer	integer	NO
class	character varying	varchar	YES
class_codespace	character varying	varchar	YES
function	character varying	varchar	YES
function_codespace	character varying	varchar	YES
usage	character varying	varchar	YES
usage_codespace	character varying	varchar	YES
species	character varying	varchar	YES
species_codespace	character varying	varchar	YES
height	double precision	double precision	YES
height_unit	character varying	varchar	YES
trunk_diameter	double precision	double precision	YES
trunk_diameter_unit	character varying	varchar	YES
crown_diameter	double precision	double precision	YES
crown_diameter_unit	character varying	varchar	YES

Table 24 – Vegetation (existing attributes)

New attributes:

column_name	data_type	udt_name	is_nullable
ndvi	Double	Double precision	YES
vegetationWaterContent	Double	Double precision	YES
Area	Double	Double precision	YES
greenInfrastructureStructuralConnectivity	Double	Double precision	YES
greenInfrastructureFunctionalConnectivity	Double	Double precision	YES
nonNativeFloraSpeciesNumber	Integer	Integer	YES
veteranTreesNumber	Integer	Integer	YES
deadWoodQuantity	Integer	Integer	YES
habitatsRestoredArea	Double	Double precision	YES
habitatFunctionalComposition	Integer	Integer	YES
shannonIndex	Integer	Integer	YES
areaUrbanFreenSpaceArea	Double	Double precision	YES
plantRootDecayRate	Integer	Integer	YES
vegetationRecoveryRate	Double	Double precision	yes
primaryProductivity	Double	Double precision	yes

Table 25 – Vegetation (new attributes)

Attributes from **Vegetation** (section *10.2*)

Attributes from **VegetationHistoricArea** (section *10.2*)

Attributes from **RiskZoneVegetation** (section *10.2*)

Waterbody

Existing attributes:

column_name	data_type	udt_name	is_nullable
idWaterBody	integer	integer	NO
objectclass_id	integer	integer	NO
class	character varying	varchar	YES
class_codespace	character varying	varchar	YES
function	character varying	varchar	YES
function_codespace	character varying	varchar	YES
usage	character varying	varchar	YES
usage_codespace	character varying	varchar	YES

Table 26 – Waterbody (existing attributes)

New attributes:

column_name	data_type	udt_name	is_nullable
maximumAnnualRiverFlow	Double	Double precision	YES
maximumAnnualRiverLevel	Double	Double precision	YES
riverBasinConcentrationTime	Integer	Integer	YES
basinResponseTime	Integer	Integer	YES
damCapacity	Double	Double precision	YES
managementRiverBasinsEnvironmentalProtection	Integer	Integer	YES

Table 27 – Waterbody (new attributes)

Attributes from **WaterBody** (section *10.2*)

Attributes from **WaterBodyHistoricArea** (section *10.2*)

Hazard Area (nzhazardarea)

Existing attributes:

column_name	data_type	udt_name	is_nullable
inpireid	text	text	YES
begin_lifespan_version	date	date	YES
end_lifespan_version	date	date	YES
idrescultaha	character	bpchar	NO
aha_serial	integer	integer	NO

column_name	data_type	udt_name	is_nullable
determinationmethod	USER-DEFINED	determinationmethodvalue	YES
typeofhazard	USER-DEFINED	naturalhazardclassification	YES
validityperiod	character varying	varchar	YES
probability	double precision	double precision	YES
geometry	USER-DEFINED	geometry	YES
magnitude_or_itensity	text	text	YES
likelihoodofoccurrence	double precision	double precision	YES
ha_serial	integer	integer	NO
idrescultha	character	bpchar	NO

Table 28 – Hazard Area (existing attributes)

New attributes:

column_name	data_type	udt_name	is_nullable
IDRESCULTHA (FK)	Character (20)	Bpchar	NO
runoffSurface	Double	double precision	YES
annualPrecipitation	Integer	Integer	YES
precipitationWettestMonth	Integer	Integer	YES
precipitationDriestMonth	Integer	Integer	YES
precipitationSeasonality	Double	Double precision	YES
precipitationWettestQuarter	Integer	Integer	YES
precipitationDriestQuarter	Integer	Integer	YES
precipitationWarmestQuarter	Integer	Integer	YES
precipitationColdestQuarter	Integer	Integer	YES
relativeWaterContent	Double	double precision	YES
meanRelativeHumidity	Double	double precision	YES
dailyHumidityCycleShocks	Integer	Integer	YES
relativeHumidityConcentration	Integer	Integer	YES
albedo	Double	double precision	YES
thermalDiffusivity	Double	double precision	YES
solarReflectanceIndex	Double	double precision	YES
airQuality	Double	double precision	YES
imperviousnessChangeAverage	Double	double precision	YES
groundSlopeAverage	Double	double precision	YES
annualUrbanChangeRatePercentage	Double	double precision	YES

column_name	data_type	udt_name	is_nullable
landTake	Double	double precision	YES
landCover	String	Integer	YES
soilWaterContent	Double	double precision	YES
populationNumber	Integer	Integer	YES
heightAboveSeaLevel	Double	double precision	YES
runoffSurface	Double	double precision	YES
annualPrecipitation	Integer	Integer	YES
precipitationWettestMonth	Integer	Integer	YES
precipitationDriestMonth	Integer	Integer	YES
precipitationSeasonality	Double	double precision	YES
precipitationWettestQuarter	Integer	Integer	YES
precipitationDriestQuarter	Integer	Integer	YES
precipitationWarmestQuarter	Integer	Integer	YES
disasterEventFrequency	Integer	Integer	YES
swi	Double	double precision	YES
liquefactionPotential	String	Text	YES
rhInsideBuilding	Double	double precision	YES
seaLevelRise	Double	double precision	YES
groundWaterTable	Double	double precision	YES
areaLandTakeArea	Double	Double precision	YES
buildingsNumber	Integer	Integer	YES
isCriticalFacility	Boolean	bool	YES
isProductiveActivity	Boolean	Bool	YES
isMajorAccidentRiskFactory	Boolean	bool	YES
vegetationBarriesSeparatingBuiltAreas	Boolean	bool	YES
soilInfiltrationCapacity	Double	Double precision	YES

Table 29 – Hazard Area (new attributes)

Attributes from **HazardArea** (section *10.2*)

Attributes from **HazardAreaHistoricArea** (section *10.2*)

Attributes from **Building Macrocategory** (section *10.3*)

EarthquakeHazardParameters (nzearthquakehazardparameters)

Existing attributes:

column_name	data_type	udt_name	is_nullable
idresculteqhp	character	bpchar	NO
eqhp_serial	integer	integer	NO
seismicconditions	double precision	double precision	YES
geologicalconditions	double precision	double precision	YES
referredabstracthazardarea	character	bpchar	YES
architecturalurbancontextconditions	double precision	double precision	YES
generalvalueearthquake	double precision	double precision	YES

Table 30 – EarthquaqueHazard (existing attributes)

New attributes:

column_name	data_type	udt_name	is_nullable
pga	Double	Double precision	YES
levelSeismicHazard	Double	Double precision	YES
earthquakeintensity	String	Text	YES

Table 31 – EarthquaqueHazard (new attributes)

Attributes from **EarthquakeHazard** (section *10.2*)

FloodHazardParameters (nzfloodhazardparameters)

Existing attributes:

column_name	data_type	udt_name	is_nullable
idrescultflhp	character	bpchar	NO
flhp_serial	integer	integer	NO
weatherconditions	double precision	double precision	YES
geomorphologicalonditions	double precision	double precision	YES
global_hydrographic_conditions	double precision	double precision	YES
global_territorial_conditions	double precision	double precision	YES
architectural_urban_context_conditions	double precision	double precision	YES
local_hydrographic_conditions_flood	double precision	double precision	YES
contrast_of_risk	double precision	double precision	YES
referred_abstract_hazard_area	character	bpchar	YES
generalvalueflood	double precision	double precision	YES

Table 32 – FloodHazard (existing attributes)

New attributes:

column_name	data_type	udt_name	is_nullable
area	Double	double precision	YES
floodDepth	Double	double precision	YES

column_name	data_type	udt_name	is_nullable
waterVelocity	Double	double precision	YES
combFloodDepthWaterVelocity	Double	double precision	YES
floodFrecuency	Integer	Integer	YES

Table 33 – FloodHazard (new attributes)

Attributes from **FloodkeHazard** (section *10.2*)

FireHazardParameters (nzfirehazardparameters)

Existing attributes:

column_name	data_type	udt_name	is_nullable
idrescultfhp	character	bpchar	NO
fhp_serial	integer	integer	NO
climaticconditions	double precision	double precision	YES
weatherconditions	double precision	double precision	YES
territorialconditions	double precision	double precision	YES
architectural_urban_context_conditions	double precision	double precision	YES
urban_fire_prevention_system	double precision	double precision	YES
referred_abstract_hazard_area	character	bpchar	YES
generalvaluefire	double precision	double precision	YES

Table 34 – FireHazard (existing attributes)

New attributes:

column_name	data_type	udt_name	is_nullable
fireWeatherIndex	Integer	Integer	YES
palmerDroughtSeverityIndex	Integer	Integer	YES
timeSinceFire	Integer	Integer	YES
fireRecurrence	Integer	Integer	YES

Table 35 – FireHazard (new attributes)

Attributes from **FirequakeHazard** (section *10.2*)

RiskZone

Existing attributes:

column_name	data_type	udt_name	is_nullable
inspireid	text	text	YES
begin_lifespan_version	date	date	YES
end_lifespan_version	date	date	YES
idrescultarz	character	bpchar	NO
arz_serial	integer	integer	NO

column_name	data_type	udt_name	is_nullable
sourceofrisk	USER-DEFINED	naturalhazardclassification	YES
validityperiod	character varying	varchar	YES
fromhazard	character	bpchar	YES
geometry	USER-DEFINED	geometry	YES
levelofrisk	double precision	double precision	YES
idrescultrz	character	bpchar	NO
rz_serial	integer	integer	NO

Table 36 – RiskZone (existing attributes)

New attributes:

column_name	data_type	udt_name	is_nullable
fatalitiesNumber	Integer	Integer	YES
nonFatalInjuriesNumber	Integer	Integer	YES
comparedMortality	Integer	Integer	YES
increasedHospitalisation	Integer	Integer	YES
staysInHospitals	Integer	Integer	YES
reducedWorkingCapacity	Integer	Integer	YES
inventoryOfHazardEvents	Integer	Integer	YES
reportedInsuranceClaims	Integer	Integer	YES
operatingHoursStormEvents	Integer	Integer	YES
peopleDisplacedNumber	Integer	Integer	YES
collapsedHeavyDamagedBuildingsNumber	Integer	Integer	YES
affectedCriticalFacilities	Integer	Integer	YES
stageDamageCurve	Integer	Integer	YES
recoveryRate	Integer	Integer	YES
slightModerateDamagedBuildings	Integer	Integer	YES
windthrow	Double	Double precision	YES
lossHabitatBiodiversity	String	Text	YES
durationInfrastructureOutage	Integer	Integer	YES
moderateDamagedMovableHeritage	Integer	Integer	YES
biologicalColonization	String	Text	YES
burnSeverityIndex	String	text	YES
repairability	Double	Double precision	Yes
economicLossCHDamagedDestroyed	Integer	Integer	Yes
affectedIntangibleCH	String	Text	Yes
heavyDamagedMovableHeritage	Integer	Integer	Yes
lossAncestralNH	String	Text	Yes

Table 37 – RiskZone (new attributes)

Attributes from **RiskZone** (section *10.2*)

Attributes from **RiskZoneHistoricArea** (section *10.2*)

Attributes from **RiskZoneProtectedSite** (section *10.2*)

7.2.3.3 *New relationships*

CityObject_in_protectedSite

A relationship has been defined between exposed element (PSPROTECTEDSITE) and cityobject. In that way it is possible to identify which city object is an exposed element:

column_name	data_type	udt_name	is_nullable
CityobjectID (PK)	integer	integer	NO
InspireID (PK)	text	text	NO
auxInfo	Text	text	YES

Table 38 – CityObject_in_protectedSite (new relationship)

New Entity/Attributes created to link **CityObjet** (from CityGML) and **ProtectedSites** (from Rescult), see *Figure 27.*

nzhazardarea-nzriskzone

- A relationship has been defined between an exposed element and the hazard area. In that way it is possible to identify in which hazard area is located a specific exposed element.

nzriskzone (new attributes)

column_name	data_type	udt_name	is_nullable
inspireid	text	text	YES
begin_lifespan_version	date	date	YES
end_lifespan_version	date	date	YES
idrescultarz	character	bpchar	NO
arz_serial	integer	integer	NO
sourceofrisk	USER-DEFINED	naturalhazardclassification	YES
validityperiod	character varying	varchar	YES
fromhazard	character	bpchar	YES
geometry	USER-DEFINED	geometry	YES
levelofrisk	double precision	double precision	YES
Idrescultrz (PK)	character	bpchar	NO
rz_serial	integer	integer	NO
IDRESCULTHA (FK)	character	bpchar	NO

Table 39 – nzhazardarea-nzriskzone (2)

New Entity/Attributes to create new relationships (**NZHazardArea with NZRiskZone**), see *Figure 27* – Entity – Relationship Diagram (new entities and relationships (1))

Cityobject_in_hazardArea

- A relathionship between hazard area and cityobject has been defined. In order to allow multiple and bidirectional relationship, an intermediate table has been defined, called cityobject_in_hazardarea. In that way any city object can be included within a hazard area. In this case, the same city object could be associated in multiple hazard areas.

column_name	data_type	udt_name	is_nullable
CityobjectID (PK)	integer	integer	NO
IDrescultha (PK)	Character (20)	Bpchar	NO
auxInfo	Text	text	YES

Table 40 – Cityobject_in_hazardArea

New Entity/Attributes to create new relationships (**Cityobject_in_hazardArea**), see *Figure 27.*

- A relationship between risk zone and cityobject has been defined. In order to allow multiple and bidirectional relationships, an intermediate table has been defined, called cityobject_in_riskzone. In that way any city object can be included within a riskzone. In this case, the same city object could be associated with multiple risk zones.
- A relationship has been defined between risk zone and hazard area. In that way it is possible to identify in which hazard area is located a specific risk zone.

Regarding OGC CityGML standard, the main elements or macro categories to use are "Building", "TransportationComplex", "WaterBody", "Vegetation" and "LandUse".

7.2.4 Indicators integration

These are the colors that are been used to identity the different entities:

Attributes from **HistoricArea** (section *10.2*)

Attributes from **BuildingHistoricArea** (section *10.2*)

Attributes from **ExposedElementHistoricArea** (section *10.2*)

Attributes from **ProtectedSiteHistoricArea** (section *10.2*)

Attributes (from **VegetationHistoricArea** (section *10.2)*

Attributes from **RiskZoneHistoricArea** (section *10.2*)

Attributes from **HazardAreaHistoricArea** (section *10.2*)

Attributes from **WaterBodyHistoricArea** (section *10.2*)

Attributes from **RiskZoneVegetation** (section *10.2*)

Attributes from **Building Macrocategory** (section *10.3*)

Attributes from **Urban Macrocategory** (section *10.3*)

The section *10.5* includes the database scripts that implement the new entity structures (CREATE TABLE) and modifications (ALTER TABLE).

The section 10.6 includes the Entity-Relationship diagram.

The section 10.5.3 includes the complete database creation scripts.

8 Conclusions

The main result of the T1.4 - "Multiscale Multisource Data Model" within WP1 of the SHELTER project is the definition and implementation of the Multiscale Multisource Data Model for SHELTER context.

The MMDM allows the representation of a HistoricArea with the following entities: HistoricArea, ProtectedSite, HazardArea, RiskZone, ObservedEvent, ExposedElement and CityObjects (Building, Vegetation, WaterBody, Transportation, CityFurniture). Those entities will contain the required geometric and semantic data in order to store relevant cultural heritage and climate change information.

In addition to that, the SHELTER MMDM also stores the required data related to Resilience ID, Resilience Index, SHELTER indicators and the data related with macrocategories that has been also related to above mentioned entities.

The implementation of the MMDM is based on a PostgreSQL+PostGIS database, where data coming from different sources will be loaded during the next phases of the project. A detailed description of used reference data models and the new tables, parameters and relationships defined for SHELTER context is provided in the implementation section *0*. Additionally, the database creation diagrams have been drawn up, defining all the entities and attributes included, and the creation of tables and the scripts update have been developed.

The SHELTER MMDM will be later used when creating the unique multiscale data model for each of the OpenLabs.

At the time of writing this document (2020.12.11), some issues have been encountered, depending on SHELTER project tasks that have not started yet, or have to be completed or clarified in other Work Packages, since this may require changes in the MMDM.

For this reason, this document will need to be updated in the future so that the Data Model collects from other modules all the necessary and missing information. The modules that are pending to be defined are the following: Social Media & Chatbot, AA Server / Authentication Server, IoT Module, Resilience Dashboard, DSS, Other Tools / Solutions.

As the tasks of other Work Packages progress, they will be analyzed to identify what needs will be collected and implemented in the data model. Joint meetings will be held with the task leaders of every WP/Task to define the requirements and needs.

Once all these requirements and needs have been identified, a platform will be developed that shows all the information collected in the different modules or generated in the different WPs. In this future dynamic platform, all the tools for the visualization of the data will be integrated, thus facilitating the decision-making, the search for solutions and the programming of scheduled actions.

9 References

Link to website

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[Link2]. https://www.ruralnetwork.scot/news-and-events/news/new-natural-cultural-heritage-fund-launches
[Link3]. http://www.citygml.org/
[Link4]. https://www.ogc.org/
[Link5]. https://www.3dcitydb.org/3dcitydb/
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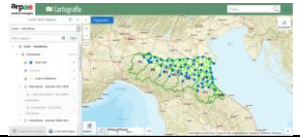
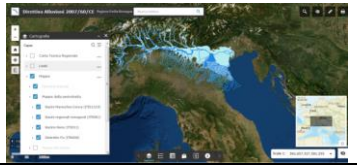
10 Appendices

10.1 Appendix I – DMF Analysis

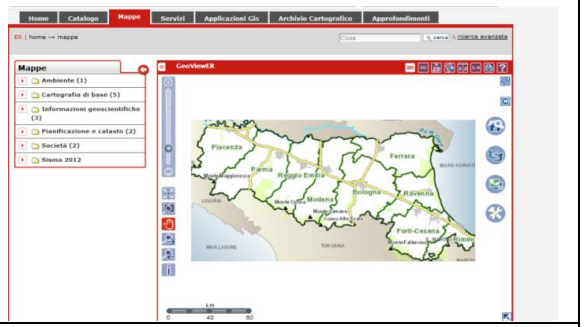
10.1.1 Ravenna

Title	Description	Links	Comments	Image
Subsidence velocity in vertical movements (isolines)	Information on the subsidence movements of the terrain (isolines) in Emilio-Romaña	https://www.arpae.it/cartografia/	It is a web viewer. The information is supposed to be downloadable and accessible via WFS service (it is unknown if it can be downloaded at this time).	
Flood hazard and risk maps	Flood hazard maps in the Emilia-Romagna region	https://servizimoka.regione.emilia-romagna.it/mokaApp/apps/DA/index.html?null	It is a web viewer. There is no way at the moment to access the information through a WMS / WFS service. Information can be obtained in shp format by requesting it directly from the agency.	
Precipitation forecast from ARPAE	Precipitation forecast from ARPAE	https://www.arpae.it/sim/?mappe_numeriche/dati&ra https://drive.google.com/drive/folders/1Yst9evpQdyKsDxP1TL7s7_W7JQoPbtWB	It is a website with tables and daily weather data. The information is downloadable from Google Drive in GRIB format (meteorological data file format).	
UNESCO Cultural Heritage catalogue (descriptions, maps, documents, galleries, videos)	UNESCO Cultural Heritage catalogue (descriptions, maps, documents, galleries, videos)	https://whc.unesco.org/en/statiesparties/ba	**Unstructured information.** Website with information, news, photos…about cultural heritage.	
EM-DAT: the international disaster database	International database of natural disasters	https://www.emdat.be/database	It is a website with information on natural disasters in csv and jpg format. It is necessary to register to be able to access the data of the database	

Title	Description	Links	Comments	Image
Critical-Historical analysis	Critical-Historical analysis		**Unstructured information**. Link not available. Descriptive information (pdf format) about the monumental area of Ravenna.	
Survey of foundations and characterization of building materials (extraction and tests of cores)	Characterization of building materials		**Unstructured information**. Link not available. Descriptive information (pdf format) of a technical nature in the Ravenna area.	
Structural changes and hearthquake timeline, graphic sheets (plans, elevations, sections), visual inspection with masonry classification	Structural changes and hearthquake timeline		**Unstructured information**. Link not available. Descriptive information (pdf format) of a technical nature in the Ravenna area.	
Crack pattern and interpretation of mechanisms	Crack pattern and interpretation of mechanisms		**Unstructured information**. Link not available. Descriptive information (pdf format) of a technical nature in the Ravenna area.	
Daily cumulative rainfall [mm]	Daily cumulative rainfall	https://simc.arpae.it/dext3r/	It is a web site. A form is filled in and weather information for the Emilia-Romagna area is obtained in PDF, csv and xls format or viewed in a web viewer.	
Ground water level	Ground water level	http://geo.regione.emilia-romagna.it/eWaterDataDistributionSgss/EwaterDetailForm?dataType=well&id=RA42-01&lang=it	It is a website with abundant hydrological information on the Emilia-Romagna region. Data is apparently not downloadable.	
Hydrometric level	Hydrometric level			
Flood Hazard Mapping	Flood Hazard Mapping	http://geo.regione.emilia-romagna.it/gstatico/documenti/direttiva_2007_60/comuni/39014.zi	Shapefiles with information on flood hazards in the Emilia-Romagna region.	

Title	Description	Links	Comments	Image
		p		
Flood Hazard Maps	Flood Hazard Maps	https://allertameteo.regione.emilia-romagna.it/	Flood hazard map in pdf format for the Emilia-Romagna region	
Flood risk maps	Flood risk maps	https://allertameteo.regione.emilia-romagna.it/	Map of flood risks in pdf format in the Emilia-Romagna region	
Real time Hydrometric levels	Real time Hydrometric levels	https://allertameteo.regione.emilia-romagna.it/livello-idrometrico	Website to view (not download) hydrometry data in the Emilia-Romagna region	
Real time hourly cumulative rainfall	Real time hourly cumulative rainfall	https://allertameteo.regione.emilia-romagna.it/precipitazioni	Website to view (not download) precipitation data in Emilia-Romagna	
Weather warnings and Awareness Reports	Weather warnings and Awareness Reports	https://allertameteo.regione.emilia-romagna.it/web/guest/singola-allerta/-/asset_publisher/FZPQSb6AzKtJ/Allerta-Bollettino/id/958992	Website with information on weather warnings in the Emilia Romagna region. The information is downloadable in pdf.	
Weather radar data	Weather radar data	https://allertameteo.regione.emilia-romagna.it/radar-meteo	Website to view (not download) weather radar data.	
Microclimatic data: temperatures (min, max), relative humidity (min, max, average)	Microclimatic data: temperatures (min, max), relative humidity (min, max, average)	https://www.arpae.it/dettaglio_documento.asp?id=6147&idlivello=1528	Website with microclimatic data. Queries can be made and the data is obtained in xls.	

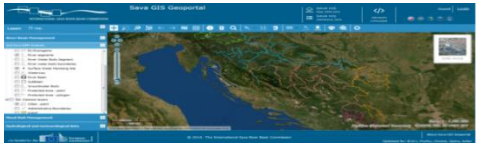
Title	Description	Links	Comments	Image
Microclimatic data: rain/wind main directions	Microclimatic data: rain/wind main directions		Graphic data in jpg available at the University of Bologna.	
Relationship between water table fluctuation and vertical displacement in the Ravenna area	Relationship between water table fluctuation and vertical displacement in the Ravenna area	https://www.sciencedirect.com/science/article/pii/S0341816218303436	**Unstructured information.** Scientific article with hydrological and geological information of Ravenna.	
Monitoring land subsidence in Ravenna municipality	Monitoring land subsidence in Ravenna municipality	https://www.int-arch-photogramm-remote-sens-spatial-inf-sci.net/XLI-B7/23/2016/isprs-archives-XLI-B7-23-2016.pdf	**Unstructured information.** Scientific article in pdf with information of Ravenna.	
Simultaneous evaluation of sea level rise and land subsidence in Marina di Ravenna	Simultaneous evaluation of sea level rise and land subsidence in Marina di Ravenna	https://www.annalsofgeophysics.eu/index.php/annals/article/view/7022/6630	**Unstructured information.** Scientific article in pdf with information of Ravenna.	
Techniques for subsidence monitoring at regional scale - Emilia-Romagna region	Techniques for subsidence monitoring at regional scale - Emilia-Romagna region	https://www.proc-iahs.net/372/315/2015/piahs-372-315-2015.pdf	**Unstructured information.** Scientific article in pdf with information of Ravenna.	
Vertical and horizontal crustal movements in central and northern Italy	Vertical and horizontal crustal movements in central and northern Italy	http://www3.ogs.trieste.it/bgta/pdf/bgta0021_BALDI.pdf	**Unstructured information.** Scientific article in pdf with information of central and northern Italy.	
Land subsidence in Ravenna (reassessment)	Land subsidence in Ravenna (reassessment)	https://link.springer.com/article/10.1007/s00254-004-1215-9	**Unstructured information.** Scientific article with information of Ravenna.	
EVOLUTION OF THE PO-DELTA COASTAL PLAIN DURING THE HOLOCENE	Evolution of the Po Delta coastal plain during the Holocene	https://www.sciencedirect.com/science/article/pii/10406182950001	**Unstructured information.** Scientific article with information of Ravenna.	

Title	Description	Links	Comments	Image
		28		
Level variations of the central and northern Italy benchmarks	Level variations of the central and northern Italy benchmarks		**Unstructured information.** Not available online.	
Data on natural subsidence - Ravenna area	Data on natural subsidence - Ravenna area		**Unstructured information.** Not available online.	
Map of land subsidence in the eastern Po River plain	Map of land subsidence in the eastern Po River plain		**Unstructured information.** Not available online.	
Climdex indices for understanding patterns in precipitation extremes	Climdex indices for understanding patterns in precipitation extremes	https://www.climdex.org/learn/indices/	Website to obtain weather information from different stations around the world. The station information is downloadable in jpg and ASCII format.	
Meteorological data - monthly observation from ARPAE	Meteorological data - monthly observation from ARPAE	https://drive.google.com/drive/folders/0B7KLnPu6vjdPRjZzNWFReTd0MDQ	Downloadable meteorological data in JSON format of the Emilia-Romagna region	
Regional Technical Map 1:5000 (from Emilia-Romagna geoportal)	Regional Technical Map 1:5000 (from Emilia-Romagna geoportal)	http://geoportale.regione.emilia-romagna.it/it/services/servizi-OGC/servizio-di-consultazione	GIS service of the Emilia-Romagna region with administrative information, topographic maps and orthophotos accessible through WMS services or by direct download (shapefile)	
AGEA RGB ortophoto (from Emilia-Romagna geoportal)	AGEA RGB ortophoto (from Emilia-Romagna geoportal)			
Database of municipalities areas (from Emilia-Romagna geoportal)	Database of municipalities areas (from Emilia-Romagna geoportal)			
Administrative boundaries 2018 (from Emilia-Romagna geoportal)	Administrative boundaries 2018 (from Emilia-Romagna geoportal)			
Database of municipalities - points (from Emilia-Romagna	Database of municipalities - points			

Title	Description	Links	Comments	Image
geoportal)	(from Emilia-Romagna geoportal)			
Database of districts areas 2019 (from Emilia-Romagna geoportal)	Database of districts areas 2019 (from Emilia-Romagna geoportal)			
Union of municipalities (from Emilia-Romagna geoportal)	Union of municipalities (from Emilia-Romagna geoportal)			

Table 41 – Ravenna – DMF Analysis

10.1.2 Sava River

Title	Description	Links	Comments	Image
Annual reports on work and activities of the International Sava River Basin Commission	Annual reports on work and activities of the International Sava River Basin Commission	https://www.savacommission.org/annual	**Unstructured information.** Documents in PDF and accessible through the web with descriptive information.	
PFRA (Preliminary Flood Risk Assessment) flood events (historical and possible in future) - Sava FRM plan - from Sava GIS geoportal (WMS layer: PFRA_floodevent_a = polygons)	PFRA (Preliminary Flood Risk Assessment) flood events (historical and possible in future) - Sava FRM plan - from Sava GIS geoportal	http://savagis.org/	It is a GIS viewer with hydrological information (basins, rivers, monitoring points), meteorology, etc. The information is accessible through a WMS service	
PFRA (Preliminary Flood Risk Assessment) flood events (historical and possible in future) - Sava FRM plan - from Sava GIS geoportal (WMS layer: PFRA_floodevent_p = points)				
Hydrologic and meteorological data, information and knowledge about water resources in the SavaRiver Basin	Hydrologic and meteorological data, information and knowledge about water resources in the SavaRiver Basin	http://savahis.org/his;jsessionid=3AA3C2FD1C8C4C499783F0847D6EFB0D	It is a GIS viewer with hydrological and meteorological information in real time. The information is accessible through a WMS service.	
UNESCO Cultural Heritage catalogue (descriptions, maps, documents, galleries, videos)	UNESCO Cultural Heritage catalogue (descriptions, maps, documents, galleries, videos)	https://whc.unesco.org/en/statiesparties/ba	**Unstructured information.** Website with information, news, photos, on cultural heritage.	

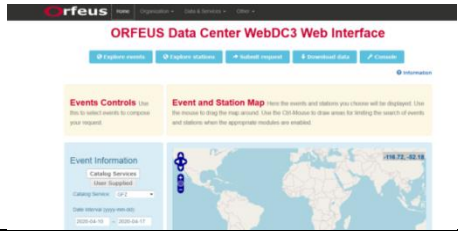
Title	Description	Links	Comments	Image
				
EM-DAT: the international disaster database	EM-DAT: base de datos internacional sobre catástrofes naturales	https://www.emdat.be/database	It is a website with information on natural disasters in csv and jpg format. It is necessary to register to be able to access the data of the database	
Climdex indices for understanding patterns in precipitation extremes	Climdex indices for understanding patterns in precipitation extremes	https://www.climdex.org/learn/indices/	Website to obtain weather information from different stations around the world. The station information is downloadable in jpg and ASCII format.	
Administrative boundaries (member state boundaries) from Sava GIS geoportal (WMS layer: adminbound)	Administrative boundaries (member state boundaries) from Sava GIS geoportal (WMS layer: adminbound)	http://savagis.org/	It is a GIS viewer with hydrological information (basins, rivers, monitoring points), metereological, administrative, relief ... The information is accessible through a WMS service	
Locations of the Areas with Potential Significant Flood Risk (APSFR) as identified by the Framework Agreement on the Sava River Basin contracting Parties (WMS layer: APSFR_a = polygons)	Locations of the Areas with Potential Significant Flood Risk (APSFR) as identified by the Framework Agreement on the Sava River Basin contracting Parties			
Areas with mutual interest for flood protection from Sava GIS FRMP (WMS layer: APSFR_ami = polygons)	Areas with mutual interest for flood protection from Sava GIS FRMP			

Title	Description	Links	Comments	Image
Locations of the Areas with Potential Significant Flood Risk (APSFR) as identified by the Framework Agreement on the Sava River Basin contracting Parties (WMS layer: APSFR_l = lines)	Locations of the Areas with Potential Significant Flood Risk (APSFR) as identified by the Framework Agreement on the Sava River Basin contracting Parties			
Locations of the Areas with Potential Significant Flood Risk (APSFR) as identified by the contracting Parties to the Framework Agreement on the Sava River Basin (FASRB) - (WMS layer: APSFR_p = points)	Locations of the Areas with Potential Significant Flood Risk (APSFR) as identified by the contracting Parties to the Framework Agreement on the Sava River Basin (FASRB)			
Cities from Sava GIS geoportal (WMS layer: city_p = points)	Cities from Sava GIS geoportal			
Competent Authorities Areas from Sava GIS geoportal (WMS layer: compauth = polygons)	Competent Authorities Areas from Sava GIS geoportal			
EU Ecoregions from Sava GIS geoportal (WMS layer: ecoregions = polygons)	EU Ecoregions from Sava GIS geoportal			
Relief map from Sava GIS geoportal (WMS layer: elevation_3857)	Relief map from Sava GIS geoportal			
Flood Hazard scenario areas from Sava GIS geoportal (WMS layer: FHRM_hazard = polygons)	Flood Hazard scenario areas from Sava GIS geoportal			
Flood Protection structures retention and reservoirs from Sava GIS geoportal (WMS layer: FPR_retres_a = polygons)	Flood Protection structures retention and reservoirs from Sava GIS geoportal			
Groundwater bodies from Sava River Basin Management Plan - Sava GIS geoportal (WMS layer: gwb = polygons)	Groundwater bodies from Sava River Basin Management Plan - Sava GIS geoportal			
PFRA (Preliminary Flood Risk Assessment) flood events (historical and possible in future) - Sava FRM plan - from Sava GIS geoportal (WMS layer: PFRA_floodevent_l = lines)	PFRA (Preliminary Flood Risk Assessment) flood events (historical and possible in future) - Sava FRM plan - from Sava GIS geoporta			
Protected areas - Sava River Basin Management (RBM) Plan from Sava GIS geoportal (WMS layer: protectedarea_a =	Protected areas - Sava River Basin Management (RBM) Plan from Sava GIS geoportal			

Title	Description	Links	Comments	Image
polygons)				
Protected areas - Sava River Basin Management (RBM) Plan from Sava GIS geoportal (WMS layer: protectedarea_p = points)	Protected areas - Sava River Basin Management (RBM) Plan from Sava GIS geoportal			
River Basin Districts - boundaries of the river basin district and sub-units within the national borders - Sava River Basin Management (RBM) Plan from Sava GIS geoportal (WMS layer: rbd_a = polygons)	River Basin Districts - boundaries of the river basin district and sub-units within the national borders - Sava River Basin Management (RBM) Plan from Sava GIS geoportal			
River Basin - Sava River Basin Management (RBM) Plan from Sava GIS geoportal (WMS layer: riverbasin = polygons)	River Basin - Sava River Basin Management (RBM) Plan from Sava GIS geoportal			
Surface water network in the Sava River Basin from Sava GIS geoportal (WMS layer: rivers = lines)	Surface water network in the Sava River Basin from Sava GIS geoportal			
River water body boundaries from Sava GIS geoportal (WMS layer: rwb_boundary = points)	River water body boundaries from Sava GIS geoportal			
SubBasin from Sava River Basin Management (WMS layer: subbasin = polygons)	SubBasin from Sava River Basin Management			
Surface Water Monitoring Sites (chemical or biological monitoring) from Sava River Basin Management (WMS layer: swmonitoringsite = points)	Surface Water Monitoring Sites (chemical or biological monitoring) from Sava River Basin Management			
Waterways from Sava River Basin Management (WMS layer: waterway)	Waterways from Sava River Basin Management			
SavaHIS Real-Time Hydrological Stations	SavaHIS Real-Time Hydrological Stations	http://savahis.org/his;jsessionid=3AA3C2FD1C8C4C499783F0847D6EFB0D	It is a GIS viewer with hydrological and meteorological information in real time. The information is accessible through a WMS service.	
SavaHIS Real-Time Meteorological Stations	SavaHIS Real-Time Meteorological Stations			

Table 42 – Sava River – DMF Analysis

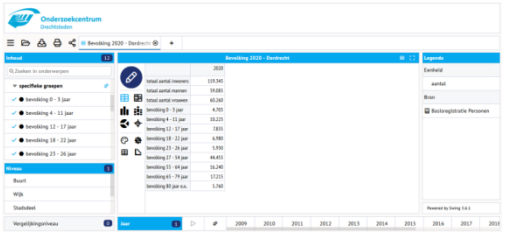
10.1.3 Seferihisar

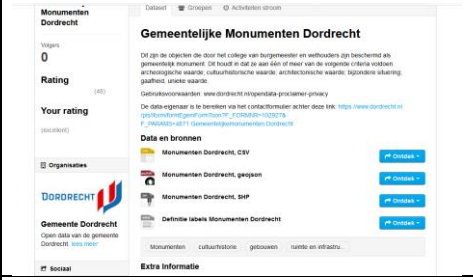
Title	Description	Links	Comments	Image
Seismic waveform data and metadata	Seismic waveform data and metadata	http://orfeus-eu.org/webdc3/	ORFEUS website with world information related to earthquakes. The data is accessible through different web services.	
EM-DAT: the international disaster database	International database of natural disasters	https://www.emdat.be/database	It is a website with information on natural disasters in csv and jpg format. It is necessary to register to be able to access the data of the database.	
Corine Land Cover (CLC) 2018 from the Copernicus Land Monitoring Service	Corine Land Cover	https://land.copernicus.eu/pan-european/corine-land-cover/lcc-2012-2018/login/?came_from=https://land.copernicus.eu/pan-european/corine-land-cover/lcc-2012-2018?tab=download	EU database with information on land cover and use. The information is accessible through web services and downloadable	

Title	Description	Links	Comments	Image
Copernicus Corine Land Cover Change (CHA) 2012 - 2018			in raster and vector format.	
UERRA dataset - estimate of daily accumulated precipitation and six-hourly air temperature and relative humidity at 2 meters above the model topography	UERRA dataset - estimate of daily accumulated precipitation and six-hourly air temperature and relative humidity at 2 meters above the model topography	https://cds.climate.copernicus.eu/user/login?destination=/toolbox-user	Meteorological information available in a database with climatic data. The information is accessible via direct download or by using scripts in GRIB or NetCDF format.	

Table 43 – Seferihisar – DMF Analysis

10.1.4 Dordrecht

Title	Description	Links	Comments	Image
Dataset of general statistics on citizens of Dordrecht	Dataset of general statistics on citizens of Dordrecht	https://ocd.buurtmonitor.nl//jive?sel_guid=f35e8449-eda9-4377-afe4-e88fcb3996ad	Website with population statistics for the city of Dordrecht. The information is downloadable in pdf, xls, csv, doc …	
Data on actual historic and current water height, wave heights, information on waterflow and waterquality	Data on actual historic and current water height, wave heights, information on waterflow and waterquality	https://geoservices.rijkswaterstaat.nl/apps/geonetwork/srv/dut/catalog.search#/metadata/%C3%A7	Website of a Dutch ministry in which a series of WMS services of various topics appear (website in Dutch)	
Data on astronomical (tidal effect) water height	Data on astronomical (tidal effect) water height			
Data on national monuments	Data on national monuments	http://www.nationaalgeoregister.nl/geonetwork/srv/dut/catalog.search#/metadata/6f84efeb-fc1d-4565-a721-80735ea57dbd	Website with a WMS service for monuments in the Netherlands	
Data on total risk (chance of occurrence X consequences) of flood	Datos sobre el riesgo total (posibilidad de ocurrencia de X consecuencias) de inundación	https://basisinformatie-overstromingen.nl/liwo/#	Website of a ministry with flood risk information (in Dutch). It has a GIS viewer and the information is exportable in PDF. It is unknown if it can also be consulted through a web service.	

Title	Description	Links	Comments	Image
Data on municipal monuments	Data on municipal monuments	https://ckan.dataplatform.nl/dataset/monumenten-dordrecht	Website with information available on monuments in the city of Dordrecht in csv, geojson and shp format	
3D model of the city and possibly historical monuments that will be implemented in IMMERSITE®	3D model of the city and possibly historical monuments that will be implemented in IMMERSITE®		Tools to be developed	
2D / 3D assets of relevant data that will be implemented into IMMERSITE®	2D / 3D assets of relevant data that will be implemented into IMMERSITE®			
EM-DAT: the international disaster database	EM-DAT: the international disaster database	https://www.emdat.be/database	It is a website with information on natural disasters in csv and jpg format. It is necessary to register to be able to access the data of the database	
Precipitation - radar/gauge 24-hour accumulations over the Netherlands	Precipitation - radar/gauge 24-hour accumulations over the Netherlands	https://data.knmi.nl/datasets/radar_corr_accum_24h/1.0	Website with precipitation information for the Netherlands. The information is downloadable in PDF format by direct download. It is assumed that it can also be viewed through a WMS.	
Climdex indices for understanding patterns in precipitation extremes	Climdex indices for understanding patterns in precipitation extremes	https://www.climdex.org/learn/indices/	Website to obtain weather information from different stations around the world.	

Title	Description	Links	Comments	Image
			The station information is downloadable in jpg and ASCII format	

Table 44 – Dordrecht – DMF Analysis

10.1.5 Baixa Limia-Serra

Title	Description	Links	Comments	Image
SIOTUGA- Planning instruments- Regional and urban planning	SIOTUGA- Planning instruments- Regional and urban planning	http://www.planeamentourbanistico.xunta.es/siotuga/	**Unstructured information**. Website with urban and spatial planning information for Galicia in PDF format	
SIOTUGA- Planning instruments- Regional and urban planning	SIOTUGA- Planning instruments- Regional and urban planning	http://www.planeamentourbanistico.xunta.es/siotuga/visor	GIS viewer with urban and spatial planning information for Galicia. Information can be accessed via WMS	
Environmental indicators	Environmental indicators	https://siam.xunta.gal/ http://siam.xunta.gal/c/document_library/get_file?folderId=65880&name=DLFE-3580.pdf	**Unstructured information.** Website with environmental information (web and pdf).	
Environmental information	Environmental information	https://gaia.xunta.es/plataforma/temas/informacion-ambiental		
Viewer maps tool	Viewer maps tool	http://mapas.xunta.gal/visores/basico/	GIS viewer of the Galician Government with numerous downloadable information in shp and WMS format	
Detection and alarms systems	Detection and alarms systems	https://mediorural.xunta.gal/es/temas/defensa-monte/irdi	**Unstructured information.** Website of the Xunta de Galicia with information on forest fires. Can not be downloaded.	
Daily risk of forest fire	Daily risk of forest fire			
Green house gases inventory. Spain. Galicia	Green house gases inventory. Spain. Galicia	https://cambioclimatico.xunta.gal/c/document_library/get_file?file_path=/portal-cambio-climatico/Documentos_xeral/Rexime_emisions/Galicia_9016.xls	Excel table with data on CO2 emissions in Galicia each year	
Metereological information (metereological stations)	Metereological information (metereological stations)	https://www.meteogalicia.gal/observacion/estacionshistorico/historico.action?idEst=10050	Webpage with downloadable information from weather stations	

Title	Description	Links	Comments	Image
			through a form in csv, json and pdf formats	
Yearly reports of fires in Galicia	Yearly reports of fires in Galicia	http://mediorural.xunta.gal/institucional/estatisticas/medio_rural/incendios_forestais/	Fire reports in xls format. Link does not work.	
Grazing land regulation inventory	Grazing land regulation inventory	https://ovmediorural.xunta.gal/sites/w_ovmru/files/tramites/texto/rexistro_publico_pastoreo/rexistro_de_pastoreo_17_01_2014.xls	Information of rangeland regulation in xls format.	
Forest activity annual report	Forest activity annual report	https://mediorural.xunta.gal/fileadmin/arquivos/forestal/estatistica/Taboas_Anuario_Estatistica_Forestal_2018_.xlsx	Forest information in xls format. Link does not work.	
Plan Hidrológico de demarcación hidrográfica Galicia Costa	Plan Hidrológico de demarcación hidrográfica Galicia Costa	https://augasdegalicia.xunta.gal/seccion-tema/c/Planificacion_hidroloxica?content=plan-hidroloxico-gc/seccion.html&sub=Subseccion_002/	**Unstructured information.** PDF document.	
Plan de Xestión de Risco de Inundación da Demarcación Hidrográfica Galicia Costa 2015-2021	Plan de Xestión de Risco de Inundación da Demarcación Hidrográfica Galicia Costa 2015-2021	https://augasdegalicia.xunta.gal/docs/7/7?content=plans-de-xestion-risco-de-inundacion/seccion.html&sub=Subseccion_001/%20	**Unstructured information.** PDF documents.	
Plan Integral de Turismo de Galicia	Plan Integral de Turismo de Galicia	https://www.turismo.gal/canle-profesional/plans-e-proxectos/plan-integral-de-turismo-2016?langId=es_ES	**Unstructured information.** Information visible on the web, but can not be downloaded.	
PLATERGA- Territorial Plan for emergencies for Galicia	PLATERGA- Territorial Plan for emergencies for Galicia	https://cpapx.xunta.gal/c/document_library/get_file?folderId=127859&name=DLFE-8406.pdf	**Unstructured information**. PDF document.	
PIFOGA - Special Civil Protection Plan for emergencies caused by forest fires in Galicia	PIFOGA - Special Civil Protection Plan for emergencies caused by forest fires in Galicia	https://ficheiros-web.xunta.gal/cpapx/plans-de-emerxencia/PEIFOGA_GAL.pdf	**Unstructured information**. PDF document.	
PLADIGA: Plan for prevention and defense against forest fires in Galicia (updated in April 2019)	PLADIGA: Plan for prevention and defense against forest fires in Galicia (updated in April 2019)	https://mediorural.xunta.gal/es/temas/defensa-monte/pladiga-2019	**Unstructured information**. PDF document.	

Title	Description	Links	Comments	Image
Plan Forestal de Galicia	Plan Forestal de Galicia	https://mediorural.xunta.gal/sites/default/files/temas/forestal/plan-forestal/1_REVISION_PLAN_FORESTAL_CAST.pdf	**Unstructured information**. PDF document.	
Plan Director de la Red Natura 2000	Plan Director de la Red Natura 2000	https://activarednatura2000.com/wp-content/uploads/2015/08/Plan-Director-Galicia.pdf	**Unstructured information**. PDF document.	
Estrategia gallega para la conservación y el uso sostenible de la biodiversidad.	Estrategia gallega para la conservación y el uso sostenible de la biodiversidad.	Enlace roto	**Unstructured information.** PDF document.	
First report about climate change in Galicia	First report about climate change in Galicia	https://cambioclimatico.xunta.gal/emisions-dos-gases-de-efecto-invernadoiro-en-galicia	**Unstructured information.** PDF document.	
Informes sectoriais - Impactos e adaptación do cambio climático en Galicia (Modelización climática)	Informes sectoriais - Impactos e adaptación do cambio climático en Galicia (Modelización climática)			
Informes sectoriais - Impactos e adaptación do cambio climático en Galicia (Clima e eventos meteorolóxicos extremos)	Informes sectoriais - Impactos e adaptación do cambio climático en Galicia (Clima e eventos meteorolóxicos extremos)			
Informes sectoriais - Impactos e adaptación do cambio climático en Galicia (Biodiversidade)	Informes sectoriais - Impactos e adaptación do cambio climático en Galicia (Biodiversidade)			
Informes sectoriais - Impactos e adaptación do cambio climático en Galicia (Poboación)	Informes sectoriais - Impactos e adaptación do cambio climático en Galicia (Poboación)			
Informes sectoriais - Impactos e adaptación do cambio climático en Galicia (Recursos hídricos)	Informes sectoriais - Impactos e adaptación do cambio climático en Galicia (Recursos hídricos)			
Informes sectoriais - Impactos e adaptación do cambio climático en Galicia (Zonas costeiras)	Informes sectoriais - Impactos e adaptación do cambio climático en Galicia (Zonas costeiras)			
Informes sectoriais - Impactos e adaptación do cambio climático en Galicia (Recursos productivos)	Informes sectoriais - Impactos e adaptación do cambio climático en Galicia (Recursos productivos)			

Title	Description	Links	Comments	Image
Informe de Cambio Climático de Galicia	Informe de Cambio Climático de Galicia			
Informe de emisións de gases de efecto invernadoiro en Galicia. Serie 1990-2015	Informe de emisións de gases de efecto invernadoiro en Galicia. Serie 1990-2015	https://cambioclimatico.xunta.gal/c/document_library/get_file?file_path=/portal-cambio-climatico/Documentos_xeral/2015_resumo_comder.pdf	**Unstructured information.** Gas emission tables in PDF format.	
COMERCIO DE DEREITOS DE EMISIÓN Resumo das emisións individuais das instalacións.	COMERCIO DE DEREITOS DE EMISIÓN Resumo das emisións individuais das instalacións.	https://cambioclimatico.xunta.gal/efecto-invernadoiro	Gas emission tables in PDF and xls format.	
Galician strategy against climate change	Galician strategy against climate change	https://cambioclimatico.xunta.gal/c/document_library/get_file?file_path=/portal-cambio-climatico/Biblioteca/EGCC.pdf	**Unstructured information.** PDF document.	
"Sector Forestal, oportunidades de futuro", 2014. SILVANUS, Asociación Profesional de Silvicultores. EOI, Escuela de Organización Industrial.	"Sector Forestal, oportunidades de futuro", 2014. SILVANUS, Asociación Profesional de Silvicultores. EOI, Escuela de Organización Industrial.	http://www.eoi.es/fdi/sites/default/files/Itinerario%20Agro.%20Rentabilizando%20nuestros%20bosques%20%20Oportunidades%20de%20negocio%20en%20el%20bosque%20%2803-06-2014%29.pdf	**Unstructured information.** PDF document..	
Atlas de impactos, vulnerabilidad y adaptación al cambio climático de la biodiversidad españolas. Ministerio de Agricultura, Pesca, Alimentación y Medio Ambiente. 2011	Atlas de impactos, vulnerabilidad y adaptación al cambio climático de la biodiversidad españolas. Ministerio de Agricultura, Pesca, Alimentación y Medio Ambiente. 2011	https://www.miteco.gob.es/es/biodiversidad/temas/inventarios-nacionales/inventario-especies-terrestres/ieet_efectos_cambio_climatico.aspx	**Unstructured information.** Web information nationwide and downloadable in pdf.	
proyect CLIGAL	proyect CLIGAL	http://siam.xunta.gal/resultados-do-proxecto%20http:/siam.xunta.gal/presentacion-do-proxecto-cligal	**Unstructured information.** Web information	
RAIAco – Observatorio Marino del Margen Ibérico y del Litoral	RAIAco – Observatorio Marino del Margen Ibérico y del Litoral	http://www.marnaraia.org/	Web of the RAIA observatory. It offers some web services and has a GIS viewer with maritime information	
Proyecto RAIATec - Tecnología Marítima e de Informaçao	Proyecto RAIATec - Tecnología Marítima e de Informaçao			
Adaptaclima I	Adaptaclima I	http://igvs.xunta.gal/web/actuamos/876	**Unstructured information.** PDF document.	
Adaptaclima II	Adaptaclima II			

Title	Description	Links	Comments	Image
MarRisk	MarRisk	https://poctep.eu/es/2014-2020/marrisk-adaptaci%C3%B3n-al-cambio-clim%C3%A1tico-de-la-costa-de-galicia-y-norte-de-portugal	**Unstructured information.** Website of a European project related to adaptation to climate change on the Galician coast.	
Proyecto CLOCK	Proyecto CLOCK	https://futureoceanslab.org/clock/	**Unstructured information.** Website of a project related to climate adaptation in marine systems.	
Proyecto PERCEBES	Proyecto PERCEBES	https://www.unioviedo.es/percebes/	**Unstructured information.** Website of a project related to barnacle fishing.	
SOGAMA Educamos	SOGAMA Educamos	http://www.sogama.gal/gl	**Unstructured information.** Website of the Galician Environment Society.	
Proxecto ríos	Proxecto ríos	http://proxectorios.org/	**Unstructured information.** Proyecto Rios website with information on the environmental situation of Galician rivers.	
EM-DAT: the international disaster database	EM-DAT: the international disaster database	https://www.emdat.be/database	It is a website with information on natural disasters in csv and jpg format. It is necessary to register to be able to access the data of the database	
Several statistic data on territory and environment (e.g. Indicators for monitoring the guidelines for spatial planning, forest fires, protected spaces, climatology...)	Several statistic data on territory and environment (e.g. Indicators for monitoring the guidelines for spatial planning, forest fires, protected spaces, climatology...)	https://www.ige.eu/web/mostrar_seccion.jsp?idioma=gl&codigo=0101	Website of the Galician statistics service. Through inquiries, statistical information can be downloaded in xls and csv format	
Data from European Forest Fire Information System (EFFIS) -	Data from European Forest Fire Information System (EFFIS) -	https://effis.jrc.ec.europa.eu/applications/data-and-services/	Copernicus Information System website. It has a GIS	

Title	Description	Links	Comments	Image
Copernicus EMS	Copernicus EMS		viewer and there is downloadable data in csv.	
Geographic information files such as covers, orthoimages, cartographic series, natural spaces, hydrography, administrative limits...	Geographic information files such as covers, orthoimages, cartographic series, natural spaces, hydrography, administrative limits...	http://mapas.xunta.gal/centro-de-descargas	Website of the SDI of Galicia with varied information to download in shp, pdf, etc.	
Biodiversity and distribution of species	Biodiversity and distribution of species	http://ideg.xunta.es/servizos/rest/services/DistribucionEspecies/Biodiversidade/MapServer	ArcGIS viewer with species distribution. Information accessible through WMS.JSON, AMF, geoJSON …	
Metadata download center	Metadata download center	http://xeocatalogo.xunta.es/geonetwork/srv/en/main.home	Catalog of metadata of the Xunta de Galicia (website)	
Paths to see general patrimony	Paths to see general patrimony	http://descargas.xunta.es/93a145b0-ea34-4bb4-b86f-d6fb77fea6791527252034620	Shapefile with heritage itineraries.	
Corine Land Cover (CLC) 2018 from the Copernicus Land Monitoring Service	Corine Land Cover (CLC) 2018 from the Copernicus Land Monitoring Service	https://land.copernicus.eu/pan-european/corine-land-cover/lcc-2012-2018/login/?came_from=https://land.copernicus.eu/pan-european/corine-land-cover/lcc-2012-2018?tab=download	EU database with information on land cover and use. The information is accessible through web services and downloadable in raster and vector format	
Copernicus Corine Land Cover Change (CHA) 2012 - 2018	Copernicus Corine Land Cover Change (CHA) 2012 - 2018			
Metereological reports	Metereological reports	https://www.meteogalicia.gal/observacion/informesclima/informesIndex.action	Galician meteorological reports downloadable in PDF format.	

Table 45 – Baixa Limia-Serra – DMF Analysis

10.2 Appendix II – Combination of entities

10.2.1 Indicators association with MMDM

10.2.1.1 *Building*

Subcategory	Indicator	Parameter/ Indicator	Reference Model	Entity	Core/ Extension	Table	Parameter	Data Type	Enumeration	Dataset ID
building characterisation	Year of construction	Parameter	CityGML	Building	Core	Building	year_of_construction	Integer		18
building characterisation	State of conservation	Parameter	CityGML	Building	Extension	Building	stateOfConservation	String	Good, fair, poor, ruin	18
building characterisation	Insulation	Parameter	CityGML	Building	Extension	Building	insulation	String		18
building characterisation	Protection level	Parameter	CityGML	Building	Extension	Building	protectionLevel	String		
building characterisation	Structural material	Parameter	CityGML	Building	Extension	Building	structuralMaterial	String		
building characterisation	Façade material	Parameter	CityGML	Building	Extension	Building	facadeMaterial	String		
building characterisation	Accessible windows	Parameter	CityGML	Building	Extension	Building	accessibleWindows	Boolean		
building characterisation	Fire-resistant sector partitions	Parameter	CityGML	Building	Extension	Building	fireResistantPartitions	Boolean		
building characterisation	Fire-protection installations	Parameter	CityGML	Building	Extension	Building	fireProtectionInstallations	Boolean		
building characterisation	Roof material	Parameter	CityGML	Building	Core	Building	roofMaterial	String		
building characterisation	Building use/function	Parameter	CityGML	Building	Core	Building	use	String		18
building characterisation	Building typology	Parameter	CityGML	Building	Extension	Building	typology	String		

Subcategory	Indicator	Parameter/ Indicator	Reference Model	Entity	Core/ Extension	Table	Parameter	Data Type	Enumeration	Dataset ID
building characterisation	Building Height	Parameter	CityGML	Building	Core	Building	measured_height	Double		

Table 46 – Building indicators

10.2.1.2 *Transportation*

Subcategory	Indicator	Parameter /Indicator	Reference Model	Entity	Core/ Extension	Table	Parameter	Data Type	Enumeration	Dataset ID
infrastructure	Road and traffic disturbance	Indicator	CityGML	Transportation	Extension	Transportation	roadTrafficDisturbance	Integer		
infrastructure	Infrastructure Redundancy	Parameter	CityGML	Transportation	Extension	Transportation	infrastructureRedundancy	String		
transport/ access	Road length	Parameter	CityGML	Transportation	Extension	Transportation	roadLength	Double		

Table 47 – Transportation indicators

10.2.1.3 *Vegetation*

Subcategory	Indicator	Parameter/Indicator	Reference Model	Entity	Core/ Extension	Table	Parameter	Data Type	Enumeration	Dataset ID
ecological capacity	Vegetation density (NDVI)	Parameter	CityGML	Vegetation	Extension	Vegetation	ndvi	Double		
ecological capacity	Vegetation water content	Parameter	CityGML	Vegetation	Extension	Vegetation	vegetationWaterContent	Double		

Table 48 – Vegatation indicators

10.2.1.4 *WaterBody*

Subcategory	Indicator	Parameter/Indicator	Reference Model	Entity	Core/ Extension	Table	Parameter	Data Type	Enumeration	Dataset ID
river characterization	Maximum annual river flow corresponding to the return period T at the drainage point of the basin	Indicator	CityGML	WaterBody	Extension	WaterBody	maximumAnnualRiverFlow	Double	03, 04, 05, 06, 07, 08	
river characterization	Maximum annual river level corresponding to the return period T at the drainage point of the basin	Indicator	CityGML	WaterBody	Extension	WaterBody	maximumAnnualRiverLevel	Double	03, 04, 05, 06, 07, 08	
river characterization	River basin concentration time	Indicator	CityGML	WaterBody	Extension	WaterBody	riverBasinConcentrationTime	Integer		02, 03, 04, 05, 06, 07, 08
river characterization	Basin Response Time	Indicator	CityGML	WaterBody	Extension	WaterBody	basinResponseTime	Integer		02, 03, 04, 05,

Subcategory	Indicator	Parameter/Indicator	Reference Model	Entity	Core/ Extension	Table	Parameter	Data Type	Enumeration	Dataset ID
										06, 07, 08, 22
water storage	Dam capacity	Parameter	CityGML	WaterBody	Extension	WaterBody	damCapacity	Double		

Table 49 – Waterbody indicators

10.2.1.5 *HazardArea*

Subcategory	Indicator	Parameter/Indicator	Reference Model	Entity	Core/ Extension	Table	Parameter	Data Type	Enumeration	Dataset ID
soil characterization	Surface runoff	Indicator	NaturalRiskZone	HazardArea	Extension	HazardArea	runoffSurface	Double		
rainfall characterization	Annual Precipitation	Indicator	NaturalRiskZone	HazardArea	Extension	HazardArea	annualPrecipitation	Integer		19, 22
rainfall characterization	Precipitation of Wettest Month	Indicator	NaturalRiskZone	HazardArea	Extension	HazardArea	precipitationWettestMonth	Integer		19, 22
rainfall characterization	Precipitation of Driest Month	Indicator	NaturalRiskZone	HazardArea	Extension	HazardArea	precipitationDriestMonth	Integer		19, 22
rainfall characterization	Precipitation Seasonality (Coefficient of Variation)	Indicator	NaturalRiskZone	HazardArea	Extension	HazardArea	precipitationSeasonality	Double		19, 22
rainfall characterization	Precipitation of Wettest Quarter	Indicator	NaturalRiskZone	HazardArea	Extension	HazardArea	precipitationWettestQuarter	Integer		19, 22
rainfall characterization	Precipitation of Driest Quarter	Indicator	NaturalRiskZone	HazardArea	Extension	HazardArea	precipitationDriestQuarter	Integer		19, 22
rainfall characterization	Precipitation of Warmest Quarter	Indicator	NaturalRiskZone	HazardArea	Extension	HazardArea	precipitationWarmestQuarter	Integer		10, 11, 19, 22
rainfall characterization	Precipitation of Coldest Quarter	Indicator	NaturalRiskZone	HazardArea	Extension	HazardArea	precipitationColdestQuarter	Integer		10, 11, 19, 22
soil characterization	Relative water content in the top few	Indicator	NaturalRiskZone	HazardArea	Extension	HazardArea	relativeWaterContent	Double		

Subcategory	Indicator	Parameter/Indicator	Reference Model	Entity	Core/ Extension	Table	Parameter	Data Type	Enumeration	Dataset ID
	centimetres of soil									
hygrometric conditions	Mean relative humidity	Indicator	NaturalRiskZone	HazardArea	Extension	HazardArea	meanRelativeHumidity	Double		10
hygrometric conditions	Daily humidity cycle shocks	Indicator	NaturalRiskZone	HazardArea	Extension	HazardArea	dailyHumidityCycleShocks	Integer		10
hygrometric conditions	Relative humidity concentration	Indicator	NaturalRiskZone	HazardArea	Extension	HazardArea	relativeHumidityConcentration	Integer		10
urban characterisation	Albedo	Parameter	InspireRiskZone	HazardArea	Extension	HazardArea	albedo	Double		11
urban characterisation	Thermal diffusivity	Parameter	InspireRiskZone	HazardArea	Extension	HazardArea	thermalDiffusivity	Double		
urban characterisation	Solar reflectance index	Parameter	InspireRiskZone	HazardArea	Extension	HazardArea	solarReflectanceIndex	Double		
pollution	Air quality. Near Surface or Tropospheric Ozone (O3) levels	Indicator	NaturalRiskZone	HazardArea	Extension	HazardArea	airQuality	Double		33
soil characterization	Yearly average imperviousness change between two reference years	Indicator	NaturalRiskZone	HazardArea	Extension	HazardArea	imperviousnessChangeAverage	Double		
land characterisation	Average ground slope	Indicator	InspireRiskZone	HazardArea	Extension	HazardArea	groundSlopeAverage	Double		02
urban characterisation	Average annual rate of change of the percentage urban	Parameter	InspireRiskZone	HazardArea	Extension	HazardArea	annualUrbanChangeRatePercentage	Double		
land characterisation	Land Take	Indicator	InspireRiskZone	HazardArea	Extension	HazardArea	landTake	Double		
land characterisation	Land cover	Indicator	InspireRiskZone	HazardArea	Extension	HazardArea	landCover	String		01, 09
soil	Soil water content	Indicat	NaturalRisk	HazardAr	Extension	HazardAr	soilWaterContent	Double		

Subcategory	Indicator	Parameter/Indicator	Reference Model	Entity	Core/ Extension	Table	Parameter	Data Type	Enumeration	Dataset ID
characterization		or	Zone	ea		ea				
demographic	Population in hazard area	Indicator	NaturalRiskZone	HazardArea	Extension	HazardArea	populationNumber	Integer		
land characterisation	Height above sea level	Parameter	InspireRiskZone	HazardArea	Extension	HazardArea	heightAboveSeaLevel	Double		02
hazard characterisation	Frequency of disaster event	Indicator	NaturalRiskZone	HazardArea	Extension	HazardArea	disasterEventFrequency	Integer		34, 35, 36, 37, 38, 39, 40, 41
soil characterization	Soil Water Index (SWI)	Indicator	NaturalRiskZone	HazardArea	Extension	HazardArea	swi	Double		
soil characterization	Liquefaction potential	Indicator	NaturalRiskZone	HazardArea	Extension	HazardArea	liquefactionPotential	String		
hygrometric conditions	Daily mean RH inside the building	Indicator	NaturalRiskZone	HazardArea	Extension	HazardArea	rhInsideBuilding	Double		
sea-level	Sea level rise	Indicator	NaturalRiskZone	HazardArea	Extension	HazardArea	seaLevelRise	Double		
soil characterization	Ground 137áter table	Indicator	NaturalRiskZone	HazardArea	Extension	HazardArea	groundWaterTable	Double		

Table 50 – Hazard area

10.2.1.6 *EarthquakeHazardParameters*

Subcategory	Indicator	Parameter /Indicator	Reference Model	Entity	Core/ Extension	Table	Parameter	Data Type	Enumeration	Dataset ID
earthquake characterisation	Peak Ground Acceleration (PGA)	Indicator	NaturalRiskZone	HazardArea	Extension	EarthquakeHazardParameters	pga	Double		
earthquake characterisation	Level of Seismic Hazard	Indicator	NaturalRiskZone	HazardArea	Extension	EarthquakeHazardParameters	levelSeismicHazard	Double		

earthquake characterisation	Earthquake intensity (Modified Mercalli scale)	Indicator	NaturalRiskZone	HazardArea	Extension	EarthquakeHazardParameters	earthquakeintensity	String	I-XII	

Table 51 – Earthquake Hazard Parameters

10.2.1.7 *FloodHazardParameters*

Subcategory	Indicator	Parameter /Indicator	Reference Model	Entity	Core/ Extension	Table	Parameter	Data Type	Enumeration	Dataset ID
flood characterization	Flood area corresponding to the return period T	Parameter	NaturalRiskZone	HazardArea	Extension	FloodHazardParameters	area	Double		03, 04, 05, 06, 07, 08, 41
flood characterization	Flood depth	Indicator	NaturalRiskZone	HazardArea	Extension	FloodHazardParameters	floodDepth	Double		
flood characterization	Water velocity (in the flooded area)	Indicator	NaturalRiskZone	HazardArea	Extension	FloodHazardParameters	waterVelocity	Double		
flood characterization	Combinations of flood depth and water velocity in the flood area	Indicator	NaturalRiskZone	HazardArea	Extension	FloodHazardParameters	combFloodDepthWaterVelocity	Double		
flood characterization	Flood frequency: linked with the return period	Indicator	NaturalRiskZone	HazardArea	Extension	FloodHazardParameters	floodFrecuency	Integer		03, 04, 05, 06, 07, 08, 34, 35, 36, 37, 38, 39, 40, 41

Table 52 – Flood Hazard Paramaters

10.2.1.8 *FireHazardParameters*

Subcategory	Indicator	Parameter /Indicator	Reference Model	Entity	Core/ Extension	Table	Parameter	Data Type	Enumeration	Dataset ID
wild fire characterization	Fire weather index	Indicator	NaturalRiskZone	HazardArea	Extension	FireHazardParameters	fireWeatherIndex	Integer		
wild fire characterization	Palmer Drought Severity Index	Indicator	NaturalRiskZone	HazardArea	Extension	FireHazardParameters	palmerDroughtSeverityIndex	Integer		
wild fire characterization	Time since fire	Indicator	NaturalRiskZone	HazardArea	Extension	FireHazardParameters	timeSinceFire	Integer		
wild fire characterization	Fire recurrence	Indicator	NaturalRiskZone	HazardArea	Extension	FireHazardParameters	fireRecurrence	Integer		

Table 53 – Fire Hazard Parameters

10.2.1.9 *RainfallHazardParameters*

Subcategory	Indicator	Parameter/Indicator	Reference Model	Entity	Core/ Extension	Table	Parameter	Data Type	Enumeration	Dataset ID
rainfall characterization	Daily maximum precipitation corresponding to the return period T	Indicator	NaturalRiskZone	HazardArea	Extension	RainfallHazardParameters	dailyMaximumPrecipitation	Double		19, 22
rainfall characterization	Hourly maximum precipitation corresponding to the return period T	Indicator	NaturalRiskZone	HazardArea	Extension	RainfallHazardParameters	hourlyMaximumPrecipitation	Double		22
rainfall characterization	Distribution of the rainfall intensity over time, corresponding to the return period T and a duration of the event	Indicator	NaturalRiskZone	HazardArea	Extension	RainfallHazardParameters	distributionRainfallIntensity	Double		22
rainfall characterization	Torrentiality index (factor)	Indicator	NaturalRiskZone	HazardArea	Extension	RainfallHazardParameters	torrentialityIndex	Integer		22
rainfall	IDF (intensity duration	Indicat	NaturalRis	HazardAr	Extension	RainfallHazardPara	idf	Double		

Subcategory	Indicator	Parameter/Indicator	Reference Model	Entity	Core/ Extension	Table	Parameter	Data Type	Enumeration	Dataset ID
characterization	frequency) curves	or	kZone	ea		meters				

Table 54 – Rainfall Hazard Parameters

10.2.1.10 *TemperatureHazardParameters*

Subcategory	Indicator	Parameter/Indicator	Reference Model	Entity	Core/ Extension	Table	Parameter	Data Type	Enumeration	Dataset ID
temperature characterization	Annual Mean Temperature	Indicator	NaturalRiskZone	HazardArea	Extension	TemperatureHazardParameters	annualMeanTemperature	Double		11
temperature characterization	Mean Diurnal Range	Indicator	NaturalRiskZone	HazardArea	Extension	TemperatureHazardParameters	meanDiurnalRange	Double		10, 11
temperature characterization	Isothermality	Indicator	NaturalRiskZone	HazardArea	Extension	TemperatureHazardParameters	isoThermality	Double		10, 11
temperature characterization	Temperature Seasonality	Indicator	NaturalRiskZone	HazardArea	Extension	TemperatureHazardParameters	temperatureSeasonality	Double		10, 11
temperature characterization	Max Temperature of Warmest Month	Indicator	NaturalRiskZone	HazardArea	Extension	TemperatureHazardParameters	maxTemperatureWarmestMonth	Double		10, 11
temperature characterization	Min Temperature of Coldest Month	Indicator	NaturalRiskZone	HazardArea	Extension	TemperatureHazardParameters	minTemperatureColdestMonth	Double		10, 11
temperature characterization	Temperature Annual Range	Indicator	NaturalRiskZone	HazardArea	Extension	TemperatureHazardParameters	temperatureAnnualRange	Double		10, 11
temperature characterization	Mean Temperature of Wettest Quarter	Indicator	NaturalRiskZone	HazardArea	Extension	TemperatureHazardParameters	meanTemperatureWettestQuarter	Double		10, 11, 19, 22
temperature characterization	Mean Temperature of Driest Quarter	Indicator	NaturalRiskZone	HazardArea	Extension	TemperatureHazardParameters	meanTemperatureDriestQuarter	Double		10, 11, 19, 22
temperature characterization	Mean Temperature of Warmest Quarter	Indicator	NaturalRiskZone	HazardArea	Extension	TemperatureHazardParameters	meanTemperatureWarmestQuarter	Double		11
temperature	Mean Temperature	Indicat	NaturalRis	HazardAr	Extension	TemperatureHazardPa	meanTemperatureCold	Double		11

Subcategory	Indicator	Parameter/Indicator	Reference Model	Entity	Core/ Extension	Table	Parameter	Data Type	Enumeration	Dataset ID
characterization	of Coldest Quarter	or	kZone	ea		rameters	estQuarter			
temperature characterization	Daily mean temperature	Indicator	NaturalRiskZone	HazardArea	Extension	TemperatureHazardParameters	dailyMeanTemperature	Double		10
temperature characterization	Thermal shock	Indicator	NaturalRiskZone	HazardArea	Extension	TemperatureHazardParameters	thermalShock	Double		10, 11
temperature characterization	Annual number of days with Tmin <0°C and Tmax>0°C	Indicator	NaturalRiskZone	HazardArea	Extension	TemperatureHazardParameters	daysTmin0Tmax0Number	Integer		
temperature characterization	Land Surface Temperature	Indicator	NaturalRiskZone	HazardArea	Extension	TemperatureHazardParameters	landSurfaceTemperature	Double		

Table 55 – Temperature Hazard Parameters

10.2.1.11 *HeatwaveHazardParameters*

Subcategory	Indicator	Parameter /Indicator	Reference Model	Entity	Core/ Extension	Table	Parameter	Data Type	Enumeration	Dataset ID
heat waves characterisation	Daily sun hours	Indicator	NaturalRiskZone	HazardArea	Extension	HeatwaveHazardParameters	dailySunHours	Integer		
heat waves characterisation	Heat wave indicator	Indicator	NaturalRiskZone	HazardArea	Extension	HeatwaveHazardParameters	heatWaveIndicator	Double		10

Table 56 – Heatwave Hazard Parameters

10.2.1.12 *StormHazardParameters*

Subcategory	Indicator	Parameter /Indicator	Reference Model	Entity	Core/ Extension	Table	Parameter	Data Type	Enumeration	Dataset ID
storm characterisation	Wind speed	Indicator	NaturalRiskZone	HazardArea	Extension	StormHazardParameters	windSpeed	Double		
storm characterisation	Air pressure	Indicator	NaturalRiskZone	HazardArea	Extension	StormHazardParameters	airPressure	Double		

Subcategory	Indicator	Parameter /Indicator	Reference Model	Entity	Core/ Extension	Table	Parameter	Data Type	Enumeration	Dataset ID
storm characterisation	CAPE Index	Indicator	NaturalRiskZone	HazardArea	Extension	StormHazardParameters	capeIndex	Double		
Storm characterisation	Lifted index	Indicator	NaturalRiskZone	HazardArea	Extension	StormHazardParameters	liftedIndex	Integer		
storm characterisation	Heavy rain	Indicator	NaturalRiskZone	HazardArea	Extension	StormHazardParameters	heavyRain	Double		
storm characterisation	Wind pressure	Indicator	NaturalRiskZone	HazardArea	Extension	StormHazardParameters	windPressure	Double		
storm characterisation	Gust strength	Indicator	NaturalRiskZone	HazardArea	Extension	StormHazardParameters	gustStrength	Integer		
storm characterisation	Storm duration	Indicator	NaturalRiskZone	HazardArea	Extension	StormHazardParameters	stormDuration	Integer		
storm characterisation	Number of storms per month	Indicator	NaturalRiskZone	HazardArea	Extension	StormHazardParameters	stormsPerMonthNumber	Integer		
storm characterisation	Variance of the average wind speed in defined area per year	Indicator	NaturalRiskZone	HazardArea	Extension	StormHazardParameters	windSpeedYearVariance	Integer		
storm characterisation	Variance of average gust speeds in defined area per year	Indicator	NaturalRiskZone	HazardArea	Extension	StormHazardParameters	gustSpeedsYearVariance	Integer		

Table 57 – Storm Hazard Parameters

10.2.1.13 *WindHazardParameters*

Subcategory	Indicator	Parameter/Indicator	Reference Model	Entity	Core/ Extension	Table	Parameter	Data Type	Enumeration	Dataset ID
wind characterization	Main wind directions in the coldest quarter	Indicator	NaturalRiskZone	HazardArea	Extension	WindHazardParameters	mainWindDirectionsColdest	String		
wind characterization	Main wind directions in the wettest quarter	Indicator	NaturalRiskZone	HazardArea	Extension	WindHazardParameters	mainWindDirectionsWettest	String		

Table 58 – Wind Hazard Parameters

10.2.1.14 *SubsidenceHazardParameters*

Subcategory	Indicator	Parameter/Indicator	Reference Model	Entity	Core/Extension	Table	Parameter	Data Type	Enumeration	Dataset ID
subsidence characterisation	Subsidence rate	Indicator	NaturalRiskZone	HazardArea	Extension	SubsidenceHazardParameters	subsidenceRate	Double		21
subsidence characterisation	Deflection ratio (relative differential settlement)	Indicator	NaturalRiskZone	HazardArea	Extension	SubsidenceHazardParameters	deflectionRatio	String		

Table 59 – Subsidence Hazard Parameters

10.2.1.15 *RiskZone*

Subcategory	Indicator	Parameter/Indicator	Reference Model	Entity	Core/Extension	Table	Parameter	Data Type	Enumeration	Dataset ID
individuals	Number of fatalities	Indicator	NaturalRiskZone	RiskZone	Extension	RiskZone	fatalitiesNumber	Integer		
individuals	Number of non-fatal injuries	Indicator	NaturalRiskZone	RiskZone	Extension	RiskZone	nonFatalInjuriesNumber	Integer		
individuals	Compared mortality	Indicator	NaturalRiskZone	RiskZone	Extension	RiskZone	comparedMortality	Integer		
individuals	Increased hospitalisation	Indicator	NaturalRiskZone	RiskZone	Extension	RiskZone	increasedHospitalisation	Integer		
individuals	Stays in hospitals	Indicator	NaturalRiskZone	RiskZone	Extension	RiskZone	staysInHospitals	Integer		
individuals	Reduced working capacity	Indicator	NaturalRiskZone	RiskZone	Extension	RiskZone	reducedWorkingCapacity	Integer		
institutional	Systematic inventory of hazard events, damages and losses	Indicator	NaturalRiskZone	RiskZone	Extension	RiskZone	inventoryOfHazardEvents	Integer		1,2,3,4,5
finance	Reported insurance claims	Indicator	NaturalRiskZone	RiskZone	Extension	RiskZone	reportedInsuranceClaims	Integer		

Subcategory	Indicator	Parameter/Indicator	Reference Model	Entity	Core/Extension	Table	Parameter	Data Type	Enumeration	Dataset ID
institutional	Operating hours due to storm events	Indicator	NaturalRiskZone	RiskZone	Extension	RiskZone	operatingHoursStormEvents	Integer		
individuals	Number of people displaced or forced to relocate	Indicator	NaturalRiskZone	RiskZone	Extension	RiskZone	peopleDisplacedNumber	Integer		

Table 60 – Risk Zone Indicators

10.2.1.16 *HistoricArea*

Subcategory	Indicator	Parameter/Indicator	Reference Model	Entity	Core/Extension	Table	Parameter	Data Type	Enumeration	Dataset ID
demographic	Population density	Indicator	SHELTER	HistoricArea	Extension	HistoricArea	populationDensity	Integer		
pollution	Street noise/ acoustic pollution	Indicator	SHELTER	HistoricArea	Extension	HistoricArea	streetNoiseAcousticPollution	Integer		
urban characterisation	Construction material (public space)	Indicator	SHELTER	HistoricArea	Extension	HistoricArea	constructionMaterial	String		
education	Number of participants in training courses executed by authorities, institutions, corporations or other bodies, specific for DRM	Indicator	SHELTER	HistoricArea	Extension	HistoricArea	numberOfParticipantsTrainingCourses	Integer		
education	Percentage of population with access to risk information	Indicator	SHELTER	HistoricArea	Extension	HistoricArea	populationAccessRiskInformationPercentage	Double		
demographic	Percentage of population below 65 years of age	Indicator	SHELTER	HistoricArea	Extension	HistoricArea	populationBelow65Percentage	Double		
demographic	Percentage of population 17 years of age or younger	Indicator	SHELTER	HistoricArea	Extension	HistoricArea	population17OrBelowPercentage	Double		
demographic	Percentage population without sensory, physical, or mental disability	Indicator	SHELTER	HistoricArea	Extension	HistoricArea	populationWithoutDisabilityPercentage	Double		

Subcategory	Indicator	Parameter/Indicator	Reference Model	Entity	Core/Extension	Table	Parameter	Data Type	Enumeration	Dataset ID
demographic	Percentage of female	Indicator	SHELTER	HistoricArea	Extension	HistoricArea	femalePercentage	Double		
demographic	Percentage of one-person household	Indicator	SHELTER	HistoricArea	Extension	HistoricArea	onePersonHouseholdPercentage	Double		
transport/ access	Distance to service centres	Indicator	SHELTER	HistoricArea	Extension	HistoricArea	serviceCentresDistance	Double		
transport/ access	Distance to fire brigades	Indicator	SHELTER	HistoricArea	Extension	HistoricArea	fireBrigadesDistance	Double		
communication	Percentage population with a telephone	Indicator	SHELTER	HistoricArea	Extension	HistoricArea	populationWithTelephonePercentage	Double		
communication	Percentage population with access to broadband internet service	Indicator	SHELTER	HistoricArea	Extension	HistoricArea	populationWithInternetServicePercentage	Double		
economic	Per capita income	Indicator	SHELTER	HistoricArea	Extension	HistoricArea	perCapitaIncome	Integer		
economic	Percentage of population above poverty line	Indicator	SHELTER	HistoricArea	Extension	HistoricArea	populationAbovePpovertyLinePercentage	Double		
governance and finance	Infrastructure and housing insurance as a percent of GDP	Indicator	SHELTER	HistoricArea	Extension	HistoricArea	infrastructureHousingInsurancePercentage	Double		
infrastructure	Psychosocial support facilities per 10,000 persons	Indicator	SHELTER	HistoricArea	Extension	HistoricArea	psychosocialSupportFacilitiesPer10kPersons	Double		
infrastructure	Hospital beds per 10,000 persons	Indicator	SHELTER	HistoricArea	Extension	HistoricArea	hospitalBedsPer10kPersons	Double		
infrastructure	Hotels/motels per 10,000 persons	Indicator	SHELTER	HistoricArea	Extension	HistoricArea	hotelsMotelsPer10kPersons	Double		
urban characterisation	Percentage of residential buildings	Indicator	SHELTER	HistoricArea	Extension	HistoricArea	residentialBuildingsPercentage	Double		
economic	Unemployment rate	Indicator	SHELTER	HistoricArea	Extension	HistoricArea	unemploymentRate	Double		

Subcategory	Indicator	Parameter/Indicator	Reference Model	Entity	Core/Extension	Table	Parameter	Data Type	Enumeration	Dataset ID
economic	Gini coefficient	Indicator	SHELTER	HistoricArea	Extension	HistoricArea	giniCoefficient	Double		
economic	Ratio of large to small businesses	Indicator	SHELTER	HistoricArea	Extension	HistoricArea	largeToSmallBusinessesRatio	Double		
activities	Percentage of firms implementing international risk management standards in the organisation structure and processes	Indicator	SHELTER	HistoricArea	Extension	HistoricArea	firmsImplementingRiskStandardsPercentage	Double		
demographic	Net international migration	Indicator	SHELTER	HistoricArea	Extension	HistoricArea	netInternationalMigration	Double		
social capital	Civic organizations per 10,000 persons	Indicator	SHELTER	HistoricArea	Extension	HistoricArea	civicOrganizationsPer10kPersons	Double		
social capital	Red cross volunteers per 10,000 persons	Indicator	SHELTER	HistoricArea	Extension	HistoricArea	redCrossVolunteersPer10kPersons	Double		
social capital	Budget of volunteer organizations	Indicator	SHELTER	HistoricArea	Extension	HistoricArea	volunteerOrganizationsBudget	Integer		
social capital	Number of registered volunteers	Indicator	SHELTER	HistoricArea	Extension	HistoricArea	registeredVolunteersNumber	Integer		
institutional	Ten-year average per capita spending for mitigation projects	Indicator	SHELTER	HistoricArea	Extension	HistoricArea	averagePerCapitaMitigationProjects	Integer		
institutional	Percentage population covered by a mitigation plan	Indicator	SHELTER	HistoricArea	Extension	HistoricArea	populationCoveredMitigationPlanPercentage	Double		
urban characterisation	Street Pattern	Indicator	SHELTER	HistoricArea	Extension	HistoricArea	streetPattern	String		
social capital	Risk Perception	Indicator	SHELTER	HistoricArea	Extension	HistoricArea	riskPerception	String		
institutional	People with access to emergency medical care	Indicator	SHELTER	HistoricArea	Extension	HistoricArea	peopleAccessEmergencyMedicalCare	Integer		
institutional	Coordination with other	Indicato	SHELTE	HistoricA	Extension	HistoricArea	coordinationOtherGovernment	Integ		

Subcategory	Indicator	Parameter/Indicator	Reference Model	Entity	Core/Extension	Table	Parameter	Data Type	Enumeration	Dataset ID
	government bodies	r	R	rea			Bodies	er		
institutional	Mechanisms for communities to engage with government	Indicator	SHELTER	HistoricArea	Extension	HistoricArea	mechanismsCommunitiesEngageGovernment	Integer		
cultural capital	Presence of a traditional culture	Indicator	SHELTER	HistoricArea	Extension	HistoricArea	traditionalCulturePresence	String		
community preparedness	Number of measures taken by individuals to reduce damage	Indicator	SHELTER	HistoricArea	Extension	HistoricArea	measuresReduceDamageNumber	Integer		
risk identification	Prediction capacity	Indicator	SHELTER	HistoricArea	Extension	HistoricArea	predictionCapacity	Integer		
equipment	Available (collective) equipment to limit damage	Indicator	SHELTER	HistoricArea	Extension	HistoricArea	availableEquipmentLimitDamage	Integer		
building characterisation	Number of one floor houses	Indicator	SHELTER	HistoricArea	Extension	HistoricArea	oneFloorHousesNumber	Integer		
communication	Media observation for public pressure	Indicator	SHELTER	HistoricArea	Extension	HistoricArea	mediaObservationPublicPressure	Integer		
economic	Economic Resilience Index adapted based on Disaster Deficit Index	Indicator	SHELTER	HistoricArea	Extension	HistoricArea	economicResilienceIndex	Integer		
gender equality	Gender-related Development Index (GDI)	Indicator	SHELTER	HistoricArea	Extension	HistoricArea	gdi	Integer		1,2,3,4,5
risk identification	Hazard monitoring and forecasting	Indicator	SHELTER	HistoricArea	Extension	HistoricArea	hazardMonitoringForecasting	Integer		1,2,3,4,5
risk identification	Hazard assessment and mapping	Indicator	SHELTER	HistoricArea	Extension	HistoricArea	hazardAssessmentMapping	Integer		1,2,3,4,5
risk identification	Vulnerability, risk assessment and mapping	Indicator	SHELTER	HistoricArea	Extension	HistoricArea	vulnerabilityRiskAssessmentMapping	Integer		1,2,3,4,5
community preparedness	Public information and community participation	Indicator	SHELTER	HistoricArea	Extension	HistoricArea	publicInformationCommunityParticipation	Integer		1,2,3,4,5
institutional	The extension to which risk is	Indicato	SHELTE	HistoricA	Extension	HistoricArea	landUseUrbanPlanningExtensio	Integ		1,2,3,

Subcategory	Indicator	Parameter/Indicator	Reference Model	Entity	Core/Extension	Table	Parameter	Data Type	Enumeration	Dataset ID
	taken into account in land use and urban planning	r	R	rea			n	er		4,5
building characterisation	Reinforcement and retrofitting of public and private assets	Indicator	SHELTER	HistoricArea	Extension	HistoricArea	reinforcementRetrofittingAssets	Integer		1,2,3,4,5
institutional	Organization and coordination of emergency operations	Indicator	SHELTER	HistoricArea	Extension	HistoricArea	organizationCoordinationEmergencyOperations	Integer		1,2,3,4,5
response	Emergency response planning and implementation of warning systems	Indicator	SHELTER	HistoricArea	Extension	HistoricArea	hasWarningSystems	Integer		1,2,3,4,5
equipment	Supply of equipment, tools and infrastructure	Indicator	SHELTER	HistoricArea	Extension	HistoricArea	equipmentToolsInfrastructureSupply	Integer		1,2,3,4,5
institutional	Simulation, updating and testing of inter-institutional response capability	Indicator	SHELTER	HistoricArea	Extension	HistoricArea	interInstitutionalResponseCapability	Integer		1,2,3,4,5
recovery	Rehabilitation and reconstruction planning	Indicator	SHELTER	HistoricArea	Extension	HistoricArea	rehabilitationReconstructionPlanning	Integer		1,2,3,4,5
institutional	Decentralized organizational units, inter-institutional and multisector coordination	Indicator	SHELTER	HistoricArea	Extension	HistoricArea	decentralizedOrganizationalUnits	Integer		1,2,3,4,5
institutional	Availability of resources for institutional strengthening	Indicator	SHELTER	HistoricArea	Extension	HistoricArea	resourcesInstitutionalStrengthening	Integer		1,2,3,4,5
economic	Budget allocation and mobilization	Indicator	SHELTER	HistoricArea	Extension	HistoricArea	allocationMobilization Budget	Integer		1,2,3,4,5
governance and finance	Existence of social safety nets and funds	Indicator	SHELTER	HistoricArea	Extension	HistoricArea	socialSafetyNetsFundsExistence	Integer		1,2,3,4,5
governance and finance	Insurance coverage and loss transfer strategies for public assets	Indicator	SHELTER	HistoricArea	Extension	HistoricArea	insuranceLossTransferStrategies	Integer		1,2,3,4,5
institutional	Count of missions due to storm	Indicato	SHELTE	HistoricA	Extension	HistoricArea	missionsNumberStormEvents	Integ		

Subcategory	Indicator	Parameter/Indicator	Reference Model	Entity	Core/Extension	Table	Parameter	Data Type	Enumeration	Dataset ID
	events	r	R	rea				er		
urban characterisation	New buildings rate	Indicator	SHELTER	HistoricArea	Extension	HistoricArea	newBuildingsRate	Double		
natural heritage characterization	Number of non-native faunal species introduced	Indicator	SHELTER	HistoricArea	Extension	HistoricArea	nonNativeFaunalSpeciesNumber	Integer		
natural heritage characterization	Species diversity within defined area per Shannon Diversity Index	Indicator	SHELTER	HistoricArea	Extension	HistoricArea	speciesDiversityShannonDiversityIndex	Integer		
natural heritage characterization	Number of species within defined area per Shannon Evenness Index	Indicator	SHELTER	HistoricArea	Extension	HistoricArea	speciesNumberShannonEvennessIndex	Integer		
natural heritage characterization	Extent of habitat for native pollinator species	Indicator	SHELTER	HistoricArea	Extension	HistoricArea	nativePollinatorSpeciesArea	Double		
natural heritage characterization	Proportion of natural areas within a defined zone	Indicator	SHELTER	HistoricArea	Extension	HistoricArea	naturalAreasProportion	Double		01, 09
natural heritage characterization	Number of conservation priority species	Indicator	SHELTER	HistoricArea	Extension	HistoricArea	prioritySpeciesConservationNumber	Integer		
natural heritage characterization	Number of native/local provenance species	Indicator	SHELTER	HistoricArea	Extension	HistoricArea	nativeSpeciesNumber	Integer		
natural heritage characterization	Number of native bird species within a defined urban area	Indicator	SHELTER	HistoricArea	Extension	HistoricArea	nativeBirdSpeciesNumber	Integer		
natural heritage characterization	Change in number of native species compared to a baseline number of species	Indicator	SHELTER	HistoricArea	Extension	HistoricArea	nativeSpeciesCompBaselineChange	Double		
training	Number of professionals trained in post-disaster recovery and preservation of cultural heritage	Indicator	SHELTER	HistoricArea	Extension	HistoricArea	professionalsCHPostDisasterRecoveryNumber	Integer		
equipment	Percentage of existing primary infrastructures provided with back-up systems	Indicator	SHELTER	HistoricArea	Extension	HistoricArea	infrastructuresBackUpSystemsPercentage	Double		
transport/	Daily average of transport	Indicato	SHELTE	HistoricA	Extension	HistoricArea	dailyTransportUsers	Integ		

Subcategory	Indicator	Parameter/Indicator	Reference Model	Entity	Core/Extension	Table	Parameter	Data Type	Enumeration	Dataset ID
access	infrastructure users	r	R	rea				er		
ecological capacity	Area under vegetation and wetlands	Indicator	SHELTER	HistoricArea	Extension	HistoricArea	vegetationWetlandsArea	Double		
local knowledge	Existence of mechanisms for integration local knowledge and local perceptions of risk and scientific knowledge, data and assessment methods	Indicator	SHELTER	HistoricArea	Extension	HistoricArea	existenceMechanismsIntegrationLocalKnowledge	Boolean		
communication	Existence of a platform for information sharing and networking using tools and routines and number of unique users	Indicator	SHELTER	HistoricArea	Extension	HistoricArea	existencePlatformInformationSharing	Boolean		
activities	Number of new businesses registered within the area in the past year, per 100,000 population	Indicator	SHELTER	HistoricArea	Extension	HistoricArea	newBusinessesRegisteredNumber	Integer		
energy	Percentage of renewable energy	Indicator	SHELTER	HistoricArea	Extension	HistoricArea	renewableEnergyPercentage	Double		
building characterisation	Site accessibility	Indicator	SHELTER	HistoricArea	Extension	HistoricArea	siteAccessibility	String		
economic	Agricultural occupation rate	Indicator	SHELTER	HistoricArea	Extension	HistoricArea	agriculturalOccupationRate	Double		
livestock characterization	Total number of cattle heads	Indicator	SHELTER	HistoricArea	Extension	HistoricArea	cattleHeadsNumber	Integer		
livestock characterization	Total number of sheep heads	Indicator	SHELTER	HistoricArea	Extension	HistoricArea	sheepHeadsNumber	Integer		
livestock characterization	Total number of goat heads	Indicator	SHELTER	HistoricArea	Extension	HistoricArea	goatHeadsNumber	Integer		
livestock	Total number of poultry heads	Indicato	SHELTE	HistoricA	Extension	HistoricArea	poultryHeadsNumber	Integ		

Subcategory	Indicator	Parameter/Indicator	Reference Model	Entity	Core/Extension	Table	Parameter	Data Type	Enumeration	Dataset ID
characterization		r	R	rea				er		
livestock characterization	Total number of swine heads	Indicator	SHELTER	HistoricArea	Extension	HistoricArea	swineHeadsNumber	Integer		
livestock characterization	Total number of equine heads	Indicator	SHELTER	HistoricArea	Extension	HistoricArea	equineHeadsNumber	Integer		
natural heritage characterization	Landscape heterogeneity	Indicator	SHELTER	HistoricArea	Extension	HistoricArea	landscapeHeterogeneity	Integer		
natural heritage characterization	Beta diversity	Indicator	SHELTER	HistoricArea	Extension	HistoricArea	betaDiversity	Integer		
natural heritage characterization	Functional diversity	Indicator	SHELTER	HistoricArea	Extension	HistoricArea	functionalDiversity	Double		
demographic	Total population	Indicator	SHELTER	HistoricArea	Extension	HistoricArea	totalPopulation	Integer		
demographic	Illiterate population	Indicator	SHELTER	HistoricArea	Extension	HistoricArea	illiteratePopulation	Integer		
ecological capacity	Habitat-suitability index under climate change scenarios	Indicator	SHELTER	HistoricArea	Extension	HistoricArea	habitatSuitabilityIndex	Integer		
ecological capacity	Total carbon sequestered and carbon sequestration rate	Indicator	SHELTER	HistoricArea	Extension	HistoricArea	carbonSequesteredCarbonSequestrationRate	Double		

Table 61 – Historic Area

10.2.2 Combination of entities

10.2.2.1 *ExposedElementHistoricArea*

Subcategory	Indicator	Parameter/Indicator	Reference Model	Entity	Core/ Extension	Table	Parameter	Data Type	Enumeration	Dataset ID
building characterisation	Daily hillside of roofs	Parameter Indicator	InspireRiskZone SHELTER	ExposedElement HistoricArea	Extension	ExposdElement HistoricArea	dailyHillsideRoofs dailyHillsideRoofs	Double		11
building characterisation	Daily hillside of façades	Parameter Indicator	InspireRiskZone SHELTER	ExposedElement HistoricArea	Extension	ExposdElement HistoricArea	dailyHillsideFacades dailyHillsideFacades	Double		11
asset characterisation	Sky view factor	Parameter Indicator	InspireRiskZone SHELTER	ExposedElement HistoricArea	Extension	ExposedElement HistoricArea	skyViewFactor skyViewFactor	Double		
building characterisation	Vibrations generated on cultural heritage by vehicular traffic	Parameter Indicator	InspireRiskZone SHELTER	ExposedElement HistoricArea	Extension	ExposedElement HistoricArea	vibrationsCHTraffic	Double		

Table 62 – ExposedElementHistoricArea

10.2.2.2 *BuildingHistoricArea*

Subcategory	Indicator	Parameter /Indicator	Reference Model	Entity	Core/Extension	Table	Parameter	Data Type	Enumeration	Dataset ID
building characterisation	Percentage of buildings complying with hazard-resistant building codes and/or standards	Parameter Indicator	CityGML SHELTER	Building HistoricArea	Extension	Building Historic Area	hasHazardResistantStandards hazardResistantStandardsPercentage	Boolean Double		
urban characterisation	Building alignment rate	Parameter Indicator	CityGML SHELTER	Building HistoricArea	Extension	Building Historic Area	isBuildingAligned buildingAlignmentRate	Boolean Double		

Subcategory	Indicator	Parameter /Indicator	Reference Model	Entity	Core/Extension	Table	Parameter	Data Type	Enumeration	Dataset ID
building characterisation	Percentage of buildings with drainage system in good condition and appropriate dimension	Parameter Indicator	CityGML SHELTER	Building HistoricArea	Extension	Building Historic Area	hasDdainageSystem drainageSystemPercentage	Boolean Double		
building characterisation	Percentage of buildings with basement in flood prone area	Parameter Indicator	CityGML SHELTER	Building HistoricArea	Extension	Building Historic Area	hasBasementFloodProneArea basementFloodProneAreaPercentage	Boolean Double		
building characterisation	Percentage of building with open ground floor or with ground floor above the maximum level of possible flood	Parameter Indicator	CityGML SHELTER	Building HistoricArea	Extension	Building Historic Area	hasOpenGroundFloorAboveMaxLevel openGroundFloorAboveMaxLevelPercentage	Boolean Double		
building characterisation	Percentage of buildings with structural materials resistant to water penetration	Parameter Indicator	CityGML SHELTER	Building HistoricArea	Extension	Building Historic Area	hasStructuralMaterialsWaterResistant structuralMaterialsWaterResistantPercentage	Boolean Double		
building characterisation	Percentage of buildings with facade materials resistant to water penetration	Parameter Indicator	CityGML SHELTER	Building HistoricArea	Extension	Building Historic Area	hasFacadeMaterialsWaterResistant facadeMaterialsWaterResistantPercentage	Boolean Double		
building characterisation	Number of blue and green roofs	Parameter Indicator	CityGML SHELTER	Building HistoricArea	Extension	Building Historic Area	hasBlueGreenRoofs blueGreenRoofsNumber	Boolean Integer		
building characterisation	Number of buildings hosting collections with storage capacity in upper floors	Parameter Indicator	CityGML SHELTER	Building HistoricArea	Extension	Building Historic Area	hasHostingCollectionsStorageCapacity hostingCollectionsStorageCapacityNumber	Boolean Integer		
risk reduction	Updating and enforcement of safety standards and construction codes	Parameter Indicator	CityGML SHELTER	Building HistoricArea	Extension	Building Historic Area	enforcementSafetyConstructionCodesUpdating	Integer		1,2,3,4,5

Subcategory	Indicator	Parameter /Indicator	Reference Model	Entity	Core/Extension	Table	Parameter	Data Type	Enumeration	Dataset ID
building characterisation	Building transformation	Parameter Indicator	CityGML SHELTER	Building HistoricArea	Extension	Building Historic Area	isTransformed buildingTransformation	Boolean String		
building characterisation	Building walls rotations	Parameter Indicator	CityGML SHELTER	Building HistoricArea	Extension	Building Historic Area	hasWallsRotations buildingWallsRotations	Boolean Integer		

Table 63 – BuildingHistoricArea

10.2.2.3 *ProtectedSiteHistoricArea*

Subcategory	Indicator	Parameter/Indicator	Reference Model	Entity	Core/ Extension	Table	Parameter	Data Type	Enumeration	Dataset ID
ecological capacity	Share of the protected lands	Parameter Indicator	ProtectedSite SHELTER	ProtectedSite HistoricArea	Extension	ProtectedSite HistoricArea	area shareProtectedLands	Double		
cultural capital	Intangible value of cultural and natural heritage	Parameter Indicator	ProtectedSite SHELTER	ProtectedSite HistoricArea	Extension	ProtectedSite HistoricArea	cnhIntangibleValue	String		

Table 64 – ProtectedSiteHistoricArea

10.2.2.4 *VegetationHistoricArea*

Subcategory	Indicator	Parameter/Indicator	Reference Model	Entity	Core/ Extension	Table	Parameter	Data Type	Enumeration	Dataset ID
ecological	Share of ecological corridors	Parame	CityGM	Vegetation	Extension	Vegetation	area	Doubl		

Subcategory	Indicator	Parameter/Indicator	Reference Model	Entity	Core/ Extension	Table	Parameter	Data Type	Enumeration	Dataset ID
capacity		ter Indicator	L SHELTER	HistoricArea		HistoricArea	shareEcologicalCorridors	e		
ecological capacity	Structural connectivity of green infrastructure	Parameter Indicator	CityGML SHELTER	Vegetation HistoricArea	Extension	Vegetation HistoricArea	greenInfrastructureStructuralConnectivity	Double		01, 09
ecological capacity	Functional connectivity of green infrastructure	Parameter Indicator	CityGML SHELTER	Vegetation HistoricArea	Extension	Vegetation HistoricArea	greenInfrastructureFunctionalConnectivity	Double		01, 09
natural heritage characterization	Number of non-native species of flora introduced	Parameter Indicator	CityGML SHELTER	Vegetation HistoricArea	Extension	Vegetation HistoricArea	nonNativeFloraSpeciesNumber	Integer		
wild fire characterization: fuel accumulation	Number of veteran trees per unit area	Parameter Indicator	CityGML SHELTER	Vegetation HistoricArea	Extension	Vegetation HistoricArea	veteranTreesNumber	Integer		
wild fire characterization: fuel accumulation	Quantity of dead wood per unit area	Parameter Indicator	CityGML SHELTER	Vegetation HistoricArea	Extension	Vegetation HistoricArea	deadWoodQuantity	Integer		
ecological capacity	Area of habitats restored	Parameter Indicator	CityGML SHELTER	Vegetation HistoricArea	Extension	Vegetation HistoricArea	habitatsRestoredArea	Double		
ecological capacity	Habitat functional composition (relative abundance of	Parameter	CityGML	Vegetation HistoricAre	Extension	Vegetation HistoricAre	habitatFunctionalComposition	Integer		

Subcategory	Indicator	Parameter/Indicator	Reference Model	Entity	Core/ Extension	Table	Parameter	Data Type	Enumeration	Dataset ID
	functional features)	Indicator	SHELTER	a		a				
natural heritage characterization	Shannon Index	Parameter Indicator	CityGML SHELTER	VegetationHistoricArea	Extension	VegetationHistoricArea	shannonIndex	Integer		01, 09
ecological capacity	Urban green space proportion	Parameter Indicator	CityGML SHELTER	VegetationHistoricArea	Extension	VegetationHistoricArea	area urbanFreenSpaceArea	Double		01, 09
natural heritage characterization	Plant/root decay rate	Parameter Indicator	CityGML SHELTER	VegetationHistoricArea	Extension	VegetationHistoricArea	plantRootDecayRate	Integer		

Table 65 – VegetationHistoricArea

10.2.2.5 *RiskZoneHistoricArea*

Subcategory	Indicator	Parameter/Indicator	Reference Model	Entity	Core/ Extension	Table	Parameter	Data Type	Enumeration	Dataset ID
damage characterisation	Number of collapsed or heavy damaged buildings	Indicator Indicator	NaturalRiskZone SHELTER	RiskZoneHistoricArea	Extension	RiskZone HistoricArea	collapsedHeavyDamagedBuildingsNumber	Integer		
damage characterisation	Affected critical facilities	Indicator Indicator	NaturalRiskZone SHELTER	RiskZoneHistoricArea	Extension	RiskZone HistoricArea	affectedCriticalFacilities	Integer		
damage	Stage Damage curve, direct	Indicat	NaturalRiskZo	RiskZone	Extension	RiskZone	stageDamageCurve	Integer		

Subcategory	Indicator	Parameter/Indicator	Reference Model	Entity	Core/ Extension	Table	Parameter	Data Type	Enumeration	Data set ID
characterisation	impacts	or Indicator	ne SHELTER	HistoricArea		HistoricArea				
recovery	Recovery rate	Indicator Indicator	NaturalRiskZone SHELTER	RiskZone HistoricArea	Extension	RiskZone HistoricArea	recoveryRate	Integer		
damage characterisation	Slight or moderate damaged buildings	Indicator Indicator	NaturalRiskZone SHELTER	RiskZone HistoricArea	Extension	RiskZone HistoricArea	slightModerateDamagedBuildings	Integer		
damage characterisation	Windthrow in defined area	Indicator Indicator	NaturalRiskZone SHELTER	RiskZone HistoricArea	Extension	RiskZone HistoricArea	windthrow	Double		
damage characterisation	Loss of habitat and biodiversity	Indicator Indicator	NaturalRiskZone SHELTER	RiskZone HistoricArea	Extension	RiskZone HistoricArea	lossHabitatBiodiversity	String		
damage characterisation	Duration of infrastructure outage	Indicator Indicator	NaturalRiskZone SHELTER	RiskZone HistoricArea	Extension	RiskZone HistoricArea	durationInfrastructureOutage	Integer		
damage characterization	Slight or moderate damaged movable heritage	Parameter Indicator	NaturalRiskZone SHELTER	RiskZone HistoricArea	Extension	RiskZone HistoricArea	moderateDamagedMovableHeritage	Integer		
damage characterisation	Biological colonization	Indicator Indicat	NaturalRiskZone SHELTER	RiskZone HistoricArea	Extension	RiskZone HistoricArea	biologicalColonization	String		

Subcategory	Indicator	Parameter/Indicator	Reference Model	Entity	Core/ Extension	Table	Parameter	Data Type	Enumeration	Dataset ID
		or								
damage characterisation	Burn Severity index	Indicator Indicator	NaturalRiskZone SHELTER	RiskZone HistoricArea	Extension	RiskZone HistoricArea	burnSeverityIndex	String		

Table 66 – RiskZoneHistoricArea

10.2.2.6 *HazardAreaHistoricArea*

Subcategory	Indicator	Parameter/Indicator	Reference Model	Entity	Core/ Extension	Table	Parameter	Data Type	Enumeration	Dataset ID
hazard area characterisation	Land take in hazard area	Parameter Indicator	NaturalRiskZone SHELTER	HazardArea HistoricArea	Extension	HazardArea HistoricArea	area landTakeArea	Double		
hazard area characterisation	Buildings in hazard area	Indicator	NaturalRiskZone SHELTER	HazardArea HistoricArea	Extension	HazardArea HistoricArea	buildingsNumber	Integer		
hazard area characterisation	Critical facilities in hazard area	Parameter Indicator	NaturalRiskZone SHELTER	HazardArea HistoricArea	Extension	HazardArea HistoricArea	isCriticalFacility criticalFacilitiesNumber	Boolean Integer		
hazard area characterisation	Productive activities in hazard area	Parameter Indicator	NaturalRiskZone SHELTER	HazardArea HistoricArea	Extension	HazardArea HistoricArea	isProductiveActivity productiveActivitiesNumber	Boolean Integer		
hazard area characterisatio	Major accident risk factories in hazard	Parameter	NaturalRiskZone	HazardArea HistoricArea	Extension	HazardArea HistoricAre	isMajorAccidentRiskFactory majorAccidentRiskFactories	Boolean Integer		

Subcategory	Indicator	Parameter/Indicator	Reference Model	Entity	Core/ Extension	Table	Parameter	Data Type	Enumeration	Dataset ID
n	area	Indicator	SHELTER			a				

Table 67 – HazardAreaHistoricArea

10.2.2.7 *RiskZoneProtectedSite*

Subcategory	Indicator	Parameter/Indicator	Reference Model	Entity	Core/ Extension	Table	Parameter	Data Type	Enumeration	Dataset ID
reparability	Repairability	Indicator Indicator	NaturalRiskZone ProtectedSite	RiskZone ProtectedSite	Extension	RiskZone ProtectedSite	repairability	Double		
damage characterisation	Direct economic loss to cultural heritage damaged or destroyed	Indicator Indicator	NaturalRiskZone ProtectedSite	RiskZone ProtectedSite	Extension	RiskZone ProtectedSite	economicLossCHDamaged Destroyed	Integer		
damage characterisation	Affected intangible cultural heritage	Indicator Indicator	NaturalRiskZone ProtectedSite	RiskZone ProtectedSite	Extension	RiskZone ProtectedSite	affectedIntangibleCH	String		
damage characterization	Heavy damaged movable heritage	Indicator Indicator	NaturalRiskZone ProtectedSite	RiskZone ProtectedSite	Extension	RiskZone ProtectedSite	heavyDamagedMovableHeritage	Integer		
damage characterisation	Loss of ancestral land and natural heritage	Indicator Indicator	NaturalRiskZone ProtectedSite	RiskZone ProtectedSite	Extension	RiskZone ProtectedSite	lossAncestralNH	String		

Table 68 – RiskZoneProtectedSite

10.2.2.8 *WaterBodyHistoricArea*

Subcategory	Indicator	Parameter/Indicator	Reference Model	Entity	Core/ Extension	Table	Parameter	Data Type	Enumeration	Dataset ID
risk reduction	Management of river basins and environmental protection	Parameter Indicator	CityGML SHELTER	WaterBody HistoricArea	Extension	WaterBody HistoricArea	managementRiverBasinsEnvironmentalProtection	Integer	1,2,3,4,5	

Table 69 – WaterBodyHistoricArea

10.2.2.9 *RiskZoneVegetation*

Subcategory	Indicator	Parameter/Indicator	Reference Model	Entity	Core/ Extension	Table	Parameter	Data Type	Enumeration	Dataset ID
ecological capacity	Vegetation recovery rate	Indicator Indicator	NaturalRiskZone CityGML	RiskZone Vegetation	Extension	RiskZone Vegetation	vegetationRecoveryRate	Double		
ecological capacity	Primary productivity (EVI/NDVI time series): biomass/species' habitat/post-fire recovery rates	Indicator Indicator	NaturalRiskZone CityGML	RiskZone Vegetation	Extension	RiskZone Vegetation	primaryProductivity	Double		

Table 70 – RiskZoneVegetation

10.3 Appendix III – Parameters association Macrocategories

10.3.1 Building Macrocategory

Parameter	Indicator	Parameter/Indicator	ReferenceModel	Entity	Core/ Extension	Table	Parameter	Data Type	DefinesValues
Building Protection Type	PREVENTION /ADAPTION-Sensitivity - Building characteristics - building characterization	Parameter	CityGML	Building	Extension	Building	protectionType	String	Monumental heritage of exceptional cultural value, World heritage building, European Label heritage building, Monument and Memorial, Archaeological building, Industrial heritage, Historic building
Use	PREVENTION /ADAPTION-Sensitivity - Building characteristics - building characterization	Parameter	CityGML	Building	Core	Building	function	Integer	
Heritage Type	PREVENTION /ADAPTION-Sensitivity - Building characteristics - building characterization	Parameter	CityGML	Building	Extension	Building	protectionType	String	
Heritage Category	PREVENTION /ADAPTION-Sensitivity - Building characteristics - building characterization	Parameter	CityGML	Building	Extension	Building	heritageCategory	String	Agricultural heritage, Archaeological sites, Architectural ensembles, Collections (movable), Cultural landscapes, Cultural routes, Groups of buildings, Heritage canals, Historic buildings, Historic gardens, Historic landscapes, Historic towns and villages, Historic town centres, Historic urban landscapes, Human settlements, Industrial and technical heritage, Intangible cultural heritage, Mixed sites, Monuments, Natural sites, Polar heritage, Prehistoric sites, Rock art, Scientific heritage,

Parameter	Indicator	Parameter/Indicator	ReferenceModel	Entity	Core/ Extension	Table	Parameter	Data Type	DefinesValues
									Significant personalities, Sites, Underwater cultural heritage, Habitations urbaines, Vernacular architecture, World heritage
Classification / Registration Status and Current Conservation Status	Sensitivity -> building charachteristics -> Urban characterization -> • Land Take • Land cover • Urban growth, avg. annual rate (%). • Average slope • Average elevation • Thermal diffusivity • Solar reflectance Sensitivity -> environmental sensitivity -> Urban characterization -> Buildings in hazard area	Parameter	InspireNaturalRiskZone	ExposedElement	Extension	ExposedElement	registrationStatusConservationStatus	String	Listed in the UNESCO WHS, Listed in European Heritage Label, Listed in the National List/Lists (Replicable Field if Cross-Country), Listed in Local List/Lists (Replicable Field if Cross-Country), Listed in the UNESCO Representative List of the Intangible Cultural Heritage of Humanity, Monument and Memorial, Archaeological building, Industrial heritage, Historic Building

Table 71 – Building Macrocategory (1)

Parameter	Indicator	Parameter /Indicator	Reference Model	Entity	Core/ Extension	Table	Parameter	Data Type	Defines Values

Parameter	Indicator	Parameter /Indicator	Reference Model	Entity	Core/ Extension	Table	Parameter	Data Type	Defines Values
Overall description of the CH asset in the current situation with its main features and components (to be listed in the field below) that will allow to directly link to specific analyses and detailed information in the Clusters of Ressources)	Sensitivity -> building charachteristics	Parameter	InspireNaturalRiskZone	ExposedElement	Extension	ExposedElement	chAssetDescription	String	
Material and Techniques	PREVENTION /ADAPTION- Sensitivity - Building characteristics - building characterization	Parameter	InspireNaturalRiskZone	ExposedElement	Extension	ExposedElement	materialAndTechniquesDescription	String	
Facade Type	PREVENTION /ADAPTION - Exposure - object/buildings/infrastructure - building characterisation - Daily hillside of façades • Daily hillside of roofs	Parameter	CityGML	Building	Extension	Building	facadeType	String	
Windows type	PREVENTION /ADAPTION - Exposure - object/buildings/infrastructure - building characterisation - Daily hillside of façades	Parameter	CityGML	Building	Extension	Building	windowsType	String	
Restauration and Reinforcements	PREVENTION /ADAPTION - Adaptive capacity - building characterisation - Reinforcement and retrofitting of public and private assets	Parameter	CityGML	Building	Extension	Building	restaurationDate restaurationType	Date String	
Function and uses	exposure -> individuals -> Demographic exposure -> Population in hazard area exposure -> Community exposure -> processes activities	Parameter	InspireNaturalRiskZone	ExposedElement	Core	ExposedElement	function	String	
Climate type	source/hazards -> magnitude -> heatwave characterization -> • ONRN indicators for heatwave	Parameter	SHELTER	HistoricArea	Extension	HistoricArea	climateType	String	

Parameter	Indicator	Parameter /Indicator	Reference Model	Entity	Core/ Extension	Table	Parameter	Data Type	Defines Values
	• Daily mean temperature • Thermal shock [Tmax-Tmin] • Daily sun hours • Mean relative humidity • Daily humidity cycle shocks [RH(n)-RH(n+1)>25%] • Relative humidity concentration [nRH>75%] source/hazards -> Intenstiy, duration and frequency -> Rainfall characterization -> IDF (intensity duration frequency) curves								
Vegetation barriers separating built areas from the sea/water basins	PREVENTION /ADAPTION - Adaptive capacity - natural capital - ecological capacity - area under vegetation	Parameter	InspireNaturalRiskZone	HazardArea	Extension	HazardArea	vegetationBarriesSeparatingBuiltAreas	Boolean	
Soil infiltration capacity (permeable surface)	source/hazards -> magnitude -> Urban characterization -> Subsidence rate sensitivity -> environmental sensitivity -> Soil -> Soil stability sensitivity -> environmental sensitivity -> Soil -> Soil water content sensitivity -> environmental sensitivity -> No subcategory -> Soil Water Index (SWI)	Indicator	NaturalRiskZone	HazardArea	Extension	HazardArea	soilInfiltrationCapacity	Double	
Building orientation and distribution	PREVENTION /ADAPTION- Sensitivity - Building characteristics - building characterization	Parameter	CityGML	Building	Extension	Building	mainOrientation	String	

Table 72 – Building Macrocategory (2)

10.3.2 Urban Macrocategory

Parameter	Indicator	Parameter/Indicator	ReferenceModel	Entity	Core/ Extension	Table	Parameter	Data Type	DefinesValues
Human Settlements Size:	PREVENTION/ADAPTION PHASE – Sensitivity – environmental sensitivity – **urban characterization**	Parameter	SHELTER	HistoricArea	Extension	HistoricArea	humanSettlementSize	String	Megapolis, Megacity, Urban agglomeration, Metropolis, Micropolis, City, Town, Village, Hamlet, Isolated dwelling
URBAN HA SCALE	PREVENTION/ADAPTION PHASE – Exposure - object/buildings/infrastructure – **building charactrerization**	Parameter	SHELTER	HistoricArea	Extension	HistoricArea	urbanHAScale	String	
DEGREE OF URBANIZATION To be checked with TEC to understand which prioritization is more effective	PREVENTION/ADAPTION PHASE – Sensitivity – Building Characteristics – urban characteristics: **Street Pattern**	Parameter	SHELTER	HistoricArea	Extension	HistoricArea	degreeOfUrbanization	String	

Table 73 – Urban Macrocategory

10.3.3 Natural Macrocategory

Parameter	Indicator	Parameter /Indicator	ReferenceModel	Entity	Core/ Extension	Table	Parameter	Data Type	DefinesValues
Environmental context and regime (Together with the cell below)	PREVENTION/ADAPTION PHASE Coping capacity o protection of natural resources Urban characterization • Share of the protected lands	Indicator	InspireProtectedSire	ProtectedSite	Extension	ProtectedSite	environmentalContext	String	Natural protected heritage, Protected natural area, Historic Garden and plantings (vegetal architectures), Natural

Parameter	Indicator	Parameter /Indicator	ReferenceModel	Entity	Core/ Extension	Table	Parameter	Data Type	DefinesValues
	• Share of ecological corridors • Risk reduction • Management of river basins and environmental protection • Updating and enforcement of safety standards and construction codes								monument, Cultural Landscape, Geological monument, Natura 2000 sites, Geopark, Silence Areas, Other Natural areas
NATURAL AREA TYPE Classification / Registration Status and Current Protection Status	PREVENTION/ADAPTION PHASE Coping capacity o protection of natural resources • Urban characterization • Share of the protected lands • Share of ecological corridors • Risk reduction • Management of river basins and environmental protection • Updating and enforcement of safety standards and construction codes PREVENTION/ADAPTION PHASE Coping capacity Protection of natural resources • ecological capacity • Vegetation density • Share of the protected lands • Share of ecological corridors	Indicator	InspireProtectedSire	ProtectedSite	Extension	ProtectedSite	naturalAreaType	String	Natural protected heritage; Other Natural Areas / green spaces; Conventional urban park, with lawns, flowerbeds, playgrounds and sports fields; Garden linked to historic buildings; River Basin; Non protected Historic or traditional planting; Designed Park/Garden (vegetal architecture); Natural area that includes designed park/garden; Green Infrastructure; Component of a green infrastructure into the built urban environment; Permanence of historic land planning (e.g. centuriation, rural land parcelling, settlement location, roadtracks, water and channel networks)

Parameter	Indicator	Parameter /Indicator	ReferenceModel	Entity	Core/ Extension	Table	Parameter	DataType	DefinesValues
Overall description of the **CH asset** in the current situation with its main features and components that will allow to directly link to specific analyses and detailed information in the Clusters of Ressources)	Sensitivity -> building charachteristics -> Urban characterization -> • **Land Take** • **Land cover** • **Urban growth, avg. annual rate (%).** • **Average slope** • **Average elevation** • **Thermal diffusivity** • **Solar reflectance** Sensitivity -> environmental sensitivity -> Urban characterization -> **Buildings in hazard area**	Parameter	InspireProtectedSire	ProtectedSite	Extension	ProtectedSite	chAssetDescription	String	
Detailed list of CH components in the case of composite CH categorization (e.g. Cultural Routes)	PREVENTION/ADAPTION PHASE – Sensitivity – environmental sensitivity – **building characterization** PREVENTION/ADAPTION PHASE – Sensitivity – environmental sensitivity – **urban characterization**	Parameter	InspireProtectedSire	ProtectedSite	Extension	ProtectedSite	chComponents	String	
Intangible Heritage Balance of cultural and natural values in the natural environment	PREVENTION/ADAPTION PHASE Coping capacity • transformative capacity/inherent resilience Social memory	Parameter	InspireProtectedSire	ProtectedSite	Extension	ProtectedSite	culturalAndNaturalValues	String	

Table 74 – Natural Macrocategory

10.4 Appendix IV – Association of dataset sources with entities

	CITYgml					Protected Site	Natural Risk Zone				Others
Dataset source	**Building**	**Transp.**	**Vegetation**	**Water Body**	**Land Use**	**Protected Site**	**Hazard Area**	**Risk Zone**	**Exposed Element**	**Observed Element**	**Base Map**
Corine Land Cover (CLC) 2018 from the Copernicus Land Monitoring Service					x						
European Digital Elevation Model (EU-DEM) v1.1 from the Copernicus Land Monitoring Service											x
Data on national monuments						x					
Data on total risk of flood							x	x			
Data on municipal monuments	x					x					
Water Occurrence from JRC Global Surface Water Explorer							x				
Water Occurrence Change Intensity from JRC Global Surface Water Explorer							x				
Water Seasonality from JRC Global Surface Water Explorer							x				
Annual Water Recurrence from JRC Global Surface Water Explorer							x				
Water Transitions from JRC Global Surface Water Explorer							x				
Maximum Water Extent from							x				

	CITYgml					Protected Site	Natural Risk Zone				Others
Dataset source	**Building**	**Transp.**	**Vegetation**	**Water Body**	**Land Use**	**Protected Site**	**Hazard Area**	**Risk Zone**	**Exposed Element**	**Observed Element**	**Base Map**
JRC Global Surface Water Explorer											
Viewer maps tool		x		x		x					
Data from European Forest Fire Information System (EFFIS) - Copernicus EMS							x				
Subsidence velocity in vertical movements (isolines)							x				
Flood hazard and risk maps							x				
Flood Hazard Mapping								x			
Regional Technical Map 1:5000 (from Emilia-Romagna geoportal)			x								
AGEA RGB ortophoto (from Emilia-Romagna geoportal)											x
Administrative boundaries 2018 (from Emilia-Romagna geoportal)											x
Administrative boundaries (member state boundaries) from Sava GIS geoportal (WMS layer: adminbound)											x
PFRA (Preliminary Flood Risk Assessment) flood events (historical and possible in future) - Sava FRM plan - from Sava GIS geoportal (WMS layer: PFRA_floodevent_a = polygons)										x	
PFRA (Preliminary Flood Risk Assessment) flood events										x	

	CITYgml					Protected Site	Natural Risk Zone				Others
Dataset source	**Building**	**Transp.**	**Vegetation**	**Water Body**	**Land Use**	**Protected Site**	**Hazard Area**	**Risk Zone**	**Exposed Element**	**Observed Element**	**Base Map**
(historical and possible in future) - Sava FRM plan - from Sava GIS geoportal (WMS layer: PFRA_floodevent_p = points)											
Hydrologic and meteorological data, information and knowledge about water resources in the SavaRiver Basin										x	
Locations of the Areas with Potential Significant Flood Risk (APSFR) as identified by the Framework Agreement on the Sava River Basin contracting Parties (WMS layer: APSFR_a = polygons)							x				
Areas with mutual interest for flood protection from Sava GIS FRMP (WMS layer: APSFR_ami = polygons)							x				
Locations of the Areas with Potential Significant Flood Risk (APSFR) as identified by the Framework Agreement on the Sava River Basin contracting Parties (WMS layer: APSFR_l = lines)							x				
Locations of the Areas with Potential Significant Flood Risk (APSFR) as identified by the contracting Parties to the							x				

	CITYgml					Protected Site	Natural Risk Zone				Others
Dataset source	**Building**	**Transp.**	**Vegetation**	**Water Body**	**Land Use**	**Protected Site**	**Hazard Area**	**Risk Zone**	**Exposed Element**	**Observed Element**	**Base Map**
Framework Agreement on the Sava River Basin (FASRB) - (WMS layer: APSFR_p = points)											
Cities from Sava GIS geoportal (WMS layer: city_p = points)									x		
Relief map from Sava GIS geoportal (WMS layer: elevation_3857)											x
Flood Hazard scenario areas from Sava GIS geoportal (WMS layer: FHRM_hazard = polygons)							x				
Flood Protection structures retention and reservoirs from Sava GIS geoportal (WMS layer: FPR_retres_a = polygons)				x							
Groundwater bodies from Sava River Basin Management Plan - Sava GIS geoportal (WMS layer: gwb = polygons)				x							
PFRA (Preliminary Flood Risk Assessment) flood events (historical and possible in future) - Sava FRM plan - from Sava GIS geoportal (WMS layer: PFRA_floodevent_l = lines)										x	
Protected areas - Sava River Basin Management (RBM)						x					

	CITYgml					Protected Site	Natural Risk Zone				Others
Dataset source	**Building**	**Transp.**	**Vegetation**	**Water Body**	**Land Use**	**Protected Site**	**Hazard Area**	**Risk Zone**	**Exposed Element**	**Observed Element**	**Base Map**
Plan from Sava GIS geoportal (WMS layer: protectedarea_a = polygons)											
Protected areas - Sava River Basin Management (RBM) Plan from Sava GIS geoportal (WMS layer: protectedarea_p = points)						x					
River Basin Districts - boundaries of the river basin district and sub-units within the national borders - Sava River Basin Management (RBM) Plan from Sava GIS geoportal (WMS layer: rbd_a = polygons)				x							
River Basin - Sava River Basin Management (RBM) Plan from Sava GIS geoportal (WMS layer: riverbasin = polygons)				x							
Surface water network in the Sava River Basin from Sava GIS geoportal (WMS layer: rivers = lines)				x							
River water body boundaries from Sava GIS geoportal (WMS layer: rwb_boundary = points)				x							
SavaHIS Real-Time Hydrological Stations										x	
SavaHIS Real-Time Meteorological Stations										x	

	CITYgml					Protected Site	Natural Risk Zone				Others
Dataset source	**Building**	**Transp.**	**Vegetation**	**Water Body**	**Land Use**	**Protected Site**	**Hazard Area**	**Risk Zone**	**Exposed Element**	**Observed Element**	**Base Map**
SubBasin from Sava River Basin Management (WMS layer: subbasin = polygons)				x							
Waterways from Sava River Basin Management (WMS layer: waterway)				x							
Past flood events in Upper Sava River Basin and Kupa River - October/November 1998 (polygons)										x	
Past flood events in Upper Sava River Basin - September 2007 (points)										x	
Past flood events in Middle Sava River Basin - May/June 2010 (polygons)										x	
Past flood events in Middle Sava River Basin - September 2010 (polygons)										x	
Past flood events in Middle Sava River Basin - September 2010 (points)										x	
Past flood events in Middle and Lower Sava River Basin (Una, Vrbs, Bosna, Drina, Bosut, Kolubara) - May 2014 (polygons)										x	
Copernicus Emergency Management Service (EMS) - Flood Rapid Mapping Activations in Sava River Basin							x				

Table 75 – Association of dataset sources with entities

10.5 Appendix V – Database Scripts

This section includes the database scripts that implement the new table structures (CREATE TABLE) and table modifications (ALTER TABLE).

10.5.1 New data structures (new tables/entities)

10.5.1.1 *Users (tc02_user)*

```
-- Table: shelter.tc02_users
-- DROP TABLE shelter.tc02_users;

CREATE TABLE shelter.tc02_users
(
  userid character varying(20) NOT NULL,
  username character varying(100),
  password character varying(20),
  userprofile integer,
  name character varying(100),
  surname character varying(100),
  email character varying(100),
  active boolean,
  lastaccess timestamp without time zone,
  totalaccessnr integer,
  language character varying(5),
  CONSTRAINT pkey_userid PRIMARY KEY (userID),
  CONSTRAINT fk_userprofileid FOREIGN KEY (userprofile)
      REFERENCES shelter.tc01_userprofile (userprofileid) MATCH SIMPLE
      ON UPDATE NO ACTION ON DELETE NO ACTION
)
WITH (
  OIDS=FALSE
);
ALTER TABLE shelter.tc02_users
  OWNER TO postgres;
```

10.5.1.2 *cityobject_in_protectedSite*

```
--
-- Name: cityobject_in_protectedsite ; Type: TABLE; Schema: shelter;
--
CREATE TABLE shelter.cityobject_in_protectedSite (
      cityobjectid integer ,
      inspireid text,
      auxInfo     text,
      PRIMARY KEY (cityobjectid, inspireid)
);
```

10.5.1.3 *cityobject_in_HA_RZ*

```
--
-- Name: cityobject_in_HA_RZ Type: TABLE; Schema: shelter;
-- Relationship between CityObject-HazarArea_RiskZone
--
CREATE TABLE shelter." cityobject_in_HA_RZ"
(
   idrescultha character varying(20),
```

```
   idrescultrz character varying(20),
   CONSTRAINT "pk_cityobject_in_HA_RZ" PRIMARY KEY (idrescultha, idrescultrz)
)
WITH (
  OIDS = FALSE
)
;
```

10.5.1.4 *RainfallHazardParameters*

```
--
-- Name: RainfallHazardParameters Type: TABLE; Schema: shelter;
-- Relationship between CityObject-HazarArea_RiskZone
-- Table: shelter.nzrainfallhazardparameters
-- DROP TABLE shelter.nzrainfallhazardparameters;

CREATE TABLE shelter.nzrainfallhazardparameters(
  referredabstracthazardarea character(1),
  idrainfallhp integer NOT NULL,
  "dailyMaximumPrecipitation" double precision,
  "hourlyMaximumPrecipitation" double precision,
  "distributionRainfallIntensity" double precision,
  "torrentialityIndex" integer,
  rfhp_serial integer,
  CONSTRAINT pk_rainfallhp PRIMARY KEY (idrainfallhp)
)
WITH (
  OIDS=FALSE
);
ALTER TABLE shelter.nzrainfallhazardparameters
  OWNER TO postgres;
```

10.5.1.5 *TemperatureHazardParameters (Nztemperaturehazardparameters)*

```
-- Table: shelter.nztemperaturehazardparameters
-- DROP TABLE shelter.nztemperaturehazardparameters;

CREATE TABLE shelter.nztemperaturehazardparameters(
  idtemphp integer NOT NULL,
  "annualMeanTemperature" double precision,
  "meanDiurnalRange" double precision,
  "maxTemperatureWarmestMonth" double precision,
  "minTemperatureColdestMonth" double precision,
  "temperatureAnnualRange" double precision,
  "meanTemperatureWettestQuarter" double precision,
  "meanTemperatureDriestQuarter" double precision,
  "meanTemperatureWarmestQuarter" double precision,
  "meanTemperatureColdestQuarter" double precision,
  "dailyMeanTemperature" double precision,
  "thermalShock" double precision,
  "daysTmin0Tmax0Number" integer,
  "landSurfaceTemperature" double precision,
  "isoThermality" double precision,
  "temperatureSeasonality" double precision,
  "referedAbstractHazardArea" character varying(20),
  CONSTRAINT pkey_nzthp PRIMARY KEY (idtemphp),
  CONSTRAINT           fk_referedbastracthazararea           FOREIGN           KEY
("referecAbstractHazardArea")
      REFERENCES shelter.nzabstracthazardarea (idrescultaha) MATCH SIMPLE
```

```
      ON UPDATE NO ACTION ON DELETE NO ACTION
)
WITH (
  OIDS=FALSE
);
ALTER TABLE shelter.nztemperaturehazardparameters
  OWNER TO postgres;
```

10.5.1.6 *HeatwaveHazardParameters (nzHeatwaveHazardParameters new table)*

```
-- Table: shelter.nzheatwavehazardparameters
-- DROP TABLE shelter.nzheatwavehazardparameters;

CREATE TABLE shelter.nzheatwavehazardparameters(
  "Idheatwavehp" integer NOT NULL,
  "dailySunHours" integer,
  "heatWaveIndicator" double precision,
  "Idrescultaha" character varying(20),
  CONSTRAINT pkey_heatwavehp PRIMARY KEY ("Idheatwavehp"),
  CONSTRAINT "referedAbstractHazardArea" FOREIGN KEY ("Idrescultaha")
      REFERENCES shelter.nzabstracthazardarea (idrescultaha) MATCH SIMPLE
      ON UPDATE NO ACTION ON DELETE NO ACTION
)
WITH (
  OIDS=FALSE
);
ALTER TABLE shelter.nzheatwavehazardparameters
  OWNER TO postgres;
```

10.5.1.7 *StormHazardParameters (nzStormHazardParameters new table)*

```
-- Table: shelter.nzstormhazardparameters
-- DROP TABLE shelter.nzstormhazardparameters;

CREATE TABLE shelter.nzstormhazardparameters(
  "Idstormhp" integer NOT NULL,
  "windSpeed" double precision,
  "airPressure" double precision,
  "capeIndex" double precision,
  "liftedIndex" integer,
  "heavyRain" double precision,
  "windPressure" double precision,
  "gustStrength" integer,
  "stormDuration" integer,
  "stormsPerMonthNumber" integer,
  "windSpeedYearVariance" integer,
  "gustSpeedsYearVariance" integer,
  "referedAbstractHazardArea" character varying(20),
  CONSTRAINT pkey_stormhp PRIMARY KEY ("Idstormhp"),
  CONSTRAINT fk_ahp FOREIGN KEY ("referedAbstractHazardArea")
      REFERENCES shelter.nzabstracthazardarea (idrescultaha) MATCH SIMPLE
      ON UPDATE NO ACTION ON DELETE NO ACTION
)
WITH (
  OIDS=FALSE
);
ALTER TABLE shelter.nzstormhazardparameters
  OWNER TO postgres;
```

10.5.1.8 *WindHazardParameters (nzwindhazardparameters new table)*

```
-- Table: shelter.nzwindhazardparameters
-- DROP TABLE shelter.nzwindhazardparameters;

CREATE TABLE shelter.nzwindhazardparameters
(
  "Idwindhp" integer NOT NULL,
  "mainWindDirectionsColdest" text,
  "mainWindDirectionsWettest" text,
  "referedAbstractHazardArea" character varying(20),
  CONSTRAINT pkey_windhp PRIMARY KEY ("Idwindhp"),
  CONSTRAINT fk_aha FOREIGN KEY ("referedAbstractHazardArea")
      REFERENCES shelter.nzabstracthazardarea (idrescultaha) MATCH SIMPLE
      ON UPDATE NO ACTION ON DELETE NO ACTION
)
WITH (
  OIDS=FALSE
);
ALTER TABLE shelter.nzwindhazardparameters
  OWNER TO postgres;
```

10.5.1.9 *SubsidenceHazardParameters (nzsubsidencehazardparameters new table)*

```
-- Table: shelter.nzsubsidencehazardparameters
-- DROP TABLE shelter.nzsubsidencehazardparameters;

CREATE TABLE shelter.nzsubsidencehazardparameters
(
  "Idsubsidencehp" integer NOT NULL,
  "subsidenceRate" double precision,
  "deflectionRatio" text,
  "referedAbstractHazardArea" character varying(20),
  CONSTRAINT pkey_subsidencehp PRIMARY KEY ("Idsubsidencehp"),
  CONSTRAINT fk_aha FOREIGN KEY ("referedAbstractHazardArea")
      REFERENCES shelter.nzabstracthazardarea (idrescultaha) MATCH SIMPLE
      ON UPDATE NO ACTION ON DELETE NO ACTION
)
WITH (
  OIDS=FALSE
);
ALTER TABLE shelter.nzsubsidencehazardparameters
  OWNER TO postgres;
```

10.5.1.10 *HistoricArea (new entity)*

```
-- Table: shelter.historicarea
DROP TABLE shelter.historicarea;

CREATE TABLE shelter.historicarea
(
  idhistoricarea serial NOT NULL,
  cityobjectgroupid integer,
  populationdensity double precision,
  streetnoiseacousticpollution double precision,
  constructionmaterial double precision,
  numberofparticipantstrainingcourses double precision,
  populationaccessriskinformationpercentage double precision,
  populationbelow65percentage double precision,
  population17orbelowpercentage double precision,
```

```
populationwithoutdisabilitypercentage double precision,
femalepercentage double precision,
onepersonhouseholdpercentage double precision,
servicecentresdistance double precision,
firebrigadesdistance double precision,
populationwithtelephonepercentage double precision,
populationwithinternetservicepercentage double precision,
percapitaincome double precision,
populationaboveppovertylinepercentage double precision,
infrastructurehousinginsurancepercentage double precision,
psychosocialsupportfacilitiesper10kpersons double precision,
hospitalbedsper10kpersons double precision,
hotelsmotelsper10kpersons double precision,
residentialbuildingspercentage double precision,
unemploymentrate double precision,
ginicoefficient double precision,
largetosmallbusinessesratio double precision,
firmsimplementingriskstandardspercentage double precision,
netinternationalmigration double precision,
civicorganizationsper10kpersons double precision,
redcrossvolunteersper10kpersons double precision,
volunteerorganizationsbudget double precision,
registeredvolunteersnumber integer,
averagepercapitamitigationprojects integer,
populationcoveredmitigationplanpercentage double precision,
streetpattern text,
riskperception text,
peopleaccessemergencymedicalcare integer,
coordinationothergovernmentbodies integer,
mechanismscommunitiesengagegovernment integer,
traditionalculturepresence text,
measuresreducedamagenumber integer,
predictioncapacity integer,
availableequipmentlimitdamage integer,
onefloorhousesnumber integer,
mediaobservationpublicpressure integer,
economicresilienceindex integer,
gdi integer,
hazardmonitoringforecasting integer,
hazardassessmentmapping integer,
vulnerabilityriskassessmentmapping integer,
publicinformationcommunityparticipation integer,
landuseurbanplanningextension integer,
reinforcementretrofittingassets integer,
organizationcoordinationemergencyoperations integer,
haswarningsystems integer,
equipmenttoolsinfrastructuresupply integer,
interinstitutionalresponsecapability integer,
rehabilitationreconstructionplanning integer,
decentralizedorganizationalunits integer,
resourcesinstitutionalstrengthening integer,
allocationmobilizationbudget integer,
socialsafetynetsfundsexistence integer,
insurancelosstransferstrategies integer,
missionsnumberstormevents integer,
newbuildingsrate double precision,
nonnativefaunalspeciesnumber integer,
speciesdiversityshannondiversityindex integer,
speciesnumbershannonevennessindex integer,
nativepollinatorspeciesarea double precision,
naturalareasproportion double precision,
```

```
priorityspeciesconservationnumber integer,
nativespeciesnumber integer,
nativebirdspeciesnumber integer,
nativespeciescompbaselinechange double precision,
professionalschpostdisasterrecoverynumber integer,
infrastructuresbackupsystemspercentage double precision,
dailytransportusers integer,
vegetationwetlandsarea double precision,
existencemechanismsintegrationlocalknowledge boolean,
existenceplatforminformationsharing boolean,
newbusinessesregisterednumber integer,
renewableenergypercentage double precision,
siteaccessibility text,
agriculturaloccupationrate double precision,
cattleheadsnumber integer,
sheepheadsnumber integer,
goatheadsnumber integer,
poultryheadsnumber integer,
swineheadsnumber integer,
equineheadsnumber integer,
landscapeheterogeneity integer,
betadiversity integer,
functionaldiversity double precision,
totalpopulation integer,
illiteratepopulation integer,
habitatsuitabilityindex integer,
carbonsequesteredcarbonsequestrationrate double precision,
buildingalignmentrate double precision,
drainagesystempercentage double precision,
basementfloodproneareapercentage double precision,
opengroundfloorabovemaxlevelpercentage double precision,
structuralmaterialswaterresistantpercentage double precision,
facadematerialswaterresistantpercentage double precision,
bluegreenroofsnumber integer,
hostingcollectionsstoragecapacitynumber integer,
enforcementsafetyconstructioncodesupdating integer,
buildingtransformation text,
buildingwallsrotations integer,
hazardresistantstandardspercentage double precision,
dailyhillsideroofs double precision,
dailyhillsidefacades double precision,
skyviewfactor double precision,
vibrationschtraffic double precision,
areashareprotectedlands double precision,
cnhintangiblevalue text,
shareecologicalcorridors double precision,
greeninfrastructurestructuralconnectivity double precision,
greeninfrastructurefunctionalconnectivity double precision,
nonnativefloraspeciesnumber integer,
veterantreesnumber integer,
deadwoodquantity integer,
habitatsrestoredarea double precision,
habitatfunctionalcomposition integer,
shannonindex integer,
urbanfreenspacearea double precision,
plantrootdecayrate integer,
collapsedheavydamagedbuildingsnumber integer,
affectedcriticalfacilities integer,
stagedamagecurve integer,
recoveryrate integer,
slightmoderatedamagedbuildings integer,
```

```
  windthrow double precision,
  losshabitatbiodiversity text,
  durationinfrastructureoutage integer,
  moderatedamagedmovableheritage integer,
  biologicalcolonization text,
  burnseverityindex text,
  landtakearea double precision,
  buildingsnumber integer,
  criticalfacilitiesnumber integer,
  productiveactivitiesnumber integer,
  majoraccidentriskfactories integer,
  managementriverbasinsenvironmentalprotection integer,
  vegetationrecoveryrate double precision,
  primaryproductivity double precision,
  climatetype text,
  humansettlementsize text,
  urbanhascale text,
  degreeofurbanization text,
  CONSTRAINT pkey_historicarea PRIMARY KEY (idhistoricarea),
  CONSTRAINT fk_cityobjectgroupid FOREIGN KEY (cityobjectgroupid)
      REFERENCES shelter.cityobjectgroup (id) MATCH SIMPLE
      ON UPDATE NO ACTION ON DELETE NO ACTION
)
WITH (
  OIDS=FALSE
);
ALTER TABLE shelter.historicarea
  OWNER TO postgres;
```

10.5.2 Structures modification (alter table)

10.5.2.1 *NzriskZone (new attributes)*

```
--
-- Name: nzriskzone foreign key - Type: CONSTRAINT; Schema: shelter; Owner: -
--
ALTER TABLE shelter.nzriskzone
  ADD COLUMN idrescultha character varying(20);
ALTER TABLE shelter.nzriskzone
  ADD CONSTRAINT fk_idrescultha FOREIGN KEY (idrescultha) REFERENCES
shelter.nzhazardarea (idrescultha) ON UPDATE CASCADE ON DELETE CASCADE;
```

10.5.2.2 *ExposedElement (new attributes)*

```
--
-- Name: nzexposedelement foreign keys - Type: CONSTRAINT; Schema: shelter;
-- Relationship with hazardArea (nzhazardarea) and cityobject_in_HA_RZ
--
ALTER TABLE shelter.nzexposedelement
  ADD COLUMN idrescultha character varying(20);
ALTER TABLE shelter.nzearthquakehazardparameters
  ADD CONSTRAINT fk_idrescultha FOREIGN KEY (idrescultha) REFERENCES
shelter.nzhazardarea (idrescultha) ON UPDATE CASCADE ON DELETE CASCADE;
ALTER TABLE shelter.nzearthquakehazardparameters
  ADD COLUMN cohzrz_idrescultha character varying(20);
ALTER TABLE shelter.nzearthquakehazardparameters
  ADD COLUMN cohzrz_idrescultrz character varying(20);
ALTER TABLE shelter.nzearthquakehazardparameters
```

```
  ADD CONSTRAINT fk_cohzrz FOREIGN KEY (cohzrz_idrescultha, cohzrz_idrescultrz)
REFERENCES shelter."cityobjetc_in_HA_RZ" (idrescultha, idrescultrz) ON UPDATE
CASCADE ON DELETE CASCADE;
```

10.5.2.3 *EarthQuakeHazardParameters (nzearthquakehazardparameters - new attributes)*

```
ALTER TABLE shelter.nzearthquakehazardparameters
  ADD COLUMN pga double precision;
ALTER TABLE shelter.nzearthquakehazardparameters
  ADD COLUMN "levelSeismicHazard" double precision;
ALTER TABLE shelter.nzearthquakehazardparameters
  ADD COLUMN earthquakeintensity text;
```

10.5.2.4 *FloodHazardParameters (nzfloodhazardparameters – new attributes)*

```
ALTER TABLE shelter.nzfloodhazardparameters
      ADD COLUMN area double precision;
ALTER TABLE shelter.nzfloodhazardparameters
      ADD COLUMN floodDepth double precision;
ALTER TABLE shelter.nzfloodhazardparameters
      ADD COLUMN waterVelocity double precision;
ALTER TABLE shelter.nzfloodhazardparameters
      ADD COLUMN combFloodDepthWaterVelocity double precision;
ALTER TABLE shelter.nzfloodhazardparameters
      ADD COLUMN floodFrecuency integer;
```

10.5.2.5 *FireHazardParameters (nzfirehazardparameters –new attributes)*

```
ALTER TABLE shelter. nzfirehazardparameters
      ADD COLUMN fireWeatherIndex integer;
ALTER TABLE shelter. nzfirehazardparameters
      ADD COLUMN palmerDroughtSeverityIndex integer;
ALTER TABLE shelter. nzfirehazardparameters
      ADD COLUMN timeSinceFire integer;
ALTER TABLE shelter. nzfirehazardparameters
      ADD COLUMN fireRecurrence integer;
```

10.5.2.6 *RiskZone (new attributes)*

```
-- Table: shelter.nzriskzone
DROP TABLE shelter.nzriskzone;
CREATE TABLE shelter.nzriskzone(
  inspireid text,
  begin_lifespan_version date,
  end_lifespan_version date,
  idrescultarz character(20) NOT NULL,
  arz_serial integer NOT NULL,
  sourceofrisk shelter.naturalhazardclassification,
  validityperiod character varying,
  fromhazard character(20),
  geometry geometry,
  levelofrisk double precision,
  idrescultrz character(20) NOT NULL,
  rz_serial            integer            NOT            NULL            DEFAULT
nextval('shelter.risk_zone_rz_serial_seq'::regclass),
  idrescultha character varying(20),
  "fatalitiesNumber" integer,
```

```
  "nonFatalInjuriesNumber" integer,
  "comparedMortality" integer,
  "increasedHospitalisation" integer,
  "staysInHospitals" integer,
  "reducedWorkingCapacity" integer,
  "inventoryOfHazardEvents" integer,
  "reportedInsuranceClaims" integer,
  "operatingHoursStormEvents" integer,
  "peopleDisplacedNumber" integer,
  "collapsedHeavyDamagedBuildingsNumber" integer,
  "affectedCriticalFacilities" integer,
  "stageDamageCurve" integer,
  "recoveryRate" integer,
  "slightModerateDamagedBuildings" integer,
  windthrow double precision,
  "lossHabitatBiodiversity" text,
  "durationInfrastructureOutage" integer,
  "moderateDamagedMovableHeritage" integer,
  "biologicalColonization" text,
  "burnSeverityIndex" text,
  repairability double precision,
  "economicLossCHDamagedDestroyed" integer,
  "affectedIntangibleCH" text,
  "heavyDamagedMovableHeritage" integer,
  "lossAncestralNH" text,
  CONSTRAINT risk_zone_pkey PRIMARY KEY (idrescultrz),
  CONSTRAINT fk_idrescultha FOREIGN KEY (idrescultha)
      REFERENCES shelter.nzhazardarea (idrescultha) MATCH SIMPLE
      ON UPDATE CASCADE ON DELETE CASCADE
)
INHERITS (shelter.nzabstractriskzone)
WITH (
  OIDS=FALSE
);
ALTER TABLE shelter.nzriskzone
  OWNER TO postgres;
-- Trigger: trigger_arz2 on shelter.nzriskzone
-- DROP TRIGGER trigger_arz2 ON shelter.nzriskzone;
CREATE TRIGGER trigger_arz2
  BEFORE INSERT OR UPDATE OF idrescultarz
  ON shelter.nzriskzone
  FOR EACH ROW
  EXECUTE PROCEDURE shelter.trigger_arz2();
-- Trigger: trigger_rz on shelter.nzriskzone
-- DROP TRIGGER trigger_rz ON shelter.nzriskzone;
CREATE TRIGGER trigger_rz
  BEFORE INSERT OR UPDATE OF idrescultrz
  ON shelter.nzriskzone
  FOR EACH ROW
  EXECUTE PROCEDURE shelter.trigger_rz();
```

10.5.3 Appendix VII – Complete DB Creation Scripts

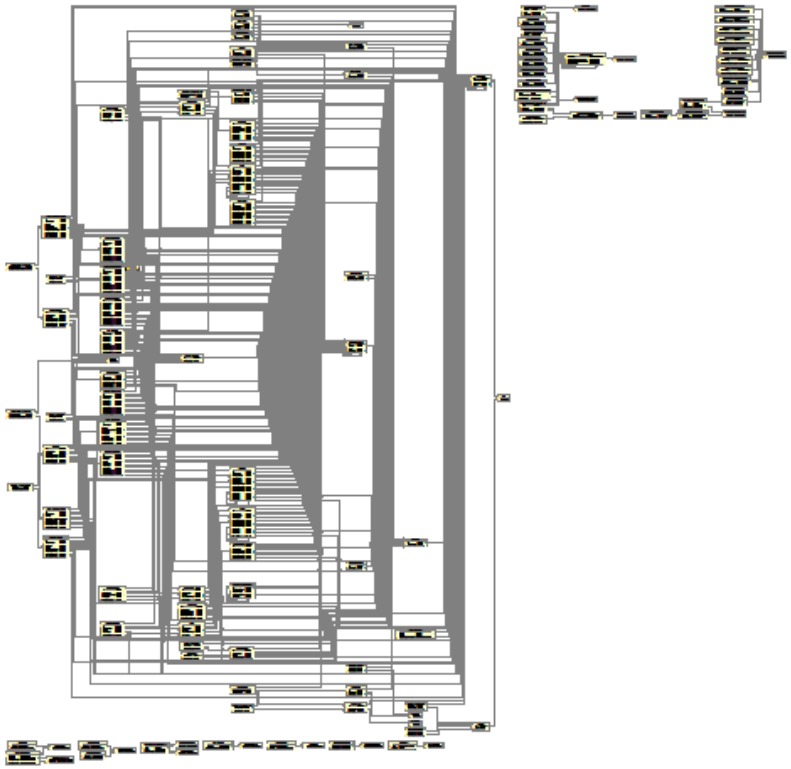
In the next attached file you can find the complete DB Creation Scripts. Please double-click to open:

shelterdb201211.backup_.sql

NOTE: If this document is in PDF version, scripts will be shown at the end of the document.

10.6 Appendix VI – Complete E-R Diagram

Complete Data model Diagram is included in the attached document: "*SHELTER DATA MODEL.PDF*". Please double-click on the image to open it:



NOTE: If this document is in PDF version, the Data Model will be shown on the next page.