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Design and Implementation of a Data Model and Data Input Module for a Multi Hazard Risk Assessment Spatial Support Decision System

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The goal of the CHANGES Spatial Decision Support System is to support end-users in making decisions related to risk reduction measures for areas at risk from multiple hydro-meteorological hazards. The crucial parts in the design of the system are the user requirements, the data model, the data storage and management, the storage of all the hazard-related data objects and maintaining the relationships between these objects in the system.

The challenge here is to design a data model and to implement a data input module that are able to handle hazard intensity and spatial probability data (rasters) and element at risk (buildings, land parcels, linear features etc.), administrative units, risk-reduction measures (vectors), have sufficient flexibility to support adding user-defined hazard types (floods, snow avalanches, debris flows, etc.), hazard intensity types, intensity maps of different return periods, economic and population vulnerability information dependent on the hazard type and the type of the element at risk, in the form of vulnerability curves, user-defined vulnerability types and subtypes and relate these with structures for loss, risk, cost-benefit analysis (CBA) and multi-criteria evaluation (MCE). Having all these structures in one model enables further computations concerning loss, risk, CBA and MCE, analysis of the original uploaded maps and visualization of the end results. On top of that we offer the possibility to handle data from different study areas.

Comparable systems are able to store or process only parts of the data. In our case we try to embed all parts in one system, starting from the data model structures for storing user uploaded attribute and spatial data, structures for storing the calculated losses, analysis records from the risk, CBA and MCE and visualize the results.

The implementation of the data model and data input module are carried out entirely with an open source technologies starting from the database management system (PostgreSQL) containing the spatial extension PostGIS, Python for the server side scripting, and JavaScript libraries (ExtJS) used for the web-based client-side user-interface. The design of the data model was based on the pre-existing demo data set we had (Italian area - Nocera).

In order to be able to input and store all spatial layers, together with their attribute data from multiple study areas, we developed a mechanism which allows this data to coexist in one database. (See Figure 1).
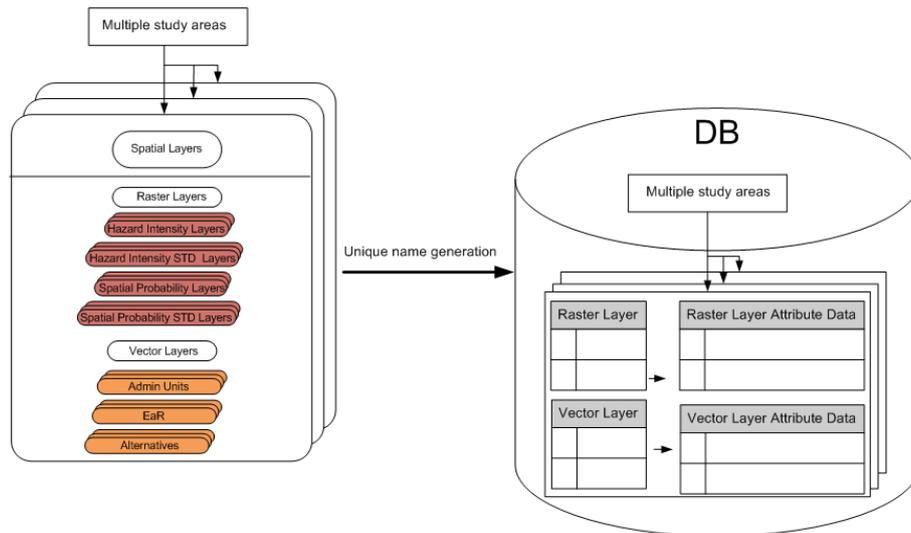
Figure 1: Storage of spatial and attribute data

Where it can be seen that all the data inside our system belong to a particular study area. Parallel to the data model and the database, we defined the flow of the input module (which exploits the database structure), starting from definition of the study area and going towards uploading the current situation spatial layers for a specific study area. This is visible from the figure below:
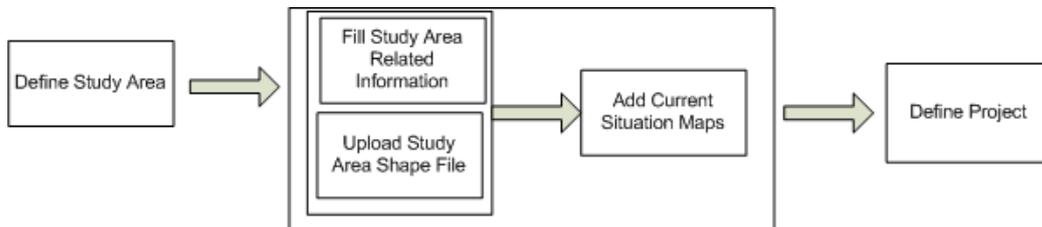

Figure 2: General flow for uploading current situation maps under a specific study area
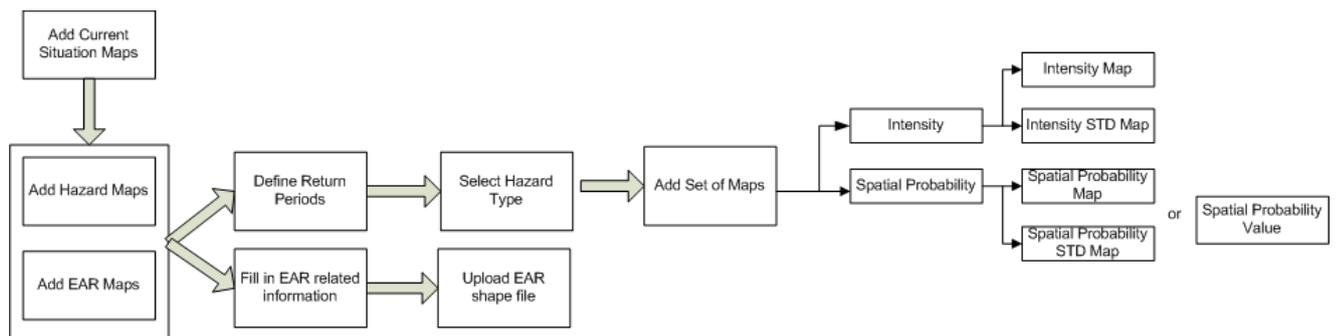

Figure 3: More detailed flow for entering current situation maps under a specific study area

As a part of the data module is the management of a combination of different scenarios (e.g. related to climate change, land use change or population change) and alternatives (possible risk-reduction measures), which we refer to it as the dashboard (see Figure 5) in our system. We have included data-structures in the data model for saving the calculated economic or population loss or saving the exposure per element at risk together with aggregation of the loss and exposure values which we use for producing the risk maps. The selection of different combinations (settings) results in producing different loss and risk maps which are organized in different containers, which we call projects (Figure 4).
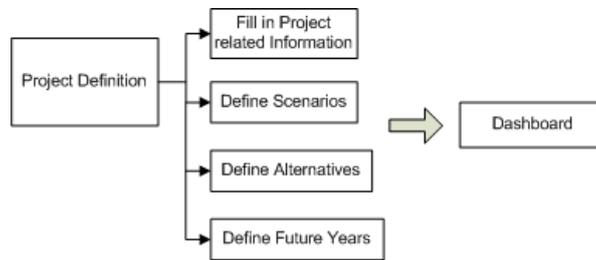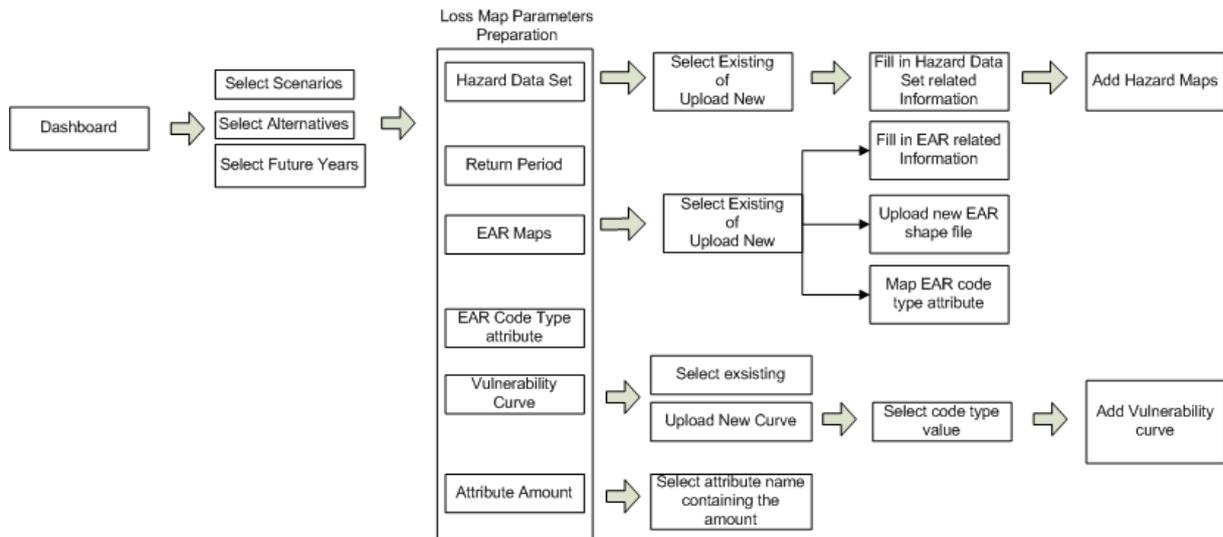
Figure 4: Project definition

Figure 5: Uploading maps under specific combination of alternatives, scenarios and future years

The risk data is later on used for cost-benefit analysis and multi-criteria evaluation. The data model contains data-structures for both CBA and MCE modules.

Besides having the inbuilt database of vulnerability curves, the users have the options of uploading their own curves. The flow of this sub module is presented on the figure below:
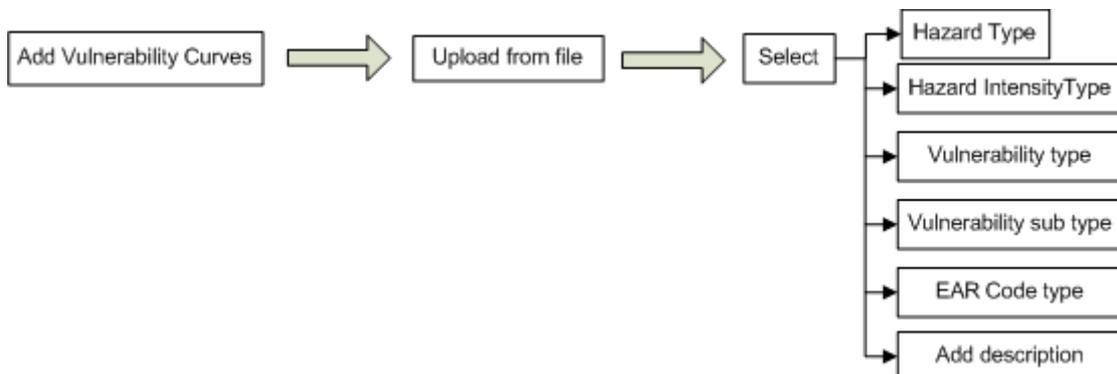

Figure 6: Uploading vulnerability curves

The eventual system offers the possibility to enter your own multiple natural hazard data via a web-interface, analyse the data, and visualize the results, doing a costs-benefit analysis or multi-criteria analysis for the purpose of supporting decisions regarding natural hazard management.

Having a carefully designed data model plays a crucial role in the development of the whole system for rapid development, keeping the data consistent, and in the end, support the end-user in making good decisions in risk-reduction measures related to multiple natural hazards.

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