A WEBGIS TOOL FOR SEISMIC HAZARD SCENARIOS AND RISK ANALYSIS

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Abstract

The WebGis development represents a natural answer to the growing requests for dissemination and use of geographical information data. WebGis originates from a combination of web technology and the Geographical Information System, which is a recognised technology that is mainly composed of data handling tools for storage, recovery, management and analysis of spatial data. Here, we illustrate two examples of seismic hazard and risk analysis through the WebGis system in terms of architecture and content. The first presents ground shaking scenarios associated with the repetition of the earthquake that struck the Lake of Garda area (northern Italy) in 2004. The second shows data and results of a more extensive analysis of seismic risk in the western part of the Liguria region (north-western Italy) for residential buildings, strategic structures and historic architecture. The adoption of a freeware application (ALOV Map) assures easy exportability of the WebGis structures for projects dealing with natural hazard evaluation.

Keywords

WebGis, Alov, earthquake scenario, seismic hazard, risk assessment .

Introduction

Earthquake hazard and risk investigations have become more and more complex, and they have to handle large quantities of spatial data as well as a large amounts of the subsequent analytical results. Indeed, the generation of plausible ground shaking scenarios has to be controlled in terms of variability and uncertainty, and the subsequent risk analysis has to consider a huge quantity of exposed elements, such as blocks of buildings, strategic lifelines, historic buildings and complex historic centres, which can often be difficult to classify.

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Geographical Information System (GIS) technology is an essential tool for it to be possible to cope with the complexity of these analyses and to assure the correct monitoring of the results. In general, GIS associates spatial georeferenced data with non-spatial attribute data, and makes it possible to perform spatial searches and overlays. Besides the important ability to store and harmonise different spatial data, GIS has the capability of solving complex geographical problems and of generating new and useful information by the user-defined combination of several existing layers.

The incredible developments of GIS technology in recent years and the increasing availability of valuable and organised geographical data (worldwide spatial data infrastructure) have modified the traditional way of using GIS as a database-mapping spatial analytical tool, and the concept of "GIS as a media" [1] has been introduced, which can thus focus on the communication of geographical information to a larger audience. By integrating GIS technology with the Internet (and especially the World Wide Web), the resulting WebGis system spreads and simplifies the exchange of geographical data, provides specific structured information and empowers users to access GIS applications without using any specific software [2].

As specific examples: a recent powerful WebGis application to hazard dissemination data is illustrated in Martinelli and Meletti [3]; a complex software architecture that assembles geological and seismological data is presented in Qu et al. [4]; and historic seismic data that have made use of simple WebGis software are shown in Hara et al. [5]. In the present study, some examples of WebGis publications that deal with hazard and seismic risk assessment are presented, as elaborated in two areas of northern Italy. These WebGis tools were developed during National projects that were funded by the Italian Civil Protection (DPC) from 2000 to 2002 and from 2004 to 2006. The adoption of WebGis solutions in interdisciplinary nationwide projects has enabled the circulation of the data and results, opportunely organised and homogenised, among all of the partners of the projects. This also represents the final product for transfer to the Civil Protection Department, such as to be of immediate use for territorial analysis for the support of decision makers. Moreover, WebGis allows users to access large amounts of data through the Internet. In this way, the divulgation of results also includes the people exposed to risk, and not only the technical scientific community or the local administrators, increasing the natural hazard awareness of the relevant population.

Implementing seismic risk analysis on WebGis

Different factors need to be combined for the assessment of a deterministic seismic risk scenario: overall damage scenarios depend on the level of ground shaking (the hazard factor) and on the type and quantity of exposed elements and their intrinsic vulnerability. Are all of these factors reproducible with GIS technology? What level of detail should be used, in line with the requirements of potential users? Which user-friendly software tools allow the managing of such complex seismic risk data?

A synthetic scheme of the comprehensive framework for seismic risk assessment is shown in Figure 1, where the most common input data are illustrated, together with the hazard, vulnerability and exposure factors [6]. It is of note that not all of the information can be directly converted into GIS layers, and not all hazard, vulnerability and exposure factors can be represented with the same level of detail. For instance, most of the input data for hazard assessment can be reproduced, such as historic information (macroseismic observations or iconographic materials), extended fault and epicentre locations, geological maps, boreholes, geotechnical properties and profiles. Also, different shaking scenarios can be easily presented considering local soil amplifications, which can be calculated for different shaking parameters (intensity, peak and spectra values of acceleration, velocity and displacement). Finally, further amplification effects that might be induced by liquefaction or morphological phenomena can be accounted for.

The above input data and shaking maps are illustrated in both of the following examples: the case of Garda illustrates only a deterministic hazard assessment, while in the case of western Liguria, exposure elements, vulnerability and damage are also considered. For the latter, vulnerability and damage factors are shown separately, with the aim of disseminating the results in a simple and immediate way, although this schematic representation is not always easy to perform with GIS technology. The exposure factors and their features are, however, usually available and easily reproducible with GIS technology.

For instance, for residential buildings, their location and all of their typological parameters (e.g. materials, number of floors, foundation types, roof and age) can be directly mapped, but their vulnerability index can be estimated only after convolution of the typological parameters inside well calibrated models. The same considerations can be carried out for the risk assessment phase: the damage probability matrix (DPM), limit state and fragility curve methods combine vulnerability and hazard factors to produce damage maps, while the losses and victim scenarios require further models about the exposure values.

The final part of the scheme in Figure 1 illustrates the complexities in performing a seismic risk assessment, with the strong connections among the exposure, vulnerability and damage factors.

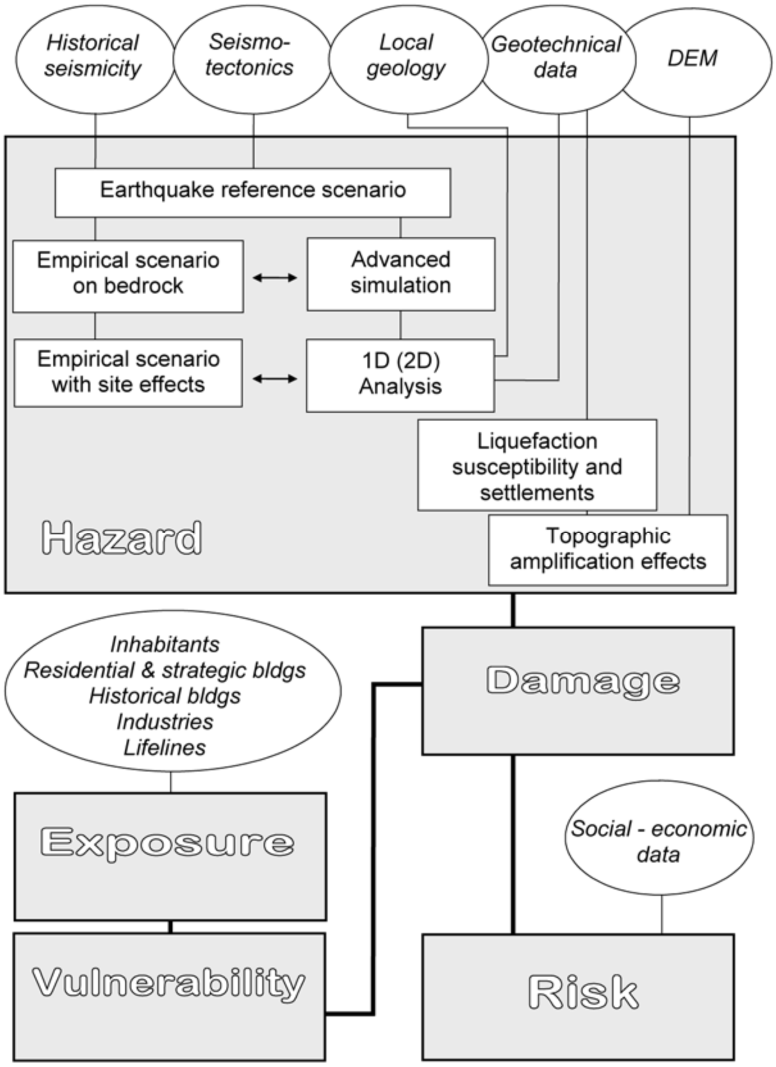

Figure 1 – Scheme of the seismic risk assessment method, illustrating the implementation of the WebGis applications for the Lake of Garda and western Liguria cases.

Seismic hazard management in the Lake of Garda area

The western side of the Lake of Garda area (central-northern Italy) was struck by a moderate magnitude earthquake (5.0 M_W) on 24 November, 2004, so this was chosen as a test area where the generation of deterministic seismic shaking scenarios could be calibrated (S3 Project: "Scenari di scuotimento e di danno atteso in aree di interesse prioritario e/o strategico", http://esse3.mi.ingv.it/garda_alov/Progetto_Garda.htm). Different scale resolution data were collected, and the analysis of the ground shaking was performed at a sub-regional scale (the Brescia provincial territory) and validated on the basis of the macroseismic data. Detailed observations on soil amplification effects were collected on a municipal scale, for the villages of the Val Sabbia zone and the coastal municipalities of Gardone Riviera and Toscolano Maderno. To cover such a large spread of resolution, the geological data were stored at scales of 1:500000, 1:100000 and 1:10000.

Ground shaking maps were produced using isotropic attenuation relationships for the estimation of the peak and spectral ground shaking values. The GR91 attenuation relationship [7] was based on the radial distance from the earthquake source and provides Mercalli-Cancani-Sieberg (MCS) intensity values calibrated for Italian observations, while the FC06 attenuation relationship [8] was constrained on more recent observations in the Mediterranean area, which are valid in the interval of 1.5 km $\leq r \leq$ 71.0 km, and 3.8 $\leq M_W \leq$ 7.4. The SP96 attenuation relationship [9] provided both velocity response spectral (SV) ordinates and ground motion values in terms of maximum velocity (PGV) and maximum acceleration (PGA), in the 0-100 km distance range and the 4.6-6.8 M_S magnitude range.

These empirical scenarios were compared with those generated by a high frequency (0.7-30.0 Hz) simulation technique, according to the deterministic stochastic method (DSM; [10]). This method allows the generation of ground motion due to an extended fault using the isochron theory [11, 12] to generalise the point-source stochastic method of Boore [13]. The structure of the collected and generated data is illustrated in Table 1: most of the basic data are vectorial cover, while the ground shaking scenarios produced are grid data.

The seismic analysis of the Lake of Garda area was carried out by GIS (ArcView and ArcGis) and are published on: http://esse3.mi.ingv.it/garda_alov/Progetto_Garda.htm. Some administrative and geographical data are from the public domain, and most of these were provided by the Regione Lombardia administration. The ground shaking scenarios generated are freely available too, with the agreement of the DPC. Indeed, at this level of resolution (the municipality scale), there are no particular constraints for data sensitivity because the resolution does not allow the user to locate strategic or private structures with sufficient precision. Different and particular restrictions are necessary in the web publication of such data at higher resolution, as in the case of the building stock of a city, or for a single structure, or even when critical areas are investigated (e.g. strategic buildings, areas under economic investigation).

A detailed description of the earthquake sources, the attenuation relationships used for the empirical scenarios, the calibration of the parameters for the advanced simulations and the predictable scenarios are illustrated in Pessina et al. [14]. The ground shaking scenarios are here presented in terms of intensity maps (Figure 2); they have been evaluated directly from the attenuation relationships, or derived from PGV and PGA calculated using the DSM method. Finally the estimated intensity values have been compared with the observed damage distributions [15].

One of the strongest capabilities of WebGis is the immediate comparison across the ground shaking maps, which is usually carried out by the researchers or reserved for the decision makers. Here, the distribution of macroseismic observations shows strong anisotropy of the ground shaking level in a 10x10 km^2 epicentral area, with higher values (ranging between VI and VII-VIII MCS) in the SW direction, and lesser damage observed (V and V-VI MCS) in sites located at comparable distances, but in the NE and NW directions (see Figure 2). The agreement of the proposed scenarios with the observed data has been explained by a probable amplification effect due to the geometry of the source (as it has very low dip), despite the relatively low magnitude of the event (5.0 M_W). Also, local soil amplification and vulnerability factors were taken into account when the dispersion of the surveyed macroseismic values was examined. Figure 2 shows both the empirical (above) and the advanced (below) scenarios, calculated including the soil characteristics, compared with the distribution of the macroseismic observations.

To analyse local site effects, a microtremor survey was performed along the main valley [16]. The sites of the survey were selected with respect to the morphological and geological information, and the results can be immediately examined in terms of the spectral ratios between the horizontal and vertical components (see Figure 3), which shows moderate amplification effects in a few sites in the valley.

Table 1 – **Structures of the layers for the Garda WebGis.**

General data	PROVINCIA: Administrative provincial boundaries REGIONI: Administrative regional boundaries OROGRAFIA: DEM image LAGO: Lake of Garda EVENTO 2004: Macroseismic observations COMUNI BRESCIA: Administrative municipality boundaries EDIFICI ISTAT 2001: Building data census RETE MOBILE: Position of velocimetric stations EVENTI RETE: Recorded aftershocks STAZIONE ACCELEROMETRICA: Position of accelerometric station CAMPAGNA MISURE 1: Noise measurement survey #1 CAMPAGNA MISURE 2: Noise measurement survey #2 GEOLOGIA 1:500.000: Geotechnical classification
Empirical scen.	EPICENTRO: 2004 epicentre INTENSITÀ FC06: FC06 intensity scenario INTENSITÀ GR91: GR91 intensity scenario FAGLIA: Surface fault projection INTENSITÀ SP96_PGV: Intensity scenario derived from PGV INTENSITÀ SP96_PGA: Intensity scenario derived from PGA
Advanced scen.	FAGLIA: Surface fault projection INTENSITÀ DSM_2004: Best fitting scenario of the 2004 event INTENSITÀ DSM_MAX: Max scenario INTENSITÀ DSM_MEDIO: Average scenario INTENSITÀ DSM_MIN: Min scenario

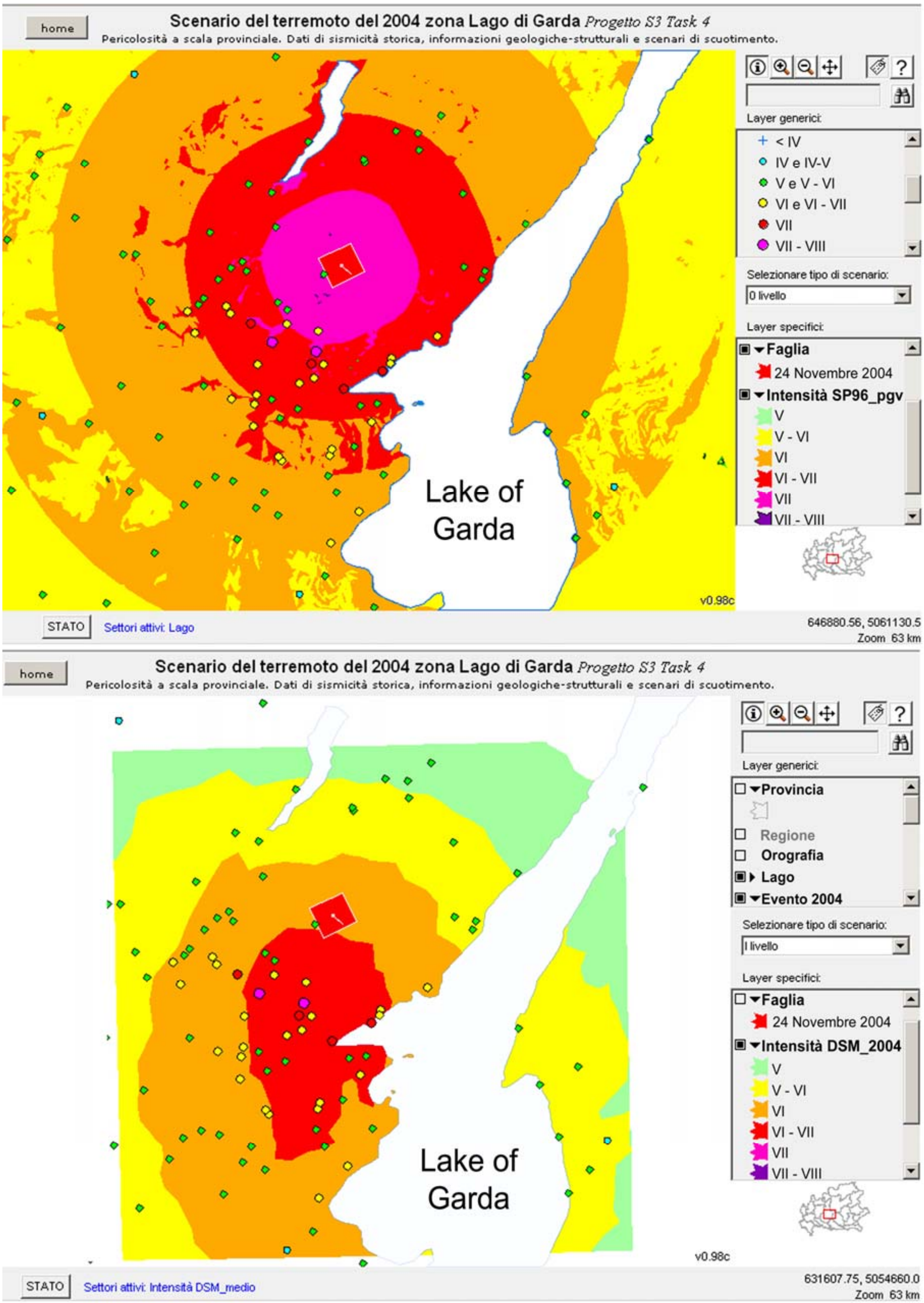

Figure 2 – Intensity scenarios calculated with empirical attenuation relationships (above), and converted from PGV advanced simulation scenarios (below). Macroseismic observations (MCS intensity) in the nearest area of the 2004 Garda event are shown for comparison.

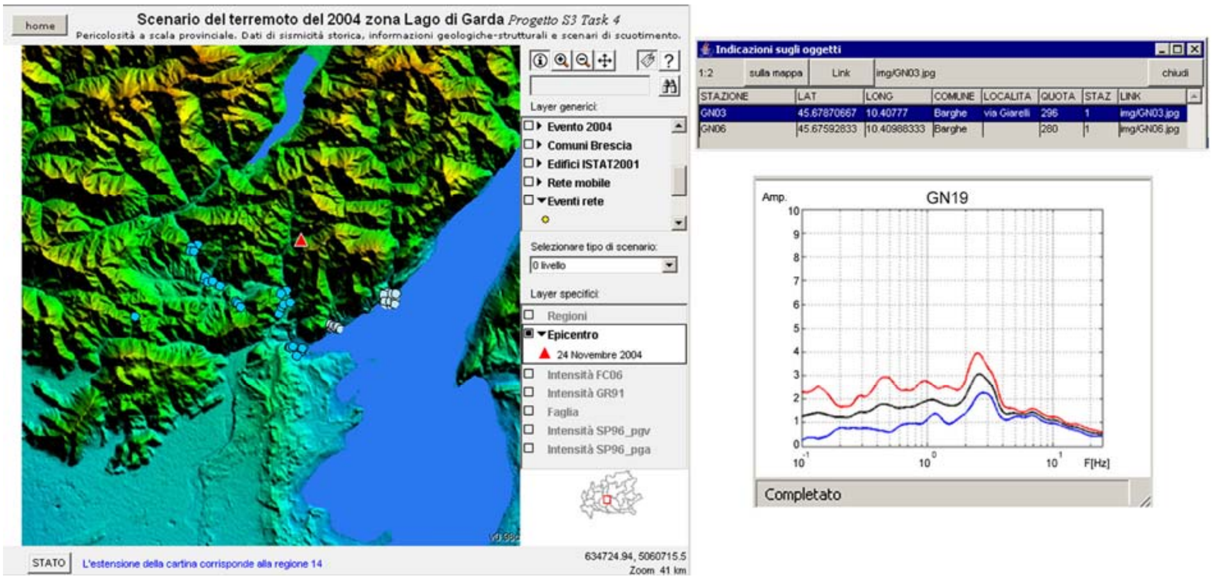

Figure 3 – Left: locations of the noise measurement surveys carried out for the Val Sabbia villages and coastline. Right: example of query on the survey database (top) and soil amplification factors (bottom).

Seismic risk management in western Liguria

The potential of the GIS technology is exploited to a greater extent in risk analysis than in hazard assessment, as the results for the damage depend on the combination of the hazard level with the presence of elements exposed to risk and their seismic vulnerability.

The damage level of buildings is the first element that is considered in a standard risk analysis, as the number of victims (deaths or injuries) depends on the strength of the building to resist the ground shaking level. GIS can profitably analyse the large number of structures that are prone to risk, considering also the local geological, geotechnical and morphological conditions in the damage assessment. Moreover, in an extended analysis, the damage level to a city or to contiguous villages is related to reciprocal relationships (e.g. healthcare supply, road systems and lifelines, energy network) that have strong geographical dependence. At a sub-regional scale, it is necessary to determine the behaviour of the global system during an earthquake and its ability to overcome the crisis in its immediate aftermath. Therefore, the analysis has to be extended from the performance of single building to the behaviour of the economic system, infrastructures, public facilities and society in general. The overall functions of the various systems can interact, increasing or decreasing the risk to people and to artefacts. In this case, the systemic damage due to the bad performance of the built-up environment considered as a whole should also be estimated [17]. For instance, the performance of the healthcare system depends not only on the damage level to the hospital structures, but also on the state of the road system (heavily damaged bridges or blocked roads prevent victims from being taken to hospitals), and it depends also on the maximum degree of saturation of each hospital in the emergency phase (as its geographical capacity for attracting and caring for victims).

The example presented refers to a seismic risk analysis for the western part of the Liguria region (Italy), mainly for the Province of Imperia, which has a medium-high hazard level, and was struck strongly by an event in 1887 (6.3 M_W) that had a probable offshore source located at about 90 km WSW of Genoa. This resulted in over 600 victims, severe destruction in the coastal towns and in the villages located in the mountains, and extended damage over a wide area in France. Particular emphasis was given to the risk evaluation of the historic centres located on hilltops or in areas of steep topography.

The analysis was developed within a National GNDT project (PE 2000-2002) [18] that was aimed at the conservation of historic buildings in the centres in Liguria. The GIS design reproduced the same pattern adopted in the risk analysis: the factors of *Hazard, Exposure, Vulnerability* and *Damage* were considered both at a sub-regional scale (the Imperia province) and at a local scale (Taggia and the other villages). The WebGis project is published on http://adic.diseg.unige.it/gndt-liguria/.

A detailed description of the layers that have been collected and published online are illustrated in Pessina and Baldi [19]. These data are characterised by a large variability in their quality and reliability. At a deeper scale of analysis (a local scale), the heterogeneity of the data increases and greater efforts were needed for their homogeneity. Table 2 shows the seismic hazard layers only for the sub-regional scale.

The *Hazard* data layers refer to neotectonic, geological, geotechnical and morphological information. The geoelectric profiles for the Taggia plain and two borehole V_S profiles were collected to support a geological/geotechnical characterisation of the alluvium basin. Ground shaking scenarios were generated by reproducing the maximum historical event (of 1887), and the same was done for the more recent inland event (of 1931). Shaking scenarios were generated using empirical attenuation relationships and subsequently compared with macroseismic observations, and low-frequency shaking scenarios were implemented in terms of the maximum velocity, adopting the semi-analytical approach of Hisada and Bielak [20]. This method simulates the complete three-dimensional wave propagation field induced by an extended kinematic source based on the static and dynamic Green functions; the seismic ground response is simulated under near fault rupture conditions and considering also directivity effects.

Strong data homogenisation was necessary to handle the historical information from six damaging earthquakes (MCS intensity ≥ VI) that affected the area, with even local effects, like landslides, liquefaction and ground cracking, required to be standardised. Iconographic historical data were also included after strong harmonisation (see Figure 4). Heterogeneous data are not usually loaded into GIS, because they need strong interpretation; however, in case of their collection here, the study gains important value-added information. For instance, the historical damage iconographic archive made possible the characterisation of the building features, the vulnerability of masonry structures and the damage typologies.

The evaluation of the *Exposure* factor implies the collection of all of the elements exposed to seismic risk, which are generally the most complex data to be assembled. Structural features of buildings and their level of occupancy were gathered by a nationwide census of dwellings [21], and were collected at the municipal scale resolution, by assembling census data. The data relating to historic centres were stored according to the urban and morphological typologies, while their grade of importance was considered by evaluating the number of monuments located inside each urban centre.

The *Vulnerability* features were assigned to each exposed elements, according to the methodology developed within the project [22].

At the end, the *Damage* was estimated for the residential buildings and historic structures at three different resolution levels (census tract, historic centre and whole municipality scale) to satisfy the needs of local and regional administrators, as well as the National Office of "Beni Culturali" (Cultural Heritage). One of the most captivating challenges was how to consider ordinary buildings and historic structures in the overall damage evaluation: the comparison is crucial when there is the need to determine the priority of intervention, in terms of time and resources. For instance, during the recent earthquake of 23 December, 2009, in the northern Apennines (Parma, Italy), usability surveys were focused on churches rather than on ordinary buildings, because the magnitude (5.1 M_W) of the event predicted light-moderate damage to residential structures, while historic structures, which would be crowded at Christmas Eve, could represent a high risk situation [23].

GIS technology allows the simultaneous representation of different data and, consequently, it makes some remarkable results clear. As for the comparison between the damage distribution and the reproduced ground motion of the 1887 and 1931 events: some unexpected high levels of damage, that was not strictly dependent on the ground shaking level, was ascribed to morphological amplification effects due to the positions of the villages on the mountains [24]. Even the location of a finite earthquake source to be used in the generation of realistic hazard scenarios was constrained by geographical considerations, based on the shape of the intensity distributions and the distances from the epicentre.

Table 2 – Layers of the *Hazard* factors for the Imperia province (on a sub-regional scale) WebGis (updated data from Pessina and Baldi, 2004 [19])

Imperia *Hazard* layers
Administrative municipal and provincial boundaries
Digital Elevation Model (DEM) 250x250 m
Geotechnical classification at 1:500,000 scale
Geotechnical classification at 1:10,000 scale (from the Piani Territoriali Coordinamento Provinciale)
Macroseismic epicentres
Faults localisation
Morphological amplification factors
Macroseismic observations of the 1887, February 23 event (1887_02_23)
Local effects1887_02_23
Historical pictures 1887_02_23
Scenario_1887: intensity from Italian attenuation relationships
Scenario_1887: PGA on rock condition from Italian attenuation relationships
Scenario_1887: PGA corrected with morphological amplification effects
Scenario_1887: PGV calculated with finite fault numerical method
Scenario_1887: intensity from local attenuation relationships
Macroseismic observations of the 29 December, 1854, event
Macroseismic observations of the 26 May, 1831,event (1931_05_26)
Local effects 1931_05_26
Fault 1931_05_2 (activated segment used in the scenario generation)
Scenario_1931: PGA on rock condition from Italian attenuation relationships
Scenario_1931: PGA corrected with morphological amplification effects
Macroseismic observations of the 8 January, 1819, event
Macroseismic observations of the 23 February, 1818, event (1818_02_23)
Local effects 1818_02_23
Macroseismic observations of the 19 July, 1963, event

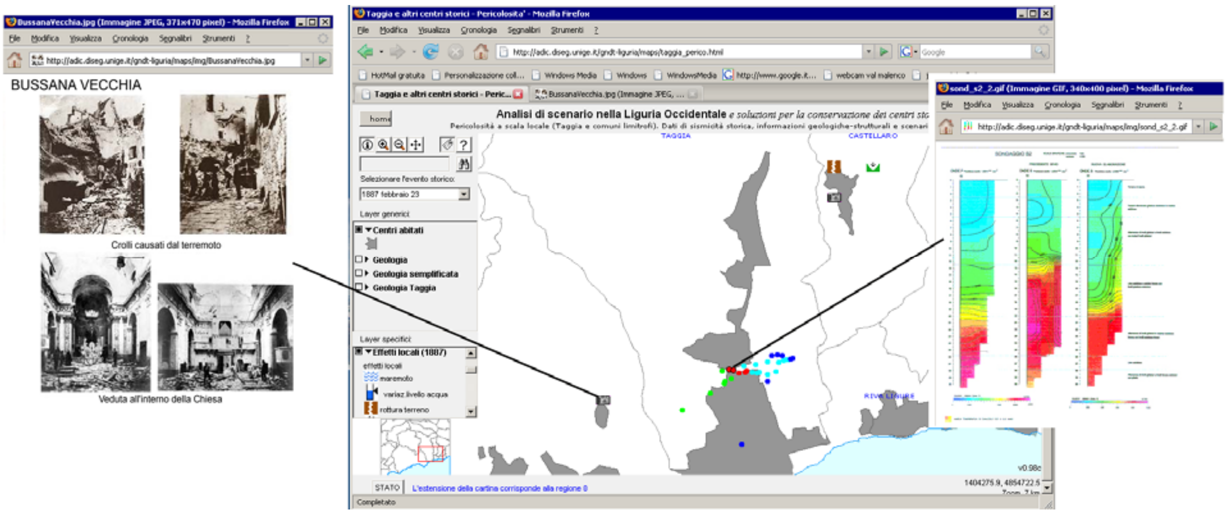

Figure 4 - View of some of the hazard layers in Taggia village (central map): the extension of the inhabited area, the location of the geotechnical surveys, and the local site effects recorded during the 1887 event are illustrated. Part of the database is constituted by iconographic data direct querying, like the image of a borehole profile (shown on the right), or historic images of damage to the Bussana Vecchia municipality, hit badly by the 1887 event (illustrated on the left).

The WebGis software solutions

The primary goal of the WebGis package is to make geographical data available to specific end-users, and potentially to the public. The application allows the end-user to view geographical data using a web browser, and without GIS; it provides interactive query capabilities and integrates the GIS solutions with other technologies.

Data-driven applications can be developed on the Internet according to server-side or client-side applications. In general, server-side applications usually have a limited user interface and a low performance, while the client-side solutions are affected by software and data-distribution limitations (mainly platform incompatibility and problems loading software). Fast performances and powerful user interfaces are necessary when GIS technology is implemented on the Internet. In this case, the drawbacks of both the client-side and server-side solutions are amplified, and the appropriate solutions must be chosen carefully.

Over 30 different WebGis packages are available at present. Among these, the most popular and commercially successful are ESRI *ArcIMS* (http://www.esri.com/arcims), Intergraph *GeoMedia WebMap* (http://www.intergraph.com) and AutoDesk *MapGuide* (http://www.autodesk.com), while UNM *MapServer* (http://mapserver.gis.umn.edu/) is an open-source application that has been widely adopted. Brief descriptions of these are given in the following:

- ESRI was the first vendor of GIS software solutions, over 30 years ago. Its WebGis package (*ArcIMS*) is an Internet product that works in the Java environment. It has an architecture consisting of presentation, business logic and data storage, which allows the user to interact with the database through the querying, analysing and editing of maps. The applications for management (*ArcIMS Manage*) allows the easy creation of websites by means of a wizard-driven application for authoring and publishing web maps without having programming skills. The main disadvantage of this software is its slow web delivery, due to the format of the ESRI Shapefile; the package also requires a powerful server to answer client requests with a reasonable delay time.

- Intergraph *GeoMedia WebMap* also allows user-friendly creation of websites. Server-side operations deliver geographical information to the end-user, and the client-side components include querying, editing and manipulation functions of the database. The mapping of vector and raster data are the main advantages of this software, together with the capability of data rendering and manipulation inside the browser. Vector data can be delivered in two formats: as a Computer Graphics Metafile (CGM) and Scalable Vector Graphics (SVG), which is a good W3C recommendation for an open-source vector graphics format (http://www.opengeospatial.org). *GeoMedia* supports file formats directly (without any conversion) from Oracle, AutoDesk, FRAMME, Microsoft Access, SQL and ESRI. The lack of a native data type lets this software reduce the delay time for conversion. One of the main disadvantages is the relative low level of security of the website created and the underlying GIS structure.

- Autodesk started making GIS packages in the 1990's, incorporating CAD into GIS, after recognising that a huge number of digital maps had been created using its proprietary DWG format. The software *MapGuide* integrates GIS and CAD technologies, and it supports many formats without data conversion and shares spatial data using standards and specifications of the Open GIS Consortium (OGC). It makes use of the Special Data Format (SDF), which is much smaller than ESRI Shapefiles, and allows faster delivery. *MapGuide* recently released a free cross-platform viewer with limited functionality (*MapGuide LiteView*) that runs as a Java servlet and converts *MapGuide* output into PNG images. Developers must be familiar with HTML web design and will need a toolkit for data editing.

- *MapServer* is open-source software developed by the University of Minnesota through a NASA sponsored project. The package is a free alternative to other commercial applications, and it is a good solution when highly customised applications are needed. *MapServer* is a Computer Graph Interface (CGI) programme that sits inactive on the web server. A request is sent in HTML format with the correct data metafile (Map File) and the server program creates and delivers an image of the requested data. *MapServer* provides a scripting interface for the construction of web and stand-alone applications, adding WebGis capability to popular scripting languages. *MapServer* needs a strong skilled programmer to develop the WebGis application.

However, most of the commercial applications have large restrictions, mainly due to the costs of the licences and their maintenance; instead, the open-source packages like *MapServer* necessitate critical programming abilities. To overcome these limitations, after widespread investigations, we chose the freeware WebGis *ALOV Map* (http://alov.org/). This was developed by the University of Sydney in the framework of the project "TimeMap" (http://www.timemap.net/), and it is freeware for educational applications. It is independent of the working platform, application software, server environment and user browser. *ALOV Map* is a portable Java application. A Java application runs in an environment known as Java Virtual Machine (JVM) and it does not require a high performance computer. Java is a simple, object-oriented and dynamic language that allows the generation of small programs (applets) that can be downloaded from the Internet and run on any Java-enabled web browser. By incorporating a Java applet into a web page, it is possible to display dynamic graphics on the web, to query database and to download information from the server. The package lets the user work with multiple layers or thematic maps (vector and raster), hyperlinked features and attribute data. The applet provides the map window, legend, bottoms (zoom-in, zoom-out, pan, selection of features), text boxes for selection of themes or domains, web links and help. In the present study, both of the projects were implemented with the stand-alone version of *ALOV Map*; ArcView shapefiles (or MapInfo MIF files), HTML files and the Alov applet file are indispensable to set up *ALOV Map*.

The choice of this software was suggested by the requirements of a simple system, which needed to be easily exportable, without the request for a challenging Data Base Management System (DBMS). Nevertheless, it ensures a simple level of data protection, easy updating and flexible data management. The limitations of the system are its low performance and a lack of advanced features for interactions with the GIS technology. The main capabilities of ALOV can be summarised in the following:

- open source, freely available for academic/scientific projects;
- direct access to simple data formats (DBF, SHP and MAP files);
- easy implementation (no skilled developers needed);
- simple protection of data;
- quite fast query delivery time (even with limitations on database structure and size);
- light hardware and operative system requirements.

Conclusions

In earthquake risk scenario analysis, where a high level of interdisciplinarity is required, GIS technology assures a strong level of interaction among the specific contributions. GIS is a spatial database that can gather and structure heterogeneous data; it is a widespread mapping tool and it allows powerful spatial analysis. The examples given here illustrate how comparisons between historical damage distribution and expected ground motion scenarios can succeed in the identification of anomalous amplification effects due to topographic conditions (as in the 1887 Liguria event) or how damage distribution can be explained by finite source and directivity effects (as in the case of the 2004 Garda event).

One of the main characteristics of a seismic GIS investigation is the choice of the scale of analysis: hazard scenarios show interesting aspects at the sub-regional scale, while damage is usually available (or required) at the local scale. Effort and time, as expensive resources, are usually necessary to collect data when the scale levels are so different.

As with the greater part of geographical data, even seismic information is currently shared with a large target of end-users, including local administrators asking for locally characterised data (as in http://www.rete.toscana.it/sett/pta/sismica/scenari/index.htm), and professional engineers and geologists needing to consult codified hazard values (as in http://esse1.mi.ingv.it) with respect to the national building code. The WebGis solution is a natural answer to the ongoing demand for high levels of information.

The web publication of seismic hazard and risk data approaches management and scientific dissemination, with practical, fast and efficient access. However, particular attention is necessary in the dissemination of "sensitive" data, as to the choice of the output scale resolution and the publication of the maps.

This acquired experience allows us to indicate that *ALOV Map* as a useful tool for WebGis publication, with a data structure that is simple to adopt for seismic project dissemination.

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