GEODEZJA I KARTOGRAFIA
GEODESY AND CARTOGRAPHY
Vol. 56, No 1, 2007, pp. 37-52

The use of a Web-based GIS for the management of databases related to natural disasters

Ioannis D. Doukas[1], Paraskevas Savvaidis[1], Ilias N. Tziavos[2], Vassilios N. Grigoriadis[2], Ioanna Papadopoulou[1], Ioannis Vavassis[3]

[1]Laboratory of Geodesy and Geomatics, Aristotle University of Thessaloniki
University Box 465, Thessaloniki, GR-54124, Greece
[2]Department of Geodesy and Surveying, Aristotle University of Thessaloniki
University Box 440, Thessaloniki, GR-54124, Greece
e-mail: tziavos@olimpia.topo.auth.gr
[3]Agiltech S.A., 18 Aetideon St., Athens, GR-15561, Greece

Received: 12 February 2007/Accepted: 27 June 2007

Abstract: Natural disasters have an effect on many important economic and social parameters and are related to a wide spectrum of sciences. Their kind, form, scale, intensity and other characteristics vary in different areas on Earth. One of the most common fields where such disasters are of great importance (either as threats or as resulting damage) is the urban environment (either the buildings or the infrastructure). The complexity of the natural disasters concerning each of the five phases in their lifecycle (prevention, mitigation, preparedness, emergency management, recovery) leads to the selection of strong and most capable tools, in order to predict their results, i.e. the damage. Since nowadays the geospatial technologies have undergone an effective shift to become better suited to the internet, the most appropriate tools for this purpose are the Web-based GIS. In this review paper, a Web-based GIS, which is under development, named SyNaRMa (Information System for Natural Risk Management in the Mediterranean) is being presented. SyNaRMa features include collection and analysis of data related to earthquakes, landslides and forest fires, simulation of natural disaster effects resulting from realistic scenarios and prediction of their impact on the natural and anthropogenic environment of the wider implementation areas. It is to be noted that its open architecture offers many benefits and conveniences for future plans as for example the incorporation within the system of data related to other natural disasters (e.g. drought, desertification, tsunamis, volcanic eruptions etc.) and the potential to be used all over the world.

Keywords: Natural disasters, Web-based GIS, impact prediction, SyNaRMa, risk management, environment

1. Introduction

Earthquakes, landslides, forest fires and other natural disasters are permanent threats for many countries, causing fatalities as well as material damage at regional, national and trans-national level. Especially, earthquakes are the mostly feared by local populations, causing paralysis of local socio-economical activities. Looking into the effectiveness of people's response to natural disasters, it can be stated that certain procedures may reduce the severity of the consequences resulting from those phenomena. For example, it is possible that landslides can be predicted and prevented by taking appropriate "a priori" actions. On the other hand, earthquakes and forest fires are unpredictable; however, their physical consequences can be accurately predicted, thus allowing the enactment of effective prevention measures towards the reduction of vulnerability. Consequently, natural disasters can be reduced or prevented through effective management (e.g. Schmidt, 2003; Xenidis et al., 2005).

Issues related to the prediction of the damage caused by several natural disasters are of fundamental importance when one is dealing with land use and development, urban planning and safety of the population, as well. Disasters and their management show an increasing trend of importance, especially when related to the urban environment. This trend can be explained just by taking into account that, while in 1975 about 38% of the Earth's population lived in urban areas, by reaching the year 2025 this percentage is expected to climb up to 60% (Grothe et al., 2005). Key-parameters like emergency, fast response, prediction, disaster preparedness, prevention of (private or public) property damage, and strategic planning at a local-regional-national level form the main axes for the management of natural disasters.

In Europe, the importance of natural-technological disasters did attract the interest and support of the European Commission (EC) from the 1980's (Fabbri and Weets, 2005). Among the most significant European actions towards this direction, in the early years were the Framework Programs for Research and Technological Development (RTD), the contribution of Information and Communication Technologies (ICT) and the results and advances of the Seveso II Directive about several kinds of disasters. Later on, the Sixth Framework Program followed (FP6, 2003–2006). In order to disseminate and network the numerous disaster relative activities of the pan-european community, the Euro-Mediterranean Disaster Information Network (EU-MEDIN) has been established. On the other hand, in order to achieve global monitoring of the environment and security, the EU in cooperation with the European Space Agency-ESA, launched the GMES project (Global Monitoring for Environment and Security), where the term "security" is related to natural disasters.

Natural or technological disasters may have similar impact on the buildings and technical infrastructure of urban environment. Earthquakes are considered as one of the most destructive natural events, with evident impact on urban infrastructure and human fatalities (Savvaidis et al., 2005). Concerning the prediction of damage on the built environment, all efforts contribute to the creation of a framework of procedures aiming at dealing with problems created after serious disaster incidents, which affect the population.

Geographical Information Systems (GIS) provide the appropriate platform for the registration and management of data related to natural disasters as well as the proper mean for the presentation of the damage caused by natural disasters, which results from the scenarios analysis process. The advantage of the GIS lies in the ability to assimilate different layers of geographic data and correlate them with each other. Web-based GIS are Geographical Information Systems providing many capabilities for management and analysis of geographic data using technologies through the internet. Those systems provide effective tools and methodologies for the management of the disasters and their impact.

SyNaRMa (**Information System for Natural Risk Management in the Mediterranean**) is a system being developed in the course of a project financed by the European Regional Fund of the European Union under the EU Community Initiative INTERREG III B ARCHIMED. The project is carried out by a consortium of partners from Greece, Italy and Jordan (Fig. 1):

- The Aristotle University of Thessaloniki, Greece (Laboratory of Geodesy and Geomatics, Department of Civil Engineering – Department of Geodesy and Surveying – Department of Geophysics, Faculty of Geology);
- The Technological Educational Institute of Larisa, Branch of Karditsa, Department of Forestry and Management of Natural Environment, Greece;
- The Institute of Engineering Seismology & Earthquake Engineering, Thessaloniki, Greece;
- The Sector of Industrial Management and Operations Research (SIMOR) of National Technical University of Athens, Greece;
- The Prefecture of Thessaloniki, Greece;
- The Municipality of Grevena, Greece;
- The Earth Science Department of the Faculty of Sciences – Messina University, Italy;
- The Inter-universitary Consortium for Prevention and Protection from Risks, Messina, Sicily, Italy;
- The Physics Department of the Calabria University, Italy;
- The Royal Scientific Society, Jordan.

The main objective of the SyNaRMa project is to build a Web-based user friendly GIS for natural disaster management that will be easily operated by even small sectors of the Civil Protection mechanism (e.g. municipalities). Moreover, it is aiming at the automization of the procedures for the collection, organization into digital form and evaluation of the records of reported damage on buildings connected to the occurrence of several natural disasters (earthquakes, forest fires and landslides for the first application of the system). Finally, it intends to set up common strategies and methods for preparedness and response to natural disasters taking advantage of the capabilities offered by the system.

GISs are being quickly developed in most Mediterranean countries but are still not in use by emergency authorities. The core partners of this project, i.e. research institutions, that have the know-how for a scientific approach to the problem of natural risks management, will transfer their knowledge to the Civil Protection, State and local bodies.

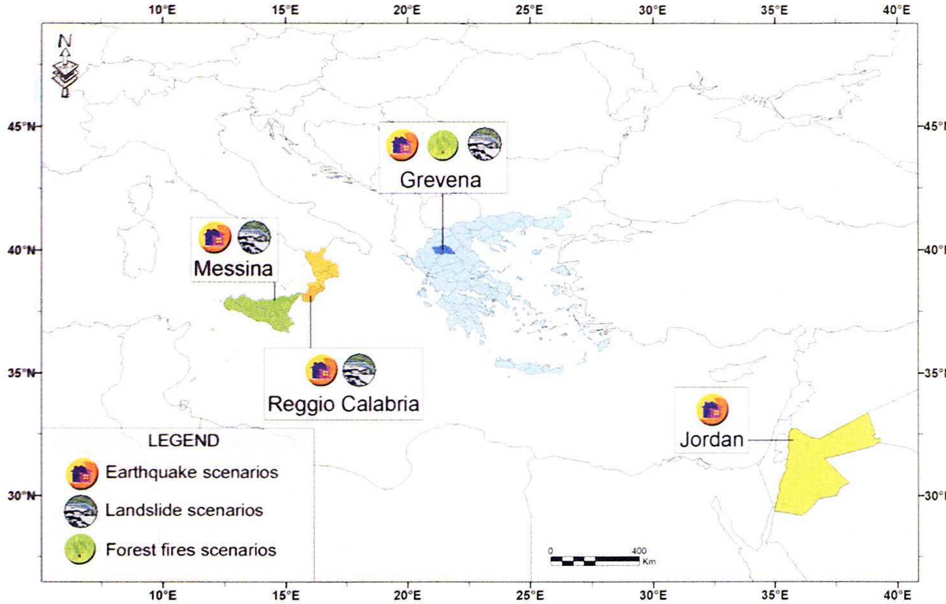


Fig. 1. The pilot areas of the SyNaRMa system and the scenarios implemented in each pilot area

The scope of the present review paper is to describe the main application of the SyNaRMa system through the management of databases/datasets related to natural disasters and to reveal the potentials of the system. Moreover, a description of the scenarios structure is provided oriented towards the earthquake, landslide and forest fire disasters. Finally, a brief discription of the system structure is presented.

2. Development of databases related to natural disasters

The datasets of the SyNaRMa system include the data that determine the geographical extension of the application and describe basic attribute characteristics of the region under investigation. Each dataset is constituted by a minimum number of fields. The system, however, allows the addition of new fields and even new layers of information. All the individual datasets and the corresponding descriptive information are provided as files of identical or compatible format.

The SyNaRMa Web-based GIS is founded on a detailed digital map of the area under consideration, focusing on specific regions related to earthquake (Grevena-Greece, Messina-Sicily, Calabria-Italy), forest fire (Valia Calda-Grevena) and landslide (Grevena, Messina) past events.

The databases of the SyNaRMa system are distinguished into two categories, the general/basic databases which constitute the geographical background and several specialized databases related to each of the three natural disasters studied in the frame of the system. Furthermore, the databases vary between those related to the parameters that affect the studied natural disasters and those related to parameters that are generated after the occurrence of an event. The last category of databases will constitute the scenarios databases, given that they will be developed after the completion of the scenarios. Taking into account the fact that the SyNaRMa system is under development, the scenarios databases are still under preparation.

The basic digital data layers included in the SyNaRMa system, as they were collected for all pilot areas, are listed below and an example is shown in Figure 2.

- Boundary of the region;
- Counties of the region;
- Roads of the region;
- Railway of the region;
- Rivers of the region;
- Lakes of the region;
- Municipalities and subregions within the city (study area);
- City Blocks and demographic data of the Municipality of study;
- Buildings of the Municipality of study;
- Map of buildings of the Municipality of study;
- Built Environment of the study region;
- Street names and numbering in the built environment of the city.

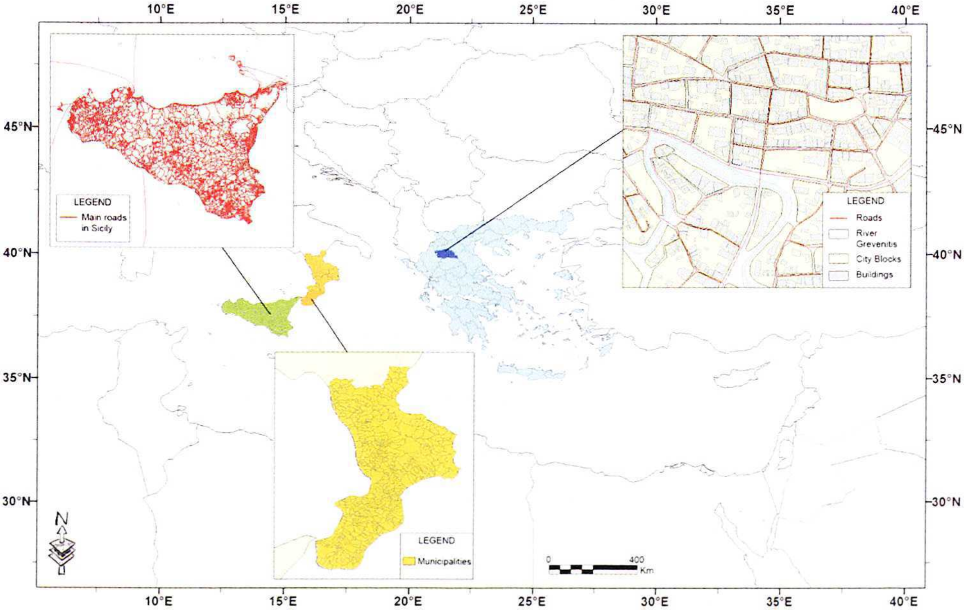


Fig. 2. An example of layers of basic digital data included in the SyNaRMa system (up left: main roads in Sicily; up right: city plan-buildings in Grevena; down: municipalities in Calabria)

All the above mentioned datasets, available at local level, were incorporated in the general map that was prepared for the whole region. In the frame of this map production, the different sets were topologically corrected and transformed into a common reference system, i.e. WGS84 (World Geodetic System 1984).

The same procedure was followed for the more specialised datasets related to risks and natural disasters which include meteorological, geomorphologic, geophysical, hydrogeological, geological, seismological and geotechnical data. An example of additional digital data layers included in the SyNaRMa system is shown in Figure 3, while a list of the required databases for each disaster under study is given below.

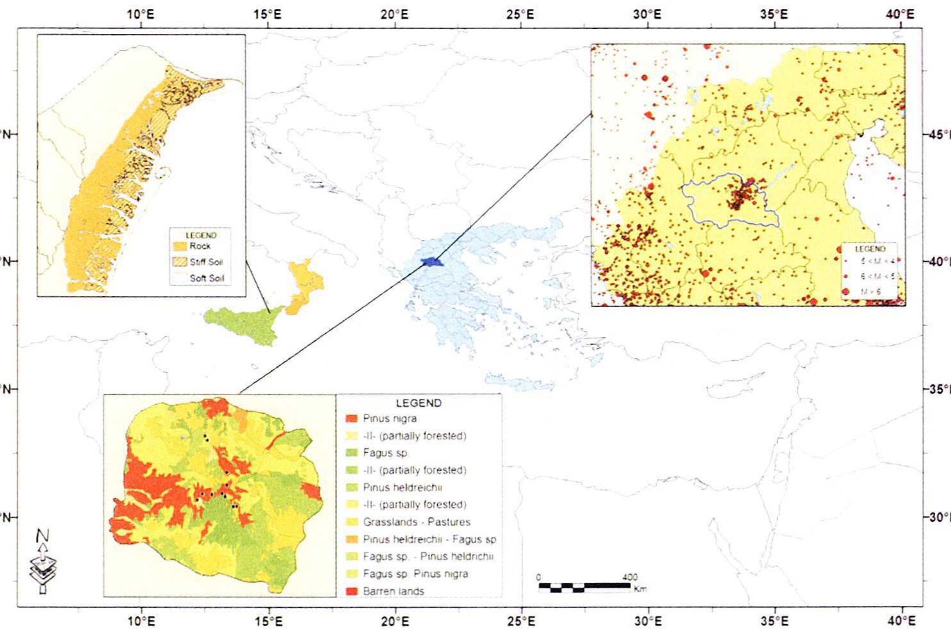


Fig. 3. An example of layers of additional digital data included in the SyNaRMa system (up left: lithology in Messina; up right: vegetation in Valia Calda; down: seismological data in the surrounding area of Grevena)

The databases/datasets related to earthquakes that constitute the main input for the earthquake scenarios are stated below:

- Recent seismicity catalogue;
- Seismogenic faults segments coordinates;
- Seismogenic sources in each region;
- Focal mechanisms;
- Historical seismicity;
- Building damage databases.

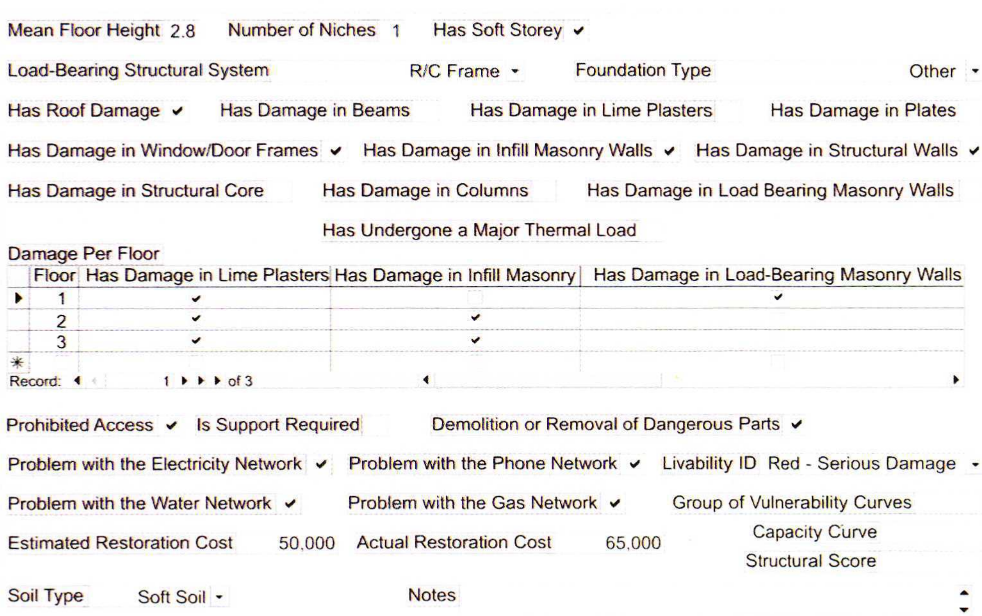
The databases/datasets related to landslides that constitute the main input for the landslides scenarios are stated below:

- Digital elevation model;
- Road network (road classification);
- Geologic formations and residential areas.

The databases/datasets related to forest fires that constitute the main input for the forest fires scenarios are stated below:

- The border of the study area;
- Digital elevation model;
- Lakes of the study area;
- Basic road network/ pathways/ forest roads;
- Basic hydrographic network;
- Forest ecosystems and species;
- Meteoroglogical parameters for the study area (air temperature, wind speed, precipitation, snow frost, humidity);
- Historical forest fires and amount of damage, pread and effects;
- Interest points.

In order for the building damage database to be developed, a user-friendly data entry tool in Microsoft Access has been created for the quick and reliable input of damage data details in the relevant database (Fig. 4). That tool will finally be replaced by a sole Web-based entry tool through the SyNaRMa system. Several validation rules have been employed for preventing accidental data entry errors and also a cross validation between different damage estimation reports pertaining to the same object, i.e. buildings, are carried out extensively in order to ensure, as much as possible, the accuracy of the data stored. Addresses of buildings whose damage has been stored in the database are linked to their geographical location on the map through an address-matching procedure.


Mean Floor Height 2.8 Number of Niches 1 Has Soft Storey ✔
Load-Bearing Structural System R/C Frame Foundation Type Other
Has Roof Damage ✔ Has Damage in Beams Has Damage in Lime Plasters Has Damage in Plates
Has Damage in Window/Door Frames ✔ Has Damage in Infill Masonry Walls ✔ Has Damage in Structural Walls ✔
Has Damage in Structural Core Has Damage in Columns Has Damage in Load Bearing Masonry Walls
Has Undergone a Major Thermal Load
Damage Per Floor

Floor	Has Damage in Lime Plasters	Has Damage in Infill Masonry	Has Damage in Load-Bearing Masonry Walls
1	✔		✔
2	✔	✔	
3	✔	✔	

Record: 1 of 3
Prohibited Access ✔ Is Support Required Demolition or Removal of Dangerous Parts ✔
Problem with the Electricity Network ✔ Problem with the Phone Network ✔ Livability ID Red - Serious Damage
Problem with the Water Network ✔ Problem with the Gas Network ✔ Group of Vulnerability Curves
Estimated Restoration Cost 50,000 Actual Restoration Cost 65,000 Capacity Curve
Structural Score
Soil Type Soft Soil Notes

Fig. 4. Fields of damage data details included in the SyNaRMa system data entry tool

It is to be mentioned that in order to decide the structure of the building damage database and the field that it will be consisted of, an extesive bibliographic review was made along with an evaluation of several similar databases that are used worlwide. Moreover, research of the inspection forms that are used in-situ was conducted in order to finalise the content of the database.

A more detailed description of the database structure might be given in another paper once the different scenario databases, which are still under preparation, have been completed. All the above mentioned datasets and electronic maps are in digital form and can be viewed and processed in ArcGIS, ESRI, or any other GIS software compatible with the provided file formats.

3. Application of the system

The application of the SyNaRMa system is oriented towards two different directions. The first objective is to provide the means for the record of the damage caused by a natural disaster using a Web-based entry tool, available in the SyNaRMa system. The second, and more extended application of the SyNaRMa tool is the scenarios that will be developed in order to identify the potential impact of a future disaster event on the urban environment.

3.1. Web-based damage recording

Towards the direction of damage recording, a valid internet connection and a portable computer will only be needed in order to record damage data from anyplace at anytime. The data entry tools are very important for maintining a valid and accurate archive of the damage caused by natural disasters. The ability to store all that information is of key importance, given that provides for the prompt estimation of the damage caused by a natural disaster event, and, in addition, the GIS allows the user to inspect visually the recorded damage, evaluate – at almost real time – the impact on structures and decide about further relief actions.

3.2. Scenarios for the identification of potential impact of future disasters

Scenarios will be developed in four different pilot areas (Grevena, Messina, Reggio Calabria, Aqaba), in order to study the potential impact of future disasters, as shown in Figure 1.

- Earthquakes
  - Grevena, GREECE
  - Messina, SICILY
  - Reggio Calabria, CALABRIA
  - Aqaba, JORDAN

- Landslides
  - Grevena, GREECE
  - Messina, SICILY
- Forest fires
  - Valia Calda, GREECE

The scenarios are being developed through a two stage process. In the first stage, the scenarios developed will produce the results of a previous disaster event based on historical data. The scope is to calibrate the parameters of the models as well as the theoretical or empirical assumptions in the relative modelling through the simulation of a past disaster event and its impact.

In the second stage, once the models are calibrated, scenarios for a possible future earthquake will be established aiming at estimating the damage that will be caused to the build environment. This allows for the localization of the most suseptible areas in case of a future disaster event and the definition of damage zones in the future. This information is of great importance for emergency planning. It is to be noted that those scenarios are developed outside the system and once they are completed they are uploaded to it.

Since SyNaRMa deals with events (disasters) which have happened on given area at a defined time period, it was considered mandatory to work on a cartographic backgroung that refers to the same time scale. This means that, for example, when a natural disaster event occurs the system will store on a separate layer the cartographic basis of the area affected, including, e.g, buildings, streets and city blocks as they were at the time the event took place. Although there is a high cost involved in storage space, the benefits from this decision are very important, especially for the evaluation of the damage caused to the buildings and the available emergency plans, as well as for studying the phenomenon and its effects through simulation scenarios.

A more comprehensive description of the scenarios structure is given below oriented towards the earthquake, landslide and forest fire disasters.

3.2.1. Earthquake scenarios

The selection of future scenario earthquakes that may affect the urban region of interest is based on a combined review of historical data, previous probabilistic and deterministic hazard assessments, seismotectonic and microseismicity studies, relocated seismicity in the broader area and the experience gained from worldwide research (Kiratzi et al., 2004). In the SyNaRMa system the results from hypothetical rupture of specific faults are considered. Empirical relations applicable to Greece (Papazachos and Papazachou, 1997), as well as seismicity information are combined to determine the dimensions of the scenario earthquake source. Strong ground motion for the selected scenario is simulated using the stochastic method for finite faults (Beresnev and Atkinson, 1997). Uncertainties due to unknown parameters such as the rupture initiation point and the distribution of slip on the fault plane are taken into account by examining a large number of random scenarios. The average values from these multiple scenarios are then used to compile maps of strong ground motion parameters, e.g. peak ground acceleration and spectral acceleration. The level of the resulting strong ground motion parameters is indicative of the potential destructiveness of the examined source. For a detailed description of the stochastic method, the reader is referred to Boore (2003) and to references therein.

Earthquake scenarios describe the expected ground motions and effects of corresponding events. In order to simulate an earthquake, assumptions on the location and the size of the event are required. However, this does not mean that the specific earthquake will indeed occur. Nevertheless, simulations of different earthquake scenarios enhance our present knowledge of the potential destructiveness of specific seismic sources and can, therefore, be used for earthquake disaster planning and preparedness purposes. Damage estimation leads to the knowledge/awareness of the extent of damage on a specific city provided that the earthquake scenario will occure. It is possible not only to know the total amount of the damage but also to detect hot points of the city through the analysis (Theodulidis et al., 2006). That information is very important to manage effective seismic disaster reduction measures, including preparedness, emergency response activities, recovery actions and policies.

3.2.2. Landslide scenarios

In the same sense, the landslide-prone areas may be simulated and possible damage to infrastructure may be estimated. In order to identify the landslide prone areas and derive a landslide susceptibility map, different methods will be applied (Savvaidis et al., 2006). The different methods deliver either qualitative or quantitative assessment. That assessment is done on the basis of the causal factors contributing to landslides. According to modelling and analysis techniques used, the main causal factors can be integrated in a spatial analysis. At first, a landslide inventory map shows the known landslides that occurred in the past. Such an inventory is the simplest way of describing the susceptibility of an area to landslides. Then, areas that are susceptible to occurrence of landslides are being identified either by using quantitative spatial analysis like statistical or deterministic analysis. Finally, landslide susceptibility will be identified by expert evaluation of the causal factors, e.g. on the basis of meteorological data (air temperature, precipitation), geomorphologic data (slope gradient, curvature, aspect), geophysical data (seismicity), hydrogeological data (watersheds, rivers and drainage system, lakes, springs and wells), geological data (fault zones, geologic formations), soil classification, vegetation etc.

3.2.3. Forest fire scenarios

In order for the forest fire scenarios to be developed, a thorough examination and simulation of past forest fires is required. In the first stage the data needed as input to simulation scenarios should be collected. The data refer to past forest fires and provide information about duration, ignition spots, burnt areas, causes, damage, as well as meteorological parameters such as rainfall, snow, wind direction and speed and temperatures.

In the second stage, several forest fire propagation models are assessed in order to determine the most appropriate one and/or modify it. The results of each model are examined and those that give more similar results to recorded events are further analyzed. The aim of this stage is to produce a model that will create the most representative simulation of forest fire propagation according to the input data each time.

Finally, the results are assessed by comparing basic features between past events and the simulation results of this event. The main parameters that should be checked are the total burnt area, the shape of the area and the direction of propagation. The corrections to the models are made by modifying coefficients and weight factors of the input data from each database used.

4. The SyNaRMa Web-based GIS

The effective management of natural disasters requires all the necessary data and information which might facilitate the competent agencies as well as the population through all the phases of disaster management (prevention, control, recovery).

The main parameters taken into account for the disaster management are the hazards, the vulnerability and the risks, the events, the damage and the reports. According to those, the system's main structure consists of the folowing modules (Fig. 5):

- *Events*: A module for input of data related to a particular disaster or event, its location and information about it. Within the scope of the particular project, events may be earthquakes, landslides and forest fires. The open architecture of the system allows the extension to other kind of disasters, such as technological disasters, accidents, urban fires, floods, etc.
- *Damage Sites*: A module for input of data related to the damage that a particular building or structure has suffered because of an event, which has occurred at some place. This is of main importance since the stored data contribute towards the evaluation of the impact of the event on the built environment and helps local authorities to provide assistance where needed.
- *Hazard Sites*: A module for input of data related to sources of possible damage. Hazard consists of phenomena or events and is defined as the probability of occurrence of a dangerous event or natural disaster at a certain time and area. Hazard sites are locations from where a disaster may start due to natural or technological causes.
- *Vulnerable Sites*: A module for input of data related to sensitive natural areas or human constructions that could possibly be affected in the case of an event, e.g. forests, parks, hospitals, schools, etc.
- *Knowledge Database*: A module that includes documents and other information concerning disasters and their impact as well as case studies and risk confrontation methodologies.
- *Administration of Application*: A module for the organization and the authorization of users. In SyNaRMa there are different user groups, each having its own user rights to access, modify, insert and visualize the system data.

- *Web-GIS Tools*: A module that allows the user to manage, analyse and properly display all the above mentioned geographically distributed data.

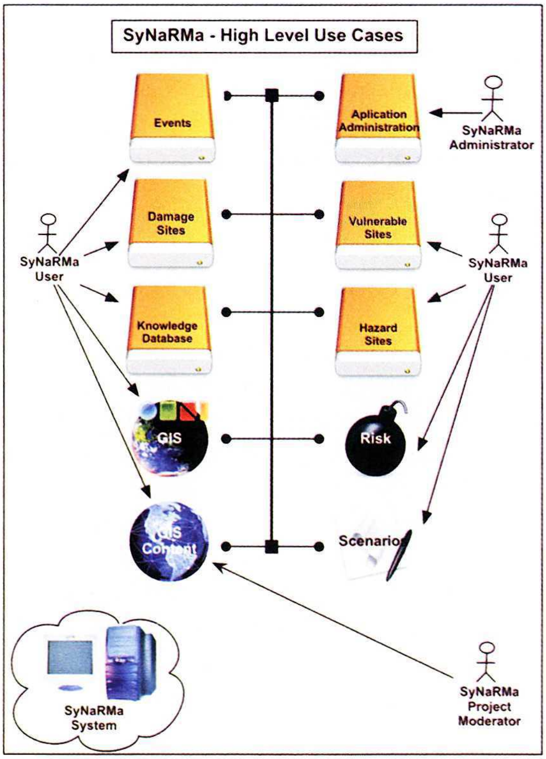


Fig. 5. Modules of the SyNaRMa system

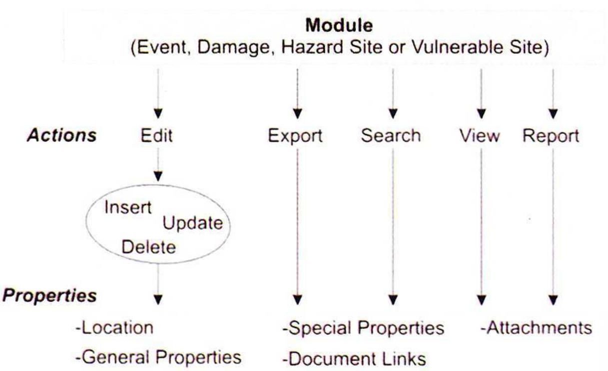


Fig. 6. Management of basic items in the SyNaRMa system

The modules related to events, damage sites, hazards sites and vulnerable sites share a common structure (Fig. 6) which consists of two categories, the actions and the properties. The actions are the functionality that the module provides to the user and the properties refer to data and links stored in the databases.

The data include the location, i.e. map coordinates, and general and specific properties. On the other hand, the links provide a unique way to include in the database additional available detailed or specific information, i.e. published reports, reference documents, photos from an event, videos, etc. The contents of the DAMAGE SITES database are organized into the following basic groups for each damaged building that was inspected once it was hit by a natural disaster:

- Natural disaster event information;
- Location (address: street name and number) of building and relevant information;
- Geometric characteristics of the building;
- Main use of the building;
- Structural type;
- Damage caused to the building and further considerations;
- Consequences caused to the people living in the building;
- Estimation of structural capacity;
- Cost of repair.

In order to use the application there is no need for pre-installed software. The user interface requires only a Web-browser and an internet connection hence making the application platform-independent. The Web-based GIS solution is less expensive when compared with the costs of maintaining distributed software. The biggest advantage though is that it provides powerful spatial analysis tools to all the users of the system while it allows real-time modification, interaction and concurrent usage from any location where internet access is available.

5. Future Plans

Given that at present the SyNaRMa system is still under development, a more detailed description of both the application of the system and the scenarios, enriched with the hypothesis made, will be provided in a future paper, once the system is fully functional.

The SyNaRMa Web-based GIS utilizes a relational database management scheme as well as the Component Object Model (COM) technology (Box, 1998). The system has been based on the ESRI ArcIMS platform which provides the necessary objects needed along with the use of Microsoft ASP.NET for developing the user-interface. The combination of the aforementioned technologies ensures that the system may be easily adapted and upgraded to include tools and interfaces for additional types of disasters than the ones currently supported.

In addition, in the future the SyNaRMa system is aiming at contributing towards the establishment of effective prevention measures for the mitigation of possible disaster effects. Moreover, emergency planning, through the scientific designation of areas for population assembly, shelter camps and escape roads in case of a disaster event is within the future plans of the SyNaRMa tool. The GIS allows for all those elements to be presented on maps. This procedure can facilitate response to emergencies, showing the most important installations necessary for the maintenance of health and public safety. Combined with risk scenarios and landslide and fire prone areas this information could be very useful in preparedness procedures and response activities. As a result, the SyNaRMa system might be also a usefull tool for the better organization of the Civil Protection authorities.

6. Conclusions

The Web-based SyNaRMa system provides the appropriate platform for recording and management of data related to natural disasters and consequently the impact of disaster events on buildings of the urban environment as well as the environment and technical infrastructure. GIS methodologies are being used effectively for spatial analysis and damage prediction. Several digital datasets are typically being used in the analysis process.

The presented framework will have the capabilty to represent the various phases of a natural disaster in the form of a GIS map with the related information provided by the integrated databases. Future instances of relevant events might be forecasted and therefore, it will facilitate decision making and planning. Furthermore, SyNaRMa aims at contributing towards the development of risk emergency plans and their evaluation by combining information from simulation scenarios or previously recorded damage effects.

The inventory of factors related to or affecting a natural disaster, as it results from the collected datasets, may be extremely large. Each case might have some parameters that demand certain study and counter procedures. On the other hand, there is a certain number of factors that are existent in all (or most) cases. Those common natural disaster related parameters can be summarized into layers of information in the corresponding geographical system. Taking into consideration that GIS has been adopted in all the emergency management phases, that is planning, mitigation, preparedness, and recovery in case of disasters, the use of common categories of data and datasets can significantly enhance the harmonization of procedures and assist the development of a common risk evaluation methodology. The design of a common GIS database structure (always open to new data) and a special global methodology will significantly contribute towards the homogenisation of methodologies concerning natural risk management at a national or international level.

Acknowledgements

Funding for this research was provided by the European Regional Development Fund under the EU Community Initiative Program INTERREG III B ARCHIMED (2000–2006).

References

Beresnev I.A., Atkinson G.M., (1997): *Modelling finite-fault radiation from the ω^n spectrum*, Bull. Seism. Soc.Am., 87, pp. 67-84.

Boore D.M., (2003): *Simulation of ground motion using the stochastic method*, Pure Appl. Geophys., 160, pp. 635-676.

Box D., (1998): *Essential COM*, Addison-Wesley Professional.

Fabbri K., Weets G., (2005): *ICT for environmental risk management in the EU research context*, in: P. van Ooosteron, S. Zlatanova, E.M. Fendel (eds.), Geo-information for disaster management, Springer, pp. 51-56.

Grothe M.J.M., Landa H.C., Steenbruggen J.G.M., (2005): *The value of Gi4DM for transport & water management*, in: P. van Ooosteron, S. Zlatanova, E.M. Fendel (eds.), Geo-information for disaster management, Springer, pp. 128-153.

Kiratzi A., Roumelioti Z., Benetatos Ch., Theodulidis N., Savvaidis A., Panou A., Tziavos I.N., Savvaidis P., Hatzigogos Th., Koutoupes S., Karantonis G., (2004): *Scenario earthquakes affecting the built environment of the prefecture of Thessaloniki*, Bulletin of the Geol. Soc. of Greece, Vol. XXXVI, Thessaloniki.

van Oosteron P., Zlatanova S., Fendel E.M. (eds.), (2005): *Geo-information for Disaster Managemnet*, Springer.

Papazachos B.C., Papazachou C., (2003): *The earthquakes of Greece* (in Greek), Ziti Publ. Co., Thessaloniki, Greece, 286 pp.

Savvaidis P., Sotiriadis A., Valadaki A., Doukas I.D., Tziavos I.N., Kiratzi A., Savvaidis A., Koutoupes S., (2005): *Use of Web-based GIS for the evaluation of earthquake damage to the built environment*, Presented at the "DPPGIS 2005" Inter. Conference, Pardubice, Czech Republic.

Savvaidis P., Theilen-Willige B., Neuhäuser B., (2006): *Guidelines for a Landslide Hazard Information System*, OASYS deliverable, p. 84, Vienna.

Schmidt H.S., (2003): *Technical requirements for early warning systems*, in: J. Zschau, A.N. Kueppers (eds.), Early warning systems for natural disaster reduction, Springer, pp. 817-821.

Theodulidis N., Roumelioti Z., Panou A., Savvaidis A., Kiratzi A., Grigoriadis V., Dimitriu P., Chatzigogos T., (2006): *Retrospective prediction of macroseismic intensities using strong ground motion simulation: The case of 1978 Thessaloniki (Greece) earthquake (M6.5)*, Bulletin of Earthquake Engineering, 4, pp. 101-130.

Xenidis Y., Angelides D., Tziavos I.N., Koutitas C., Savvaidis P., (2005): *An integrated framework for sustainable coastal zones management in Greece*, Accepted for publication in the WSEAS journal and proceedings as an invited paper of the conference "Energy, Environment, Ecosystems, Sustainable Development 2005", 12-14 July, Athens, Greece.

Wykorzystanie systemu GIS z użyciem internetu do zarządzania bazami danych dotyczących klęsk żywiołowych

Ioannis D. Doukas[1], Paraskevas Savvaidis[1], Ilias N. Tziavos[2], Vassilios N. Grigoriadis[2], Ioanna Papadopoulou[1], Ioannis Vavassis[3]

[1]Zakład Geodezji i Geomatyki, Uniwersytet Arystotelesa w Salonikach
University Box 465, Thessaloniki, GR-54124, Grecja
[2]Wydział Geodezji i Miernictwa, Uniwersytet Arystotelesa w Salonikach
University Box 440, Thessaloniki, GR-54124, Grecja
e-mail: tziavos@olimpia.topo.auth.gr
[3]Agiltech S.A., 18 Aetideon St., Athens, GR-15561, Grecja

Streszczenie

Klęski żywiołowe mają wpływ na wiele ważnych parametrów ekonomicznych i socjalnych i dotyczą zagadnień związanych z szerokim spektrum dyscyplin naukowych. Ich rodzaj, forma, skala, natężenie i inne charakterystyki są różne w różnych rejonach Ziemi. Jednym z obszarów, gdzie klęski żywiołowe są niezmiernie ważne (jako zagrożenia lub jako wywołane nimi zniszczenia) są tereny zurbanizowane (budynki lub infrastruktura). Złożoność klęsk żywiołowych w każdej z 5 faz ich cyklu życiowego (zapobieganie, łagodzenie, gotowość, awaryjne zarządzanie, powrót do poprzedniego stanu) wymaga wyboru specjalistycznych narzędzi w celu przewidzenia ich konsekwencji, tj. zniszczenia. Współczesne technologie zarządzania informacją przestrzenną pozwalają na sprawne zarządzanie informacją w warunkach rozproszonych baz danych, wobec czego najodpowiedniejszym narzędziem do tego celu są systemy GIS wykorzystujące do komunikacji internet (Web-GIS). W niniejszej pracy został zaprezentowany system typu Web-GIS o nazwie SyNaRMa (Information System for Natural Risk Management in the Mediterranean). Do zadań tego systemu należy zbieranie i analiza danych dotyczących takich klęsk żywiołowych jak: trzęsienia ziemi, osuwiska i pożary lasów, a także symulowanie konsekwencji klęsk żywiołowych w oparciu o realistyczne scenariusze. System umożliwia również opracowywanie prognoz oddziaływania klęsk żywiołowych na naturalne i antropogeniczne środowisko. Należy zwrócić uwagę, że otwarta architektura opracowanego systemu umożliwia dalszy jego rozwój, np. w kierunku połączenia z systemem baz danych dotyczących innych klęsk żywiołowych (np. susze, pustynnienie, tsunami, wybuchy wulkanów itp.) oraz zapewnia możliwość jego użycia na całym świecie.