PART V: CASE STUDIES, INITIATIVES AND EXPERIENCES

CHAPTER 22
LOSS SCENARIOS FOR REGIONAL EMERGENCY PLANS: APPLICATION TO CATALONIA, SPAIN

T. Susagna[1], X. Goula[1], A. Roca[1], L. Pujades[2] , N. Gasulla[3] and J. J. Palma[3].
1. Institut Cartogràfic de Catalunya, Barcelona, Spain
2. Universitat Politècnica de Catalunya, Barcelona, Spain
3. Direcció General d'Emergències i Protecció Civil, Barcelona, Spain

22.1. Introduction

The organization of human and material resources to face up to an earthquake crisis is established through emergency plans at different scales (national, regional and local). National plans often establish the criteria for preparing regional and local plans mainly based on intensity of ground shaking. However, in order to decide which counties or municipalities need to prepare a specific emergency plan, vulnerability and risk should be assessed and damage scenarios generated.

The emergency plans include various levels of intervention, bringing out an adequate amount of resources, depending on the severity of the event.

An approach was developed for the area of Catalonia, Spain, in which earthquake risk and damage scenarios are estimated. Activation levels for plans are defined in function of the focal parameters of the seismic event and on population distribution at that time.

These activation levels take into account not only ground shaking but also many other factors related to physical, human and societal vulnerability, such as the number of uninhabitable dwelling buildings, the number of homeless and the direct economic losses. All these parameters can be estimated for a regional damage scenario previously developed for an earthquake occurring at any point of the territory with any magnitude.

In order to generate damage scenarios, several methodologies exist, some of which have been developed in different chapters of this book, including those which provide detailed vulnerability and damage assessment at local scale. The example presented here corresponds to a simplified statistical approach for regional-scale assessment. This type of methodologies are useful for helping the preparation of national and regional emergency plans and other applications at this scale which do not require a very detailed analysis of building characterization. One can also apply these methods when preliminary results are required in a short time, when budget for detailed and costly studies is not available and when detailed data on buildings can not be obtained, as is particularly the case in developing countries.

22.2. Risk assessment

Catalonia is considered to be in general a region of moderate seismicity. However, there are some areas in which the probability of occurring situations of seismic emergency is higher. The studies to identify these zones are presented in the SISMICAT, the Seismic

C. S. Oliveira, A. Roca and X. Goula (eds.). Assessing and Managing Earthquake Risk, 463 - 478.

Emergencies Plan of Catalonia (DGEiSC, 2003), covering the following three main aspects:

1) The seismic hazard assessment gives an estimation of the intensity of the seismic action that can be reasonably expected in each municipality of Catalonia.
2) The seismic vulnerability assessment gives an estimation of the damages that the seismic action can cause on the exposed structures considered in each municipality: dwelling houses and buildings with other uses for the population, essential services for the community, and constructions that, due to their activities, could significantly increase the damage and even induce catastrophic effects.
3) Through the combination of these two components, hazard and vulnerability, risk scenarios for each municipality of Catalonia can be elaborated and therefore the populations at higher risk can be identified.

22.2.1. SEISMIC HAZARD ASSESSMENT

With the purpose of preparing the necessary information to carry out a correct evaluation of the seismic hazard (see Chapter 2 of this book) the Cartographic Institute of Catalonia (ICC) elaborated a new earthquake catalogue (Susagna and Goula, 1999) that collects and unifies seismic information from various existing sources and from new researches. Also a new seismotectonic zonation based on geologic and seismic criteria was made (Fleta et al., 1996). The seismic hazard assessment was then carried out combining deterministic and probabilistic methods that consider these new data (Secanell et al., 2004).

The map that determines the different areas of the territory based on its seismic hazard, considering the soil effect, is the map of seismic zones, which is presented in Figure 22.1 in terms of intensity values for an annual probability of $2x10^{-3}$ (equivalent to a return period of 500 years)

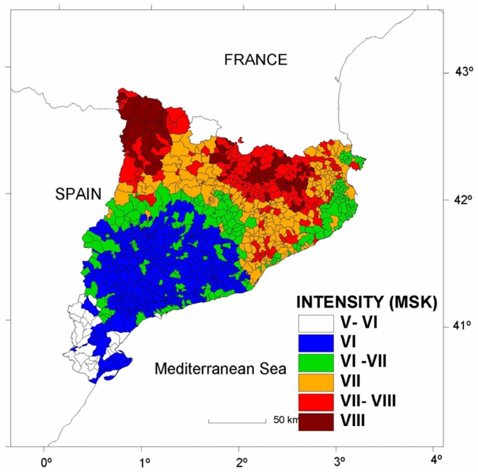


Fig. 22.1. Seismic hazard map for 500 years return period taken into account soil effects

22.2.2. VULNERABILITY ASSESSMENT

For the evaluation of seismic vulnerability, different methods have been considered, depending on the type of elements at risk: for dwelling or similar buildings (hospitals, firemen stations) methods are based on their constructive and structural properties (see Chapter 6); for lifelines (gas and electricity conductions, electric transforming stations, etc.) methods are based on their specific technical characteristics (see Chapter 9). A detailed local-scale vulnerability assessment requires a previous collection of detailed data of each element at risk. This is always a very hard and costly task that can not be carried out in a first approach for a general, regional level, emergency plan. Instead, for a first regional-level evaluation simpler techniques, of a general statistical character, have to be used. Therefore, the methods used here have in common that they consider damages to be caused by seismic actions expressed in terms of macroseismic intensity based on the new scale of intensities EMS-98 (Grünthal, 1998) which completes the definition of the scale of intensity MSK, considered for the seismic zones map in Figure 22.1 The present construction typologies can be expressed without too many difficulties in terms of the typologies defined in EMS-98 and the expected damages for a certain intensity can be deduced from a matrix of probability of damages in agreement with this scale.

The methodology applied to dwelling buildings has a statistical character to make use of easily available statistical data, without needing a hard search for detailed information on individual buildings that requires intense fieldwork. This implies that the results obtained for each municipality, which is the selected unit of work, always refer to global values, without giving detailed results for individual buildings.

A first approach to the vulnerability assessment of hospitals and firemen stations was also required. The same approach for dwelling buildings has been applied introducing the concept of a probabilistic individual building assessment, as presented in 22.2.4. It is clear that when knowledge about the seismic behaviour of a specific building is required, as is the case of those with essential services for the community, further detailed analysis would be needed, but as a first approach, the "probable" response of some individual building can be assessed, associating to this individual building the statistical vulnerability distribution of the class of buildings it belongs to.

The classification of the dwelling buildings of Catalonia (near a million), according to the defined classes of vulnerability in the EMS-98, has been elaborated from data from the buildings census made in 1990 by the Institute of Statistics of Catalonia (IEC); the available information is the age, the height and the geographic location of the buildings.

The age and the height are clearly associated to the seismic vulnerability of the buildings. The age not only has importance by its effect on the process of loss of the resistance of the building but is indicative of constructive techniques, variable throughout time. According to information collected by specialists it has been possible to make three groups of buildings according to the period of construction: previous to 1950, between 1950 and 1970 and after 1970. On the other hand, the height influences the response of the buildings to a seismic action. In the case of the buildings of Catalonia, that have been constructed to hold gravitational loads solely, this parameter has served to differentiate buildings that have a safety margin with respect to which they are in the resistance limit. Buildings were classified by height in three ranges: low, up to 12 m (less than 5 plants), high more than 18 m (more than 5 plants) and the buildings of intermediate heights (5 plants, 15 m). The fact that buildings are in an urban or rural area is also considered. Table 22.1 shows the distribution of the dwelling buildings of Catalonia (aprox. 935,000) according to the three indicated groups.

Table 22.1. Distribution of dwelling buildings of Catalonia by height, age and location

Date of Construction		Pre – 1950		1951-1970		Post - 1970	
Geographic Situation		Urban	Rural	Urban	Rural	Urban	Rural
Height	< 5 stories	232740	31119	212070	16304	315504	37346
	= 5 stories	7065	9	14083	24	11937	22
	> 5 stories	12699	2	21963	33	22028	44

As it is shown in Table 22.1, most of the buildings of Catalonia, around 90%, are located in urban nuclei. A similar percentage is observed for the low rise buildings (less than 5 stories). When looking at the age of the buildings, a large percentage of the construction has taken place since 1970, as 41% of the buildings were built after that date.

The different building structural typologies existing in Catalonia were identified by age of construction. Additional knowledge on state of conservation of the building stock in the study region has also been considered. Weighing all the information available, within the criteria of the EMS-98 and the judgment of experts allowed a classification of the buildings of Catalonia into 18 Typologies described, by Chávez (1998) as percentages of vulnerability classes A, B, C and D of the EMS-98, in function of the three above mentioned parameters: age, height and location in urban or rural area (Table 22.2).

Table 22.2. Classification of buildings in Catalonia in vulnerability classes, according to EMS-98

	< 1950		1951-1970		> 1970	
	Urban	Rural	Urban	Rural	Urban	Rural
< 5 plants	20% A + 80% B **Typology 1**	30% A +70% B **Typology 4**	5 % A + 50% B + 45%C **Typology 7**	15 % A + 70% B + 15%C **Typology 10**	85%C +15%D **Typology 13**	5% A + 20% B + 65%C + 10%D **Typology 16**
= 5 plants	20% A + 80% B **Typology 2**	40% A + 60% B **Typology 5**	10% A + 60% B + 30%C **Typology 8**	20% A + 70% B + 10%C **Typology 11**	5% A + 20% B + 65%C + 10%D **Typology 14**	10% A + 30% B + 55%C + 5%D **Typology 17**
> 5 plants	40% A + 60% B **Typology 3**	60% A + 40% B **Typology 6**	15 % A + 70% B + 15%C **Typology 9**	30% A + 65% B + 5%C **Typology 12**	8% A + 27% B + 60%C + 5%D **Typology 15**	15% A + 45% B + 40%C **Typology 18**

22.2.3. LOSS ESTIMATION

An estimation has been carried out of the damages that can afflict buildings in the different municipalities for the intensities of the map of seismic zones presented in Figure 22.1. In addition, as a result of the damage caused in the buildings, a scenario of the consequences for the population of each municipality has been made.

22.2.3.1. *Loss estimation to dwelling buildings*
The estimation of the damage has been made by means of probability damages matrices that have been determined for the classes of vulnerability A, B, C, D, E and F, the degrees of damages of 0 (no damage) to 5 (total collapse) and the degrees of intensity (VI to X) of the EMS-98 scale (Chávez, 1998; Chávez et al., 1998). An example for intensity VIII is presented in Figure 22.2.

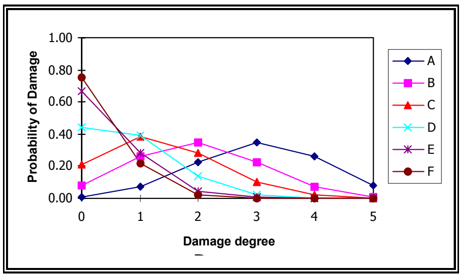


Fig. 22.2. Probability damages matrix for intensity VIII

As a result of the evaluation of the physical damage, the number of buildings of each municipality distributed according to the different damage degrees is obtained. From the damage experienced by the buildings has been elaborated an estimation of how many of them could stay in uninhabitable conditions, considering those that undergo the degrees of damages 4 and 5 to be in this state as well as 50% of those that experience damage 3. These results are of maximum importance for the evaluation of the possible number of homeless after occurrence of the earthquake.

The estimation of the number of buildings for each municipality that would be uninhabitable, considering the seismic action defined in Figure 22.1 is shown in Figure 22.3.

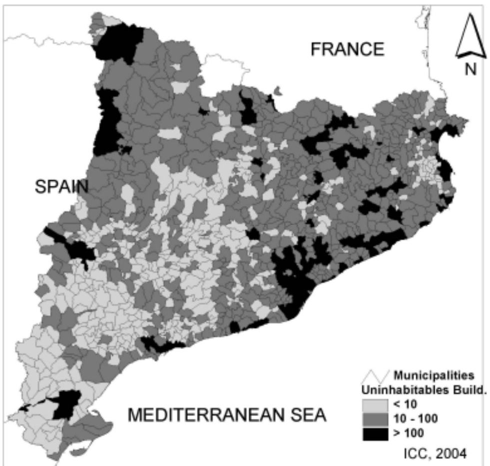


Fig. 22.3. Map with the estimation of the number of uninhabitable buildings for each municipality for the degrees of intensity considered in the map of Figure 22.1

The results of these estimations show that a great number of municipalities, near 400, would not be much affected, i.e., would have less than 10 uninhabitable buildings; approximately a half of municipalities of Catalonia would have between 10 and 100 uninhabitable buildings and less than 100 municipalities would have more than 100 uninhabitable buildings.

22.2.3.2. *Estimation of human casualties*

The possibility of having human victims as a result of the action of an earthquake is directly related to the number of buildings damaged and to the number of persons that live there. But it also depends on other circumstances such as the season, the day of the week and the hour of the earthquake occurrence and the preparedness of the people in charge of Civil Protection and the citizens requiring face first aid.

In a first approach the number of victims of different severity can be estimated using damage data from past earthquakes (Coburn and Spence, 1992) considering the results of damaged buildings that have been previously obtained together with data of the population census.

The result obtained is that in most of the municipalities, more than 800, the average number of people by building is less than 5 and only some municipalities, such as Barcelona and others of their zone of influence, arrive at average values of almost 30 inhabitants per building. A map with the estimation of the number of homeless due to the non- inhabitability of their houses, for each municipality, is shown in Figure 22.4.

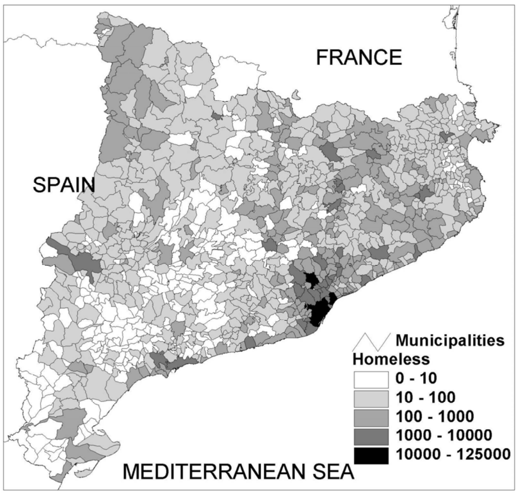


Fig. 22.4. First estimation of the distribution of the number of homeless in the different municipalities for the intensities given in the hazard map

The inhabitants of almost two thirds of the total number of municipalities of Catalonia would not be much affected by an earthquake (less than 100 people per municipality). The upper bound corresponds to the city of Barcelona with a total of more than 100,000 people that could become homeless, in case of occurrence of the intensity indicated in this municipality in the map of seismic zones of Figure 22.1.

22.2.4. DAMAGE ESTIMATION AT HOSPITALS

An estimation of the damages that the hospitals could suffer, considering the intensities of the map of seismic zones presented in Figure 22.1 and the classification of the buildings in the 18 defined typologies (table 22.2) has been carried out. Each typology has a characteristic behaviour that has been calculated using the probability damages matrices and the distribution of the buildings in vulnerability classes. The percentage of each damage degree (from damage 0, to damage 5, collapse of the building) that can undergo the building by different intensities has been obtained (González et al., 2002).

For each typology the distribution of the probability of damages for each degree of damage and each intensity has been plotted. Also the different behaviours of the buildings have been grouped on the basis of the morphology of the curves of probability of damages (Figure 22.5). Four classes of behaviour are defined as a response to the seismic action:

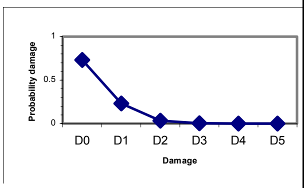
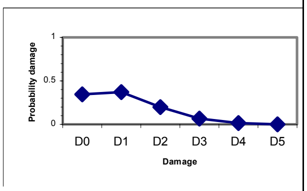
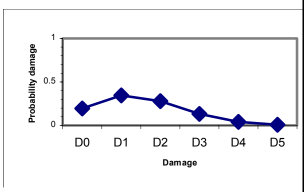
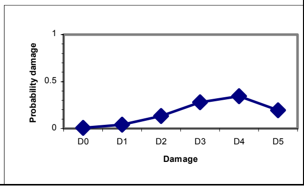
<table>
<tr><th>BEHAVIOUR BUILDINGS</th><th>FEATURES</th><th>INSTALLATIONS</th></tr>
<tr><td>
</td><td>BEHAVIOUR 1
Less than 10% of damage > D2</td><td>Undamaged</td></tr>
<tr><td>
</td><td>BEHAVIOUR 2
Between 10-40% of damage >D2 Between 0-15% of damage >D3</td><td>Operative</td></tr>
<tr><td>
</td><td>BEHAVIOUR 3
40% or more of damage >D2 Between 15-40% of damage >D3</td><td>Not Operative Inhabitable</td></tr>
<tr><td>
</td><td>BEHAVIOUR 4
More than 50% of damage >D3 More than 20% of damage >D4</td><td>Not Operative Uninhabitable</td></tr>
</table>

Fig. 22.5. The different behaviour of the hospitals based on the curves of probability of damages

- Behaviour 1 means that after the earthquake the building would be undamaged and stay able to continue with its functions.
- Behaviour 2 means that after the earthquake the installation is still operative, but an inspection of all the facilities is recommended.
- Behaviour 3 means that after the earthquake the installation would be out of service, although the building continues being inhabitable. An inspection of the building is recommended in this case.
- Behaviour 4 means that it will be necessary to evacuate the building.

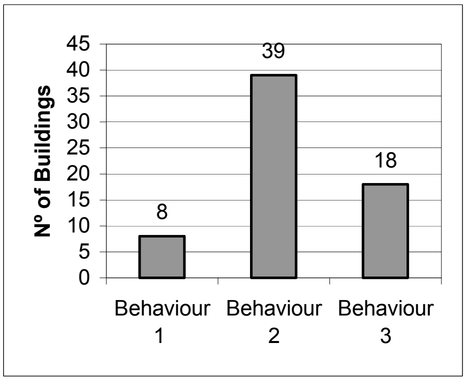


Fig. 22.6. Number of hospitals for each type of behaviour

The number of hospitals corresponding to each behaviour type is shown in Figure 22.6: 8 hospitals would have Behaviour 1, 39 would have Behaviour 2, 18 would have Behaviour 3 and no hospital would have Behaviour 4.

Further developments concerning analysis of hospital systems have been discussed in Chapter 12.

22.2.5. LOSS ESTIMATION IN LIFELINES

The lifelines are constituted of those infrastructures that are essential for the normal development of human activity and, in general, include lines that make possible the mobility of merchandise and people (transport), great lines of energy and basic elements provision, as for example, water, electricity, gas and fuels and, finally those that ensure communications (see Chapter 9).

In order to consider the damages in the lifelines, the methodology proposed by the "Applied Technical Council" (ATC), from California and in particular, methods ATC-13 (1985) and ATC-25 (1991) developed under the sponsorship of the Federal Emergency Management Agency (FEMA) have been applied. These methods are of easy use if the data on the elements to be analysed are available; this aspect is very important due to the great number of elements to be considered. It is necessary to say that the obtained results are of statistical nature and that allow only to give a first plot of the most vulnerable points of the lifelines in the study region. More detailed specific studies will have to be carried out in the elements of highest vulnerability or of highest strategic importance.

With this methodology the following lifelines have been analysed: road network, railway transport, electrical system, water supply, gas network and dams.

Each lifeline is considered to be constituted by basic elements: walls, bridges, highways, electrical lines, mechanical equipment, electrical equipment, etc. Each basic element has a vulnerability function that relates the intensity of the earthquake to the proportion of damage that the basic element will undergo. From the determination of the damage of each one of the basic elements that compose the lifeline the damage of this line can be assessed.

The classic scales of intensity profit from the experience of a great number of earthquakes and, for example, scale MSK refers to damages to lifelines only from intensity degree VIII (sometimes the rupture of some joints of pipelines takes place). For intensity IX the scale indicates considerable damages in deposits of liquids, partial breaking of underground canalisations and, in some cases railroad bending and interruption of highways service. For intensity X dangerous damages in dams, serious damages in bridges, railroads turned aside and, sometimes, waved, underground conductions turned or broken, and pavement of the streets and asphalt suffering great undulations are envisaged. Therefore, it is not very probable that damages on lifelines in areas with intensity VI or VII appear.

The obtained results show that, in general, lifelines have a good behaviour for the levels of intensity associated to a return period of 500 years (always lower than or equal to VIII). The more significant damages would take place mainly in the mechanical and electrical equipment and in those of high technology that form part of the transport and communications nets of electricity, gas and water, of the great networks of transport like for example freeways and railroads and those of the communication systems (telephone, radio, television, among others). It is therefore in the pumping stations, the transforming stations and substations and the communications centres or other centres equipped with equipment of high technology where it can be expected that incidences arise in case of earthquakes of intensity VII-VIII and VIII.

22.3. Damage scenario mapping: a tool for emergency preparedness

A methodology has been proposed to generate damage scenarios that gives an estimation of the possible effects of a given earthquake for the preparation of emergencies. The method can also be used to give a first damage estimation, immediately after the occurrence of an earthquake.

The main objective of the simulation of damage scenarios is to carry out a quick evaluation of the possible intensities that could have been felt in each municipality of the region, the number of persons that could have felt the earthquake with each intensity degree and the surface (km^2) of the affected area for each intensity degree. If the earthquake has an intensity high enough to produce damages, the method gives an estimation of damages to buildings, human casualties and economic losses.

This methodology can be also used to simulate the damages of historical damaging earthquakes if they would occur today. The simulation of damages corresponding to an earthquake scenario similar to that of one of the largest earthquakes that occurred in the Pyrenees in historical times will be shown in 22.3.2.

Another application of the methodology is the zonation of the territory in order to establish the criteria for activation of different levels of the earthquake emergency plan according to the severity of the estimated consequences of the events.

22.3.1. METHODOLOGY

The methodology consists of three steps:

1) Estimation of epicentral intensity. If the epicentre depth and magnitude of the earthquake are known, it is possible to estimate the epicentral intensity from a correlation between magnitudes and intensities felt by the population in the last years.
2) Intensity attributed to each municipality. It is necessary to adopt a law of attenuation of the intensity versus the distance. The relationship used for Catalonia has been fitted to the intensity data points contained in the database of felt earthquakes (Susagna et al., 1996; 2001).
3) Estimation of damage in buildings, assessment of the human casualties and evaluation of economic losses. In the case of intensities greater than V these computations are carried out following the methodology presented in 22.2. The number of uninhabitable buildings, the number of homeless, and the damages to the people are also computed. Data on building occupancy (inhabitants / building) for each municipality and average surface of the houses are used. The economic losses produced by the damage to the buildings are estimated and, finally, are expressed in terms of the Gross National Product (GNP). The surface that could be covered by debris is also estimated.

A Geographical Information System (GIS) is used in this application - *ESCENARIS V1.00* (RSE, 2003) - to visualise the results together with different information layers. An example of a scenario map and list of municipalities is shown in Figure 22.7.

22.3.2. DAMAGE SCENARIO FOR AN EARTHQUAKE SIMILAR TO AN HISTORICAL ONE.

The earthquake that occurred in 1428 in the *Ripollès* (Girona) near the border between Spain and France is one of the greatest seismic events that the region has suffered in the past. Chronicles and other documents contemporary to the event report effects in a quite extensive way, including destruction of towns, churches, castles, etc., and the death of 800 people (Banda and Correig, 1984; Olivera et al., 2005). This is the reason for the interest in the simulation of a scenario of the possible effects of an earthquake like this one of 1428 if it occurred at the present time.

In this case, the attenuation of the intensity with the distance has been fitted with the values of epicentral intensity and intensities in several localities given by Banda and Correig (1984). A map with the simulation of intensities possibly felt in each of the present day municipalities of Catalonia is shown in Figure 22.8 (González et al., 2001).

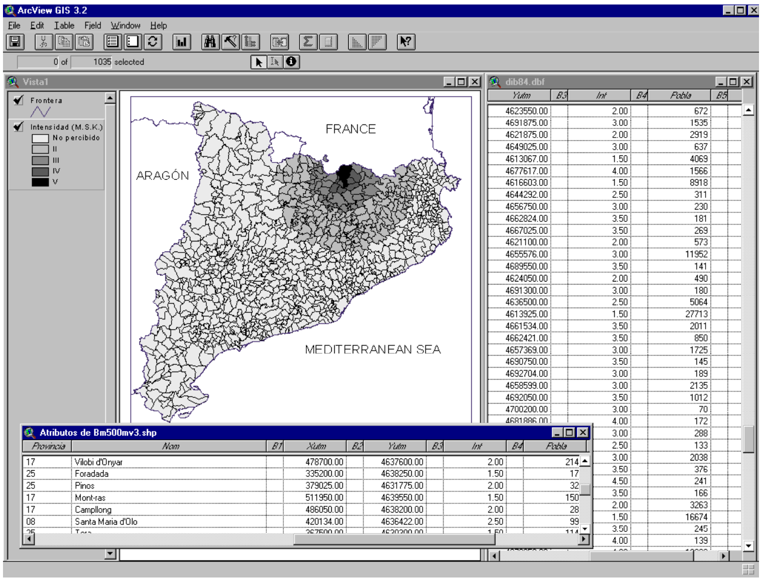


Fig. 22.7. Example of a scenario map with the list of municipalities for an earthquake of M=4.0 in the Pyrenees

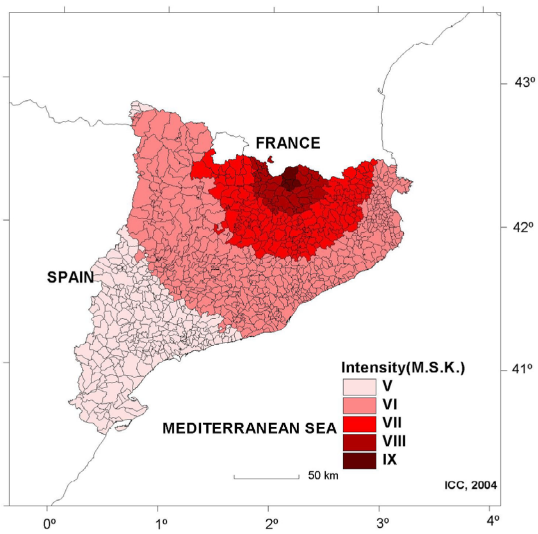


Fig. 22.8. Probable felt intensity map for the earthquake that occurred in the *Ripollès* in 1428, Imax = IX

An estimation of the different damage grades, affecting the dwelling buildings of each municipality as well as the number of homeless and victims has been done. A summary of damages for the whole of Catalonia has been completed. The results are shown in Table 22.3. The estimated *destroyed area* refers to the probable surface with debris. The direct economic cost of the resulting damage - only referred to the dwelling buildings -

is about 8% of the annual GNP of this community. Other direct costs related to installations other than dwellings and indirect costs (e.g. related to the interruption of services and interruption of economic activities) are not considered.

22.3.3. CRITERIA OF ACTIVATION OF THE PLAN OF SEISMIC EMERGENCIES IN CATALONIA (*SISMICAT*)

22.3.3.1. *Present situation*

The emergency plans include various levels of intervention (ALERT, EMERGENCY 1 and EMERGENCY 2), bringing out the adequate amount of resources, depending on the severity of the event.

Table 22.3. Earthquake scenario simulation for an earthquake in the Ripollès of Imax=IX

Uninhabitable buildings	Homeless	Economic losses (M€)
23 570	136 901	4 978

Economic losses (%GNP of Catalunya)	Destroyed Area (m^2)
8	207 712

These activation levels are defined in the current plan (SISMICAT) taking into account the ground shaking and the population density.

Three types of zones are distinguished, according to their population density: Zone A, Zone B and Zone C, constituted by municipalities with population density (inhabitants per $km^{2)}$ greater than 100, between 10 and 100 and less than 10, respectively (Figure 22.9).

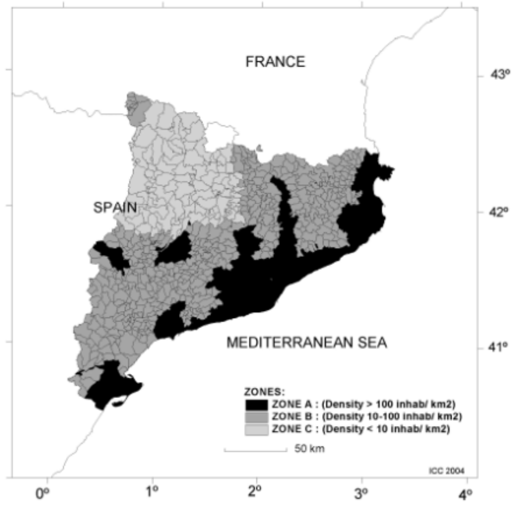


Fig. 22.9. Map of zones according to their population density

The activation levels are defined as follows:

- *Alert*: The Alert level is activated when wide preventive and control measures are required. The activation in this phase of alert implies a warning to the acting groups, information to the involved organisms and services, information to the population if requested, and follow-up of the tasks to be done. Actions from Security and Intervention groups are only considered in a preventive way.
- Emergency 1: It entails putting into operation of the organizational structure of emergency management with the general or partial mobilization of the tools and means assigned to the plan. The SISMICAT plan is activated in emergency 1 when a seismic event with important, but local and limited effects on the territory takes place. This situation will be evaluated from the information available at the moment of the emergency considering the following criteria: the degree of affect on the population and the kind of actions required (e.g. information, evacuation, etc.), the geographical extension of the crisis (e.g. number of affected municipalities) and the tools needed.
- Emergency 2: The plan is activated in Emergency 2 when the seismic effects affect an important extension of the territory on the basis of the same criteria above mentioned.

A synthesis of the criteria adopted in the SISMICAT Plan for triggering the above defined activation levels, for each zone of the territory, from felt intensity and complementary data is shown in Figure 22.10 and in Table 22.4. The Pre-Alert level corresponds, as it is indicated by its name, to a non-activation of Civil Protection Services.

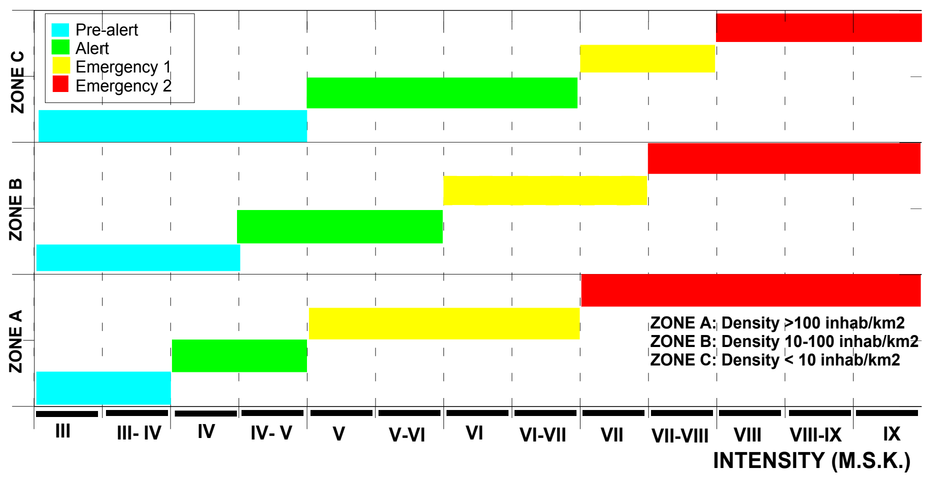


Fig. 22.10. Different level of activation of the emergency plan, depending on the intensity of the seismic action and the population density (zones A, B and C)

Table 22.4. Criteria of activation of the different levels on the basis of population density, macroseismic intensity and other additional criteria from information on effects. (* *comarca* is an administrative division comprising a number of municipalities)

Activation evels	**Intensity**			**Other criteria**
	Zone height density populate (A)	**Zone medium populate (B)**	**Zone low populate (C)**	
ALERT	IV to IV-V	IV-V to V-VI	V to VI-VII	Some people with minor injuries 1-10 homeless
EMERGENCY 1	V to VI-VII	VI to VII	VII to VII-VIII	1-10 dead people 10-100 homeless Panic Failure of basic services (local level) Possibility of dominoes effect
EMERGENCY 2	≥VII	≥VII-VIII	≥VIII	>10 dead people >100 homeless Failure of basic services (at the scale of *comarca**) Domino Effect ,with activation of other special plans.

22.3.3.2. *A tool for the definition of the level of activation*

These activation levels can be defined taking into account not only the estimation of ground shaking but also other factors related to physical, human and societal vulnerability, such as the expected number of uninhabitable dwelling buildings, the number of homeless or the direct economical losses. All these parameters can be estimated for a regional damage scenario developed previously for an earthquake occurring at any point of the territory with any magnitude.

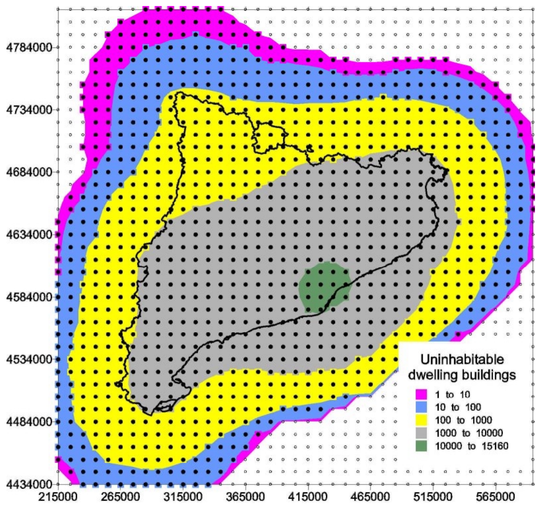


Fig. 22.11. Number of uninhabitable dwelling buildings after an earthquake of M5.5, occurring at each point of the grid

The methodology proposed is based on a graphical representation that concentrates all the regional damages estimated for an earthquake on its epicentre. Then, each point of the territory can be characterized by the severity of damages caused by an earthquake with epicentre in this given point, for each possible magnitude. The same methodology explained in the preceding sections has been applied to compute damages. As an example of the method, the number of uninhabitable dwelling buildings that would be observed after an earthquake of M5.5 is shown in Figure 22.11.

If the value of one parameter of damage is fixed, it is possible to construct new maps with the magnitude of the earthquake needed at any point of the grid to produce this damage.

A seismic zonation proposed for an emergency plan activation is shown in Figure 22.12 and in Table 22.5 (Reinoso et al., 2003). In this table the ranges of magnitude are defined for each zone and for each level of activation, indicating the grades of damages expected (Figure 22.12).

With the aid of the zonation established on this basis, immediately after an event detected by the seismological network, the preliminary level of intervention can be quickly decided.

This procedure will then be implemented in connexion with the real-time VSAT transmissions based regional seismological network of the ICC to provide the Civil Protection authority with fast information to trigger e adequate levels of activation of the Seismic Emergency Plan.

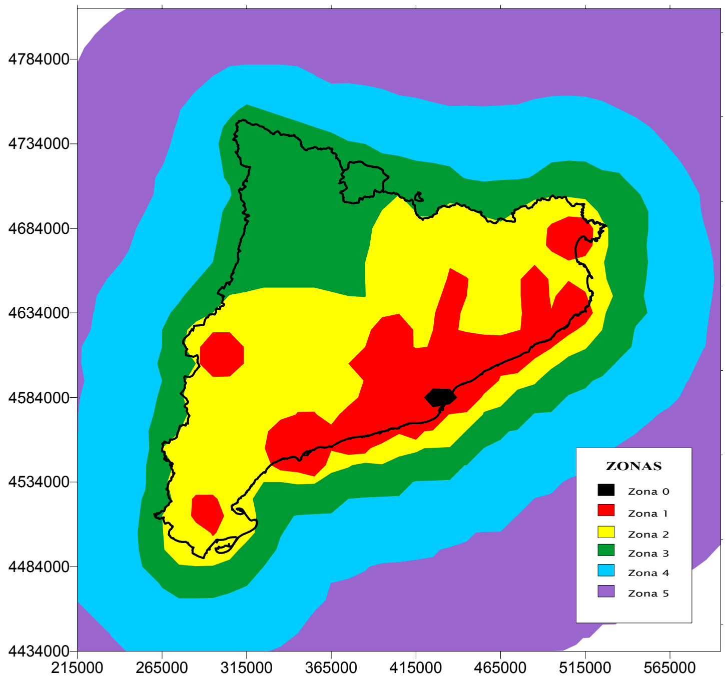


Fig. 22.12. Seismic zonation proposed for activation of the emergency plan

Table 22.5. Ranges of values of magnitude for each zone and for each level of activation

Seismic criteria for emergency plan activation			
ZONES	**Alert** More than 25 000 inhabitants feel an earthquake with intensity ≥ IV	**Emergency 1** Uninhabitable dwelling buildings: < 500 Homeless: < 2.000 Losses: < 180 M€	**Emergency 2** Uninhabitable dwelling buildings: > 500 Homeless: > 2.000 Losses: > 180 M€
0	Magnitude 3.8 to 4.3	Magnitude 4.3 to 4.6	Magnitude > 4.6
1	Magnitude 3.8 to 4.3	Magnitude 4.3 to 4.8	Magnitude > 4.8
2	Magnitude 4.0 to 4.6	Magnitude 4.6 to 5.1	Magnitude > 5.1
3	Magnitude 4.3 to 4.8	Magnitude 4.8 to 5.4	Magnitude > 5.4
4	Magnitude 4.6 to 5.1	Magnitude 5.1 to 5.9	Magnitude > 5.9
5	Magnitude 5.1 to 5.6	Magnitude 5.6 to 6.1	Magnitude > 6.1

Aknowledgements

The methodology for damage assessment was developed by Justina Chávez in her PhD Thesis. She had the support of Josep Presmanes and Fructuós Mañá for the classification of vulnerability typologies. Marta González adapted the algorithms to the application of damage scenarios, which was automated by Núria Romeu in the ESCENARIS v1.1 code. Edwin Reinoso developed the methodology for the seismic zonation for activation levels. We are grateful to all them for the help provided.