European Federation of Geologists (EFG)

Advice Document

to the

European Commission

on

Civil Protection and Natural Hazards

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Abstract

The observed increasing numbers of natural disasters, together with the increase in number of victims and significant impacts on socio-economic infra-structure requires active development of prevention and mitigation measures. An initiative of the European Commission has been launched to work on an integrated strategy of prevention and mitigation measures, to reduce the number of disasters and/or reduce the damage to infra-structure, economics and social life.

Better understanding of the mechanisms behind natural hazards is required. This will provide a better insight into the problems and will subsequently lead to application of the best preventative methods. Geology is involved in most natural hazards and is therefore an important factor that should definitely be taken into account.

The initial focus in this strategy should be directed to those hazards with highest risk and greatest impact. These include floods, land slides and earthquakes.

A lot of research has already been carried out regarding geo-hazards. An inventory of all the available information is therefore highly recommended as a first step. This can in part be done by the groups of experts.

Groups of experts should be set up to exchange knowledge and expertise. They can provide the European Commission with invaluable background information on each hazard, on geoscientific research techniques that should be applied and they can provide recommendations for measures to be taken. The European Federation of Geologists (EFG), which covers a very broad field of expertise in the Earth Sciences, is currently working on the establishment of a network of geo-hazard experts throughout Europe. The EFG can act as communication platform and link between the European Commission and the geo-hazard experts.

European Federation of Geologists - EFG

The European Federation of Geologists (EFG) was first established in 1980. The nations at present represented in the Federation as Full Members are; Belgium, Czech Republic, Finland, France, Germany, Hungary, Iceland, Ireland, Italy, Luxembourg, The Netherlands, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, Switzerland and the United Kingdom. In addition to these Full Members, Bulgaria, Norway, Romania, Turkey and Canada are present as Observer Members, while the American association is an Associate Member Its mission is to promote the profession and practice of Geology and its relevance.

Activities of the EFG are manifold and are all focussed on geo-scientific professional affairs and the geo-scientific contribution to society. One of its main tasks is the coordination of activities in preparing briefing papers and advice documents on geological issues and presenting these to European bodies, national governments and other relevant organisations. Besides, the EFG considers it as its task to safeguard and promote the present and future interests of the geological profession in Europe by focussing on work mobility between different European countries, by promoting the harmonisation of education and training, to promote the code of professional ethics of the EFG and to promote the establishment of continued professional development systems to create a high standard of qualified professionals.

The European Federation of Geologists covers a very broad field of expertise in the Earth Sciences with respect to natural hazards. This expertise ranges from engineering geology to hydro-geology and from understanding the mechanisms behind earthquakes and volcanoes to knowledge on fluvial (river) systems and coastal erosion.

The EFG are in contact with all types of geological companies and institutes, such as the geological surveys (also represented by the EuroGeoSurveys), water management bodies, universities, research institutes, engineering industries and environmental analysis companies. The EFG has recently initiated a project to set up groups of experts on different geological topics that are of relevance to society. Our goal in this EFG-project is to bring together experts from all European countries and to create a platform for the exchange of knowledge and expertise. This will lead to the ability to provide advice documents and recommendations that are based on the view of experts from all corners of Europe, instead of being based on the view of just a few research institutes. Until now we have been supported by all national geological associations, by geological surveys (in co-operation with EuroGeoSurveys), by special research institutes on geo-hazards, by special national working groups on geo-hazards and so on. These have all provided contribution to this document and are willing to participate in advising the European Commission in this project on civil protection and natural hazards.

This broad network of expertise is a powerful and important tool, which will be of significant use to the European Commission in providing knowledge and advice from the geological perspective in this project on Civil Protection and Environmental Accidents, as well as in future projects. The European Federation of Geologists therefore considers itself as being a very useful platform and link between the European Commission and these geo-scientific experts throughout Europe.

1. Introduction

The European Commission is planning to adopt by May 2003 a Communication on Civil Protection and Environmental Accidents. After the major impacts of flooding in Germany, Austria and several applicant countries last year, the European Commission became increasingly aware of the necessity to improve civil protection from these and other natural hazards. It has been noticed that the number of natural disasters has increased in the last few years, emphasising the need for action. Based on a Communication from the European Commission to the European Parliament and Council (28.8.2002 – COM (2002) 481) on these Central European floods, an initiative has evolved to work on integrated EU strategy on prevention, preparedness and response to natural, man-made and other hazards.

This integrated EU strategy is necessary because of the increasing number of natural disasters, together with a higher number of victims and their enormous economic impacts. These disasters are in part related to population growth, moving more and more into geo-hazardous areas, but are also related to climate change. The analysis on civil protection for natural hazards is not only focussed on the reduction of the number of victims, as with traffic accidents, but there is also focus on complete destruction of the infra-structure, economy and the social life of people.

The better we understand the natural mechanisms and the behaviour and properties of the subsurface, the better we can set up mitigation measures that can ultimately lead to prevention or full preparedness to these threatening hazards. Clearly, Geology is an important factor that should not be overlooked in this respect.

This document will provide information on the central role that Geology has in identifying areas of natural hazard risk and recommending the appropriate mitigation measures. Geo-scientific techniques that are recommended to be used in natural hazard analysis will be briefly described. Also, information will be provided on how much has already been done regarding research on geo-hazards, creation of risk maps and other activities.

2. Background on natural hazards

In this document we will only focus on the hazards in which geology is involved. These include most of the natural hazards, and are often referred to as geo-hazards.

It has been observed that the number of natural disasters in Europe has significantly increased in the last few decades, not just in frequency but also in magnitude of destruction. This is a trend that is observed worldwide. The number of victims, the enormous economic, infra-structural and social impacts are a major cause for concern to government agencies and to civil society.

- Statistics

On Worldwide scale the following is observed: In the period 1980-2000 the total number of deaths related to natural hazards are 1,211,159 (source: CRED). Deaths directly related to selected geo-hazards are reported as:

Geo-hazard	Number of deaths 1980-2000
Floods	170,010
Earthquakes	158,551
Volcanic eruptions	25,050
Land slides	18,200

The United Nations has established that the total costs associated with natural disasters has risen 10 fold in the past 40 years. Recent Earth quakes in Turkey (1999), El Salvador (2001) and India (2001) caused loss of 40,000 lives and made many more homeless, running into costs of tens to hundreds of billions of Euros.

In 2001, natural hazards caused over 25,000 deaths, which is twice the number of lives lost in 2000.

The 1999 World Disaster Report estimated that in the period 1988-1997 landslides alone caused 9000 deaths worldwide and total damages of approximately 450 million Euros.

At European scale, we also observe increasing numbers of natural disasters, and with significant numbers of victims and financial costs. For example, **Italy** has a high vulnerability for geo-hazards. Since 1968 to the present date a total of 4,000 deaths have been registered due to earthquakes, whereas the number of persons forced to abandon their houses have been about 792,000. Related costs are estimated to be approximately 50 billion Euros. Landslide hazards are present in more than fifty percent of Italy and have caused 2,447 deaths between 1945 and 1990. Floods have become more frequent in Italy during the last decade, with a total of 2,345 registered fatalities between 1948 and 2002.

Floods in **Central Europe** also occur more frequently, especially in Germany, Austria, Belgium, the Netherlands, Hungary and applicant countries. The flooding event from last year is expected to have cost at least 50 billion Euros, and is expected to rise further due to ongoing reconstruction work. In **Hungary**, the two highest registered floods occurred in the last three years. The six warmest years were in the last ten years. Meteorological measurements in the **United Kingdom** reported that the autumn in 2000 was the wettest since records began in 1766. Some areas in the United Kingdom saw the worst floods for 300 years. The largest part of **the Netherlands** is below or just above sea level. Keeping in mind the climate change and sea level rise, the Netherlands is at potentially high risk.

Problems related to land subsidence are estimated to cost in excess of 600 million annually in the United Kingdom (Earls, 2003).

Many more examples can be provided, but the aim of the above is to illustrate the necessity to take preventive and mitigation measures to reduce the number of victims and to reduce the damage to the socio-economic infra-structure.

- Regional variation

Each country has to deal with natural hazards, but the type, frequency and intensity varies from region to region and from country to country.

All European countries are confronted with floods and land instability. The latter includes land slides, but also subsidence due to gas extraction, collapse of old mines, etc. (see section 4.1.1).

Other hazards, such as earthquakes, vary in intensity from country to country. Southern Europe can be hit by intense earthquakes, in contrast to low-scale earthquakes in northern Europe, as for example in Sweden and the Netherlands.

Health risks associated with naturally occurring high radon and trace element values in rocks and soils are present to varying degree throughout the Community.

- Way forward

It is obvious that the geology of an area plays a dominant role in the degree to which these hazards are present. Clearly therefore the better we understand all geological processes in Europe, the better we are able to deal with the problems. For example, the better we understand the subsurface with respect to fault structures and the stress and strain in the Earth's crust, the better we are able to identify and localize risk areas for earthquakes.

Good understanding of all geological processes will lead to better insight in how and what type of prevention or mitigation measures should be taken. Explanation of the geological contribution in each natural hazard will be described in section 4.1.1.

Instead of trying to deal with all hazards at the same time, it is recommended that initial focus be directed to the most high risk hazards and which have greatest impact on society. These include: floods, land slides and earthquakes. These types of geo-hazard are therefore given most attention in this document.

Furthermore, it is recommended to take this project step by step, without loosing ourselves in too much detail.

The first phase should focus on establishing the current state of knowledge. It appears that in many, if not all countries, initiatives have been taken to analyse natural hazards. Many types of mitigation measures have also been developed and are in use by many countries. It is therefore of importance to bring together experts on these topics from all European Union member states and applicant countries to exchange knowledge and expertise.

Secondly, historical disaster-maps should be created (if not already available) to localize potential future risk areas for each natural hazard, starting with the three main hazards.

In the third phase the historical disaster-maps should be integrated with other information such as cities, rail roads and industry. This will indicate areas with high risks for people and society.

Following from this, best practice methods can subsequently be developed by the experts and the European Commission on how best to analyse and monitor the identified vulnerable areas.

Studies can then be initiated to find the best prevention or mitigation measures, using knowledge resulting from previous steps.

3. Existing Community instruments

A lot of work regarding analysis and prevention of natural hazards has already been done in each country. A quick investigation under all European national geological associations resulted in a list of national institutes, organisations, working groups and individual experts. These include the Geological Surveys, research institutes, special university departments on geo-hazards, working groups on geo-hazards within a national geological association, water management bodies, companies and consultancies that are involved in geo-hazard research, etc..

To illustrate:

- Recently an international Centre for Geo-hazards (ICG) has been set up in Norway, as a cooperative venture between Norwegian universities, a research institute and the Norwegian Geological Survey.
- The Geological Society of London, the British geological association, has a special engineering working group on geo-hazards that includes experts from universities, the British Geological Survey (BGS), consultancy companies and others.
- The Geological Survey of Hungary in cooperation with several other geological surveys has spent a lot of time and effort into geo-hazard analysis. Special focus has been on floods, related to flood risks around the Danube and Tisza rivers. Risk maps are already available for the region around these rivers.
- The International Institute for Geo-information Science and Earth Observation ITC in the Netherlands is working on several research projects that includes the use of satellites for scientific research (‘remote sensing’) for risk assessment of natural hazards (earthquakes, floods, land instability) and disaster management.
- The work on geo-hazards and risk management in the Czech Republic is predominantly carried out by private companies.
- In France the French ‘Bureau de Recherche Géologique et Minière’ (BRGM) is involved in building and updating the data base dealing with the different natural risks. The French Earth Physical Institute (IPG) studies volcanic and seismic activities worldwide.

This listing of expert groups can be extended in much more detail, but that is not the intention of this document. This list merely illustrates that the research on natural hazards is already being carried out on a large scale. Besides, it is not only carried out by Geological Surveys, but geo-hazard analysis is also widespread under different research institutes, companies, consultancies, universities and individuals. It is almost a prerequisite to set up an integrated network of experts from different sources and from all European countries to exchange knowledge and expertise. The European Federation of Geologists (EFG) can help in this respect, by acting as platform or link between all experts on geo-hazards and as link between the European Commission and these experts.

4. Proposals for short-term actions

The need to take this project step by step has been emphasized In Chapter 2 – *Way forward*. This step by step approach is recommended as a means to maintain an overview on the essential priorities and to avoid getting lost in too much detail. Therefore, the short term actions should be restricted to focussing on those hazards with greatest potential impacts on society. These include floods, land slides and earthquakes. At a later stage, the project can be extended with analysis and prevention measures for the less risky and intensive hazards. In this chapter the focus will only be on natural hazards in which geology is involved, i.e. the geo-hazards.

4.1 Horizontal legislation on risk and hazard mapping

In this section a list of all types of geo-hazards will be provided. In addition brief descriptions will be given on each of the geo-hazards and how geology is related to the hazard will be explained. In addition, several recommendations will be made on the type of approach and techniques that would be useful to deal with these problems. Please note that these recommendations are 'stand-alone'. More detail and better integrated approaches are expected to result from the planned network of geo-experts (see chapter on EFG and chapter 3).

4.1.1 Geo-hazards

The different types of geo-hazards are: floods, land slides, earthquakes, volcanoes, subsidence and collapse, coastal erosion, tsunamis, debris / mud flows, avalanches, rock fall, geochemically anomalous naturally occurring rocks and soils, radon, land contamination and various offshore geo-hazards. In the following brief descriptions will be given of each type.

- Floods

Floods occur when rivers and streams burst their banks, ground water levels rise to the surface, snow and ice melt rapidly and when there are exceptionally high tides and/or strong winds during coastal storms.

There are three types of floods, namely flash floods, river floods and coastal floods. Flash floods occur suddenly after very heavy rainfall. These flash floods are often related to poor land management practices within the river catchment system, in which vegetation is removed for e.g. wine production, resulting in increase in soil erosion and speeding up the water circulation at the soil surface. This has been observed in many European countries, such as in France, Italy, Portugal and Hungary.

Preliminary attention should of course be given to weather forecasts and communication between meteorological institutes of each country. However, a detailed understanding of the factors affecting the water flow in river valleys, flood plains and coastal and estuarine environments is crucial.

Geo-scientists can assist in identifying areas that are vulnerable to flooding, because of their knowledge of landscape, hydrology, geology, river systems and an understanding of rock and soil behaviour with respect to storage and transmission of water. For example, knowledge on the behaviour of rocks and soils and their water saturation levels are important: two years ago in the north of France flooding occurred due to heavy rainfall inducing a general rise of the water table. Many houses were flooded for two months, although local authorities informed the people that it would only last one week.

In addition, the combination of floods with other geo-hazards, such as land slides should always be kept in mind (see *land slides* below).

It is recommended that appropriate geological maps be compiled and prepared for all areas which are vulnerable to the risk of flooding. Additionally, it will be necessary to carry out analysis on rock and soil samples to understand the exact behaviour of the subsurface with respect to permeability, water saturation, etc.. Geological surveys and research institutes are already using satellite remote sensing systems to analyse landforms and to produce digital terrain models vital to assessing associated risks. It is recommended that the capability and contribution of remote sensing in flood risk analysis be further investigated.

\- *Land slides*

Land slides are a well-known natural hazard, occurring quite often and with devastating effects to people and infra-structure. Land slides mostly occur in Quarternary deposits that are made up of fine sand, silt and clay. They are related to hydro-geological, geo-morphological and geo-structural conditions. For example, the large amounts of clay deposits in the Apennine areas in Italy 'encourage' all kinds of surface movements. Land slides commonly appear in connection with spring snowmelt and thawing of frozen ground, as well as during periods of intensive rain fall, leading to saturation of water and high water pressure in the ground. Land slides can also be related to poor land use management practices, such as deforestation in potential risk areas.

Geological studies are essential for a thorough knowledge of the terrain in order to:

- Identify all problems related to natural and induced hazards, which are mainly related to hydro-geological conditions, with concurrence of the geo-morphological situation and aggravation of poor stability properties of the geological deposits involved.
- To understand the subsurface in vulnerable areas
- To indicate areas with deposits that are more prone to develop land slides are both prerequisites in taking correct prevention or mitigation measures, and;
- Develop appropriate engineering design criteria to prevent and/or mitigate the potential hazard.

It is recommended that:

- geological maps be prepared for these potential risk areas, especially focussing on deposits that are vulnerable to land slides.
- Soil samples should be analysed to better understand the behaviour of these deposits with respect to e.g. permeability, water capacity, and slope angle.
- Drilling, geophysical and geotechnical fieldwork is required before construction begins in areas of highest vulnerability.

In addition, it is noted that remote sensing technique in combination with other relevant data can make a significant contribution in early warnings, prevention and mitigation measures. Remote sensing data derived from satellites are excellent tools in mapping the spatial distribution of disaster related geo-data within a short period of time. It may detect the precursors of disastrous events as anomalies in a time series. ESA operates satellites with numerous geo-hazard applications and is at the cutting edge of deformation monitoring from space.

- Earthquakes

Earthquakes are also notorious natural hazards and can have enormous impact on life and infra-structure. A combination with other hazards exists because many earthquakes can also trigger land slides on- and offshore, which may cause liquefaction of the subsurface and they can trigger tsunamis.

Understanding the subsurface with respect to active and passive faults, stress and strain are required for accurate earthquake risk assessment. National Geological Surveys of each member country possess general geological maps and work continuously to update them. These maps typically illustrate information on rock types and fault structures in the subsurface. However, in many cases the information relevant to risk assessment is not easily understood by non-geologists. Hence, customised risk analyses maps are required.

Each country has seismological institutes that monitor vibrations in the earth's surface. An integrated, world-wide network exists between these seismological institutes. Geo-scientific research groups are focussing on the search for the pre-cursors of earthquakes as the key step towards prediction. Better communication and cooperation between different geological institutes in Europe will contribute greatly to mitigating these risks.

- Volcanoes

Volcanic activity in Europe occurs in Iceland, Italy, Greece and the Azores.

Five volcanic areas are active in **Italy**: Etna, Vesuvio, Vulcano, Stromboli and Campi Flegrei. The Vesuvio is listed among the five most dangerous volcanoes in the world.

In the **Azores Islands**, volcanic eruptions are considered a lesser threat. The last volcanic eruption was in 1957 in Faial Island.

Seismic measurements, geochemical analysis, 3D electromagnetic tomography, satellite remote sensing systems (such as interferometry), beside other techniques can provide essential information on predictions of volcanic eruptions.

- Coastal Erosion

The natural balance between sea and land is not static, but is constantly changing with net accretion of retreat of land. Coastal zones are of great socio-economic importance, for example main harbours are important economic portals for a country. These are often found in deltaic settings, e.g. Rotterdam in the Netherlands and cities in the Po Valley, Italy.

Dunes and dikes are coming under more and more stress due to rise in sea level. A good understanding of coastal erosion mechanisms, the record of climate change and knowledge on geological and ecological factors is required to design ‘soft’ defence systems. Such systems are now recognised as being more durable and more environmentally adaptable than the ‘hard’ defence practices of previous centuries.

In many countries coastal erosion is a serious threat, such as in the Netherlands, the United Kingdom, Ireland, France, Portugal, Italy, Greece and France. However, it appears that in many European countries not enough scientific attention is being given to this serious problem.

- Subsidence & collapse

Subsidence of land is an important factor that should be taken into account in new construction projects for buildings and infra-structure. Land subsidence can be due to many factors:

- Compaction mechanism of the subsurface, due to loading effects and/or dewatering system (e.g. Italy and the Netherlands)
- Gas extraction (e.g. in the Netherlands)
- Evaporite extraction, including salt and gypsum (e.g. in France, the Netherlands and Northern Ireland)
- Karstification, i.e. dissolution of limestone rocks creating holes and enormous caves in the subsurface (e.g. in Ireland, Slovenia and United Kingdom)
- Collapse of old mines (Portugal, Czech Republic, United Kingdom and Hungary)

Geological knowledge of the subsurface is required with respect to compaction properties, its bending or fracturing behaviour, karstification mechanisms, etc.. Geophysical techniques and geological mapping can provide timely information for remediation, planning and investment decisions affecting infra-structure.

- Tsunamis

Tsunamis are large waves that are associated with earthquakes and/or rapid sub-marine mass movements. They present extreme threats to coastal areas. For example, the Messina earthquake in 1908, Sicily, developed a tsunami that was responsible for most of the 60,000 deaths. Last year, during the Stromboli eruption in Italy, a tsunami has caused severe damage to the coastal structures of nearby islands. Tsunamis caused the loss of 174 lives in Norway in Loen and Tafjord.

Integrated studies by geo-scientific experts are required to even better understand the relations between earthquakes, land slides and tsunamis and to develop techniques to detect potential land slide risk areas offshore.

- Debris / Mud Flows, Avalanches and Rock fall

Some of these hazards are in part related to floods and land slides. It is important to understand the effect of climatic changes to cohesion of rocks and soil. For example, the lift of the lower limit of permafrost to higher levels due to climate change has direct impact on stabilities of huge masses of unconsolidated rocks (mainly moraine). Risk assessments focussed on this type of hazard are becoming more and more important in e.g. Switzerland.

Rock fall occurs in rock walls, or on slopes that are made up of gravel or sand. Falls of stones and cobbles along the rock walls take place in autumn and spring as a result of frost weathering.

- Radon and geochemical anomalous rock types

High natural levels of naturally occurring minerals, such as arsenic and lead in soil or ground water can lead to blight, unnecessary clean up costs if not factored into spatial planning, impact on society and personal health. Knowledge of the spatial distribution and geochemical association of these, and other elements, is an essential prerequisite to proper planning and design of mitigation measures.

Radon, which is a radio-active gas produced in the decay of Uranium-238 which is present in a range of rock types, emanates from subsoil or bedrock. This gas can accumulate in buildings and can be a significant risk to health.

Geological mapping of these rock types is required and can assist in future construction planning for new urban areas.

- Land contamination

Land contamination issues are for a large part dealt with by the environmental impact assessments. However, there are many examples of contamination arising from historic activities.

Land contamination can occur due to contamination by the industry, land fill, disposal sites, agricultural practices, and indeed by general societal activities and pressures. Understanding the ground water migration systems, aquifers, permeable zones and sealing rocks are necessary if the contamination of ground water and threatening the health of people is to be avoided.

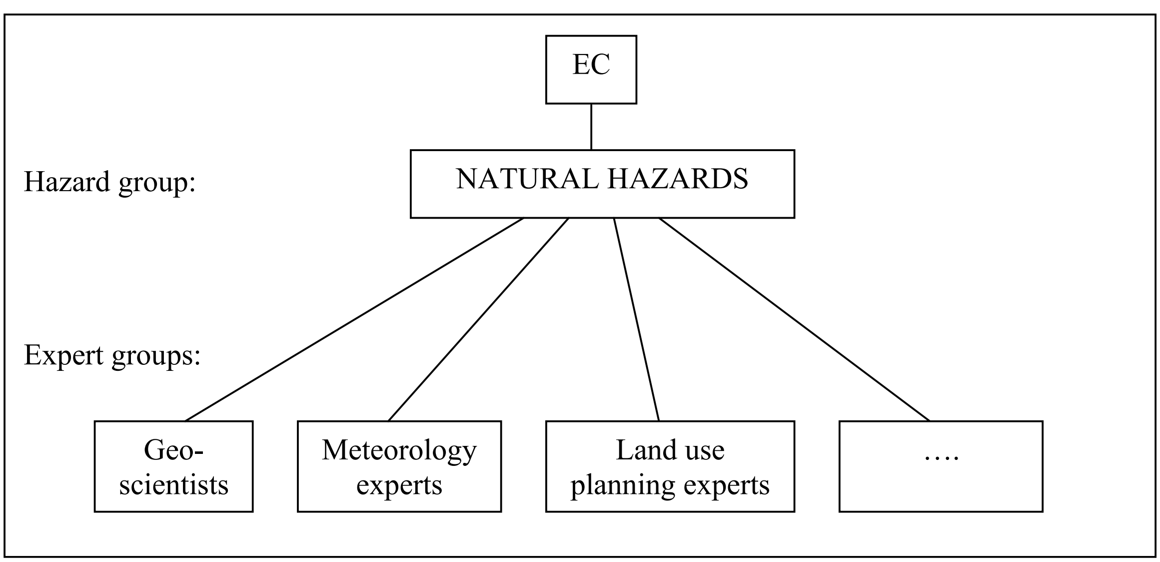
- Offshore geo-hazards

Offshore geo-hazards include, in addition to submarine slides and tsunamis, geological features that are related to gas migration in the subsurface, like mud volcanoes, pockmarks, shallow gas zones and gas hydrates. These geological features are potential hazards for drilling and production platforms, pipeline routes and they may act as triggers for slides and mass flows (turbidites). Climate changes resulting in variation of ocean circulation and rise in temperature may destabilise gas hydrates and can lead to slope instability.

4.1.2 Expert Groups

The Civil Protection project can only result in success if expert groups are set up and consulted. It is important that these groups of experts have a broad field of expertise, such that all sections of the individual problems are dealt with. In addition, it is important that these groups of experts are representative of all or most European countries, such that the proposed methodologies are based on a European view and not based on the perspective of just a few countries.

It is recommended that different 'hazard-groups' be established, in which several expert teams are represented. For example a 'hazard-group' on Natural Hazards, in which the representatives of different expert groups are participating, such as geo-science experts, meteorology experts, land use management planning experts, etc. (see schematic framework example below). Another 'hazard-group' could deal with technological hazards. Each expert group can provide detailed knowledge on their field of expertise, which is integrated with expertise from other fields within the 'hazard groups'. These 'hazard groups' are the best source for establishing definitions of the required three to four risk levels.



The European Federation of Geologists (EFG), can provide lists of experts already working on the different geo-hazards, focussed on the understanding of the mechanisms behind the different hazards, developing techniques for risk analysis and proposing prevention or mitigation measures. For more details, see the chapter on EFG and chapter 3, in which the capabilities of the EFG are described in this respect, and what is already being done within Europe regarding geo-hazard analysis.

4.1.3 Risk maps

Maps containing information on potential risk areas are necessary to take preventive or mitigation measures. It is recommended to first establish history hazard maps, in which the main and fairly recent disasters are mapped out. These history maps provide useful information on the more vulnerable regions and where the focus should first be directed to developpreventive and mitigation measures.

It should be kept in mind that a lot has already been done in several countries. For example, in Hungary complete risk maps on flooding exist around the Danube and Tiszla rivers. The Netherlands has a well-developed system that includes information on both natural hazards and technical hazards. Local authorities update these maps whenever required and general information is online available to the public. It will be necessary to compare the different existing systems and set up some kind of standard mapping method that will be comparable throughout Europe.

The Geographical Information System (GIS) is recommended as the right platform to use for this purpose. Different maps can be generated and the data can be overlain for easy risk studies. For example, a historical flood disaster map, a map containing information on technical hazards (chemical plants, etc.), a map with infra-structure information, etc.. This GIS system facilitates the interpretation of the different hazard information sources and is therefore also a useful tool to have a better insight into the risks for combined hazards.

The groups of experts, within a ‘hazard-group’ (see section 4.1.2), should be consulted in proposing best ways to generate the various maps and what application- and data base system should be used.

4.1.4 Risks and land-use planning

Knowledge on natural hazards and their mechanisms will provide better insight into how to avoid the development of new risk areas. For example, deforestation in certain areas can increase the risk of flash flood hazards enormously (see chapter 4.1.1 on floods). It will also induce faster erosion and greater possibility for land slides.

Information from experts on the mechanisms of natural hazards will be essential to understand what man-made actions could increase the vulnerability for hazards in specific areas, such as in mountainous regions or on fluvial plains. The actions can subsequently be adjusted to avoid increase in risk or other preventive measures can be established.

It is recommended that the groups of experts define in as much detail as possible the mechanisms of natural hazards and what factors could further increase the risk in specific areas

4.1.5 Taking measures to reduce risks

The experts can provide background information about each hazard type, in which type of setting they occur (e.g. in mountainous regions or in valleys), what the mechanism behind the hazard is and what type of measures can be taken to avoid further increase in risk and/or how to mitigate or prevent the hazard. History hazard maps and risk maps (see section 4.1.3) will provide information on locations of vulnerable areas. A combination of this information is recommended, in conjunction with possible further consultation by experts for designing measures to reduce the risk for natural hazards, which can subsequently be carried out, especially in regions where risks reach unacceptable levels.

4.2 Safety Impact Assessment

Legislation exist within the European Union which states that major projects have to be accompanied by environmental impact assessments. Several countries, such as Spain, also have national legislations that geo-scientific research has to be carried out before construction begins. In this geo-scientific research the subsurface is analysed to determine its quality, focussed on vulnerability for subsidence, land slides, and other effects. For more information, see section 4.1.1 per geo-hazard.

To reduce the risk of disasters occurring, it is recommended to establish a legislation that requires research on vulnerability of natural hazards. Geo-scientific research should definitely be part of this Safety Impact Assessment, because of its high contribution in most of all natural hazards.

4.3 Further measures to take account of risks in European Union policies

Specific tools should be considered that would guarantee the level of risk and the vulnerability of the people. The proposed development of history disaster maps and risk maps, setting up groups of experts, developing and defining techniques to analyse natural hazards, developing techniques to prevent or mitigate hazards and to establish the Safety Impact Assessment is the right approach in this respect.

When all this information is harmonised and integrated, it should be possible to indicate areas for which corrective measures should be adopted as a matter of priority. These maps, when combined using the Geographical Information System (GIS; see section 4.1.3), can provide information on economic risks, on life risks and on risks for combined hazards.

In addition, it is very important that people and local authorities are well informed on the different natural hazards that can occur in their region. It is recommended to create information maps on each type of natural hazard. These information maps can be sent to local authorities as well as to the media (e.g. newspapers) to inform all people on the background, consequences, prevention and mitigation measures that are, or will be taken by the European Union. These information maps can be generated by the groups of experts. Additionally, informative courses can be provided by experts to inform local authorities in regions that are labelled as being high risk areas to natural hazards.

5. Proposals for medium-term actions

For short term actions it has been recommended to focus on the natural hazards with highest impact to society, infra-structure and economy. These include: floods, land slides and earthquakes.

For medium-term actions it is suggested to extend the creation of risk maps, the research on specific geo-hazards, the design and development for preventive and mitigation measures by focussing on the less important hazards as well.

Better communication networks and further standardisations and harmonisation can be dealt with as a matter of medium-term action.

5.1 Information exchange on active disasters

Good communication networks for reporting on active national nature disasters should be established. Regarding geo-hazards, it is recommended to consult and set up a communication contact at each National Geological Survey in Europe for direct reporting. In addition, the group of experts will be able to provide additional up-to-date information when necessary. A standardised method for reporting may be set up to facilitate the communication and dissemination of the information to other European countries.

5.2 Other medium-term measures

5.2.1 Links and communication between services and information to the people

The floods in Central Europe last year have shown the importance of international communication between meteorological institutes and communication to the people, such that everybody concerned is warned in due time.

This type of communication should not only count for floods, but should also be considered for other natural hazards, assuming it is possible and if they are not yet established. For example, volcanic eruptions can be predicted with sufficient anticipation. In Italy a special Civil Protection project has been established around the active volcanic regions. It is taking care of early warnings to people and evacuation of areas around the volcano in case of danger. These experiences from Italy on volcanic eruptions may be of use in other countries suffering from these hazards. Parts of this system may also be applicable for other natural hazards. Therefore, exchange of information is considered essential and is recommended.

5.2.2 Standardisation

Regarding geo-hazards, it would be useful to develop certain construction standards (see section 4.2) for eaxmple as in Spain, to diminish damage to buildings and infra-structure due to subsidence, and to avoid future disasters. However, it is important to keep in mind the different national legislations that already exist on this topic. In addition, setting up standardisations for e.g. construction should be done in co-operation with the groups of experts, who can determine what type of research is actually required and to recommend analysis techniques for quick evaluation of the subsurface, bearing in mind that this may vary from country to country and from region to region.

6. Conclusions

- Geology is involved in most natural hazards. Therefore, geo-scientific research is a prerequisite in establishing correct measures to reduce the number of disasters in Europe and/or to mitigate their effects.
- A lot of research has already been done on geo-hazards at National Geological Surveys, at research institutes, at universities, at organisations and companies. The available information should be inventoried, collected and harmonised in one type of application system and data base.
- Focus should at first be restricted to those hazards with greatest potential impacts on society. These include floods, land slides and earthquakes.
- Groups of experts should be established to exchange knowledge and expertise. These expert groups will be an invaluable source of information for recommendations and advice to the European Commission on what kind of geo-scientific analysis is required for geo-hazards, what kind of analysis techniques should be used, etc..
- The European Federation of Geologists considers itself as a good communication platform and link between the European Commission and geo-scientific experts.