ESPON

EUROPEAN SPATIAL PLANNING OBSERVATION NETWORK

The Spatial Effects and Management of Natural and Technological Hazards in Europe - ESPON 1.3.1

EXECUTIVE SUMMARY

GTK

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EXECUTIVE SUMMARY

Edited by

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GEOLOGIAN TUTKIMUSKESKUS

GEOLOGISKA FORSKNINGSCENTRALEN
GEOLOGICAL SURVEY OF FINLAND

This executive summary of the final report represents the final results of a research project conducted within the framework of the ESPON 2000-2006 programme, partly financed by the ERDF through the INTERREG III ESPON 2006 programme.

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Foreword

This summary of the final report presents an overview of the results of the project "1.3.1 - The spatial effects and management of natural and technological hazards in general and in relation to climate change", which was conducted within the ESPON 2000-2006 Programme. The full report can be downloaded from the ESPON website, www.espon.lu. The project was co-ordinated by the **Geological Survey of Finland (GTK)** in cooperation with the following institutions:

Institute of Spatial Planning (IRPUD), Germany

Center for Urban and Regional Studies/Helsinki University of Technology (CURS/HUT), Finland

Institute of Ecological and Regional Development (IOER), Germany

Swedish Meteorological and Hydrological institute (SMHI), Sweden

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Contents:

The ESPON Hazards project in a nutshell

The final report of the ESPON 1.3.1 Hazards project shows the spatial patterns of natural and technological hazards in Europe as an overview on all NUTS3 areas and identifies possible impacts of climate change on selected natural hazards. The approach of the project was to use existing results of hazard research and to combine those in such a way, that the obtained information is comparable over the entire EU 27+2 area. The natural and technological hazards that are relevant for the EU 27+2 area in the ESPON context were selected by specified risk schemes. A so-called spatial filter was applied to ensure that the selected hazards and risks are relevant for spatial planning concerns. For example, floods and major accident hazards have a spatial relevance, meanwhile planning cannot mitigate risks like meteorite impacts or murder.

Not all hazards are equally relevant for the entire EU 27+2 area, as the importance of hazards differs among the territory and the perception of the risk. A weighting system, the Delphi method, was used to develop an integrated European hazard map. Before developing an integrated picture of aggregated hazards in Europe, the method was tested in several case study areas. The resulting integrated hazard map shows a pattern of high and very high hazardous areas in the shape of a scorpion that has its head in central and southern Germany, the arms reaching out into the Iberian Peninsula and the United Kingdom, respectively, and a tail that covers parts of central-eastern European countries before it turns southwards through accession countries into Greece. In this sense the most hazardous spaces of Europe go well beyond both, the so-called "Pentagon" and the "Blue Banana" areas.

The risk of hazards is a result of the hazard potential and the vulnerability. The integrated European vulnerability is based on a weighted combination of population, GDP (national and regional) and the proportion of fragmented natural areas to all natural areas. The vulnerability tends to decrease from east to west because of a lower coping capacity, as based on the lower national GDP/capita. Unfragmented natural areas show a lower trend towards vulnerability, and densely populated areas with a high regional GDP per capita show the highest vulnerability, as the total amount of people and assets per km^2 poses a higher vulnerability of total damage in case of a disaster. The risk maps reveal a similar "scorpion" pattern of medium risk, meanwhile the highest risk density is found in the "pentagon" area.

The analysis of hazard cluster maps shows that certain Interreg IIIB regions can be associated with certain hazard agglomerations and also with hazard clusters. These hazard clusters comprise storms, floods and storm surges in the North Sea Region and the southern part of the Baltic Sea Region; drought potential and forest fires in the ARCHIMED and South West Europe regions; as well as earthquakes and landslides in the southern part of the CADSES region. Hazards, which magnitude is assumed to increase with the effects of climate change appear to be most severely affecting areas in the Mediterranean and in central Europe.

The report shows the spatial picture of natural and technological hazards that pose challenges for balanced and sustainable development in Europe. Regions are exposed to hazards in varying degrees, placing them in different "risk positions". The EU Policy instruments should contribute to even out these differences as a matter of European solidarity. Consequently, risk management should be understood as an important task for the cohesion policy. Overall, better inclusion of risks related to natural and technological hazards in EU policies is needed. The report therefore presents some policy recommendations and a proposal for a handbook for spatial planning and risk assessment.

Scientific approach and main results

The range of hazards that affect the development of regions within the European Union is wide, but in the context of the European Spatial Planning Observation Network (ESPON) not all hazards are relevant. Therefore relevant hazards were selected according to specified risk criteria. The selection of hazards was done in three steps, defining the risk type, the spatial relevance and a possible impact of climate change.

The risk typology focuses on the risk perspective instead of the hazard perspective. This broadens the possibility of describing the interactions between hazards and the societal reaction and response to hazards (for example aspects of risk perception). Both aspects have to be considered in a risk management process. The German Advisory Council on Global Change (WBGU) criteria served as a basis for the classification and characterisation of risks.

The categorisation of risks into certain types does not yet enable to extract those risks from the great number of possible risks that are relevant for the ESPON context. For example, murder, drug abuse or road accidents definitely belong to the highest risks in Europe. On the other hand, a meteorite impact could destroy large parts, if not even all of Europe. But since these risks do not have a clear spatial relation, the selection of risks excludes certain risks by a spatial filter.

The *spatial filter* screens risks according to their spatial character. The occurrence of spatially relevant hazards is limited to a certain disaster area that is regularly or irregularly prone to hazards (e.g. river flooding, storm surges, volcanic eruptions). Spatially non-relevant hazards can occur more or less anywhere (e.g. car accidents, meteorite impacts).

On the basis of these criteria, the hazards in table 1 are of high relevance for the EU 27+2 area in the ESPON context. Of these, floods, flash floods, storm surges, avalanches, landslides, droughts, forest fires, winter storms, and extreme temperatures are assumed to be influenced by climate change.

Hazards are natural extreme events or technological accident phenomena that can lead to threats and damages among the population, the environment and/or material assets. The origin of hazards can be purely natural (e.g. earthquakes) or technological (e.g. accidents in a chemical production plant), as well as a mixture of both (e.g. sinking of an oil tanker in a winter storm and subsequent coastal pollution). Natural extreme events usually become a hazard when human beings or material assets are threatened. All so-called natural hazards occur on a more or less regular basis, as they are phenomena that belong to natural processes. Being part of natural processes they do not pose any threat to the natural system itself, as the nature is used to recover from natural hazards and adapt its life forms to it. In extreme cases when humans influence natural hazards, e.g. arson in the case of forest fires, these hazards are not purely natural any longer and can cause severe damages to the nature itself.

Technological hazards pose threats to human assets and the nature, as they can have impacts and pollution that do not belong to natural processes. Also, technological hazards can have very long lasting non-natural effects (e.g. oil spills and nuclear fallout).

The focus of this report lies on representing the natural and technological hazards in administrative regions, on NUTS3 level, of the ESPON space. Since all of the EU 27+2 regions are populated and bear human assets, all natural and technological phenomena that can be hazardous to human life, properties, and the nature are defined as hazards.

Table 1: Selected natural and technological hazards

Natural and technological hazards	Indicators
Avalanches	Areas that have reported landslide/avalanche potential (derived from several sources)
Drought potential (based on recorded rainfall scarcity)	Amount of observed droughts 1904 –1995
Earthquakes	Peak ground acceleration
Extreme temperatures	Hot days Heat waves (7-day maximum temperature) Cold days Cold waves (7-day minimum temperature)
Floods	Large river flood event recurrence (1987 – 2002)
Forest fires	Observed forest fires per 1000 km² (1997 – 2003); Biogeographic regions
Landslides	Questionnaire, expert opinion of geological surveys of Europe
Storm surges	Approximate probability of storm surges
Tsunamis	Areas that have experienced tsunamis, areas in close vicinity to tectonically active zones
Volcanic eruptions	Known volcanic eruptions within the last 10 000 years
Winter and tropical storms	Approximate probability of winter/tropical storms
Technological hazards	Indicators
Air traffic hazards	Civil commercial airports, amount of passengers per year
Major accident hazards	Number of chemical production plants per km^2 per NUTS3 region
Nuclear power plants	Location of nuclear power plants, distance from nuclear power plants, based on fallout experience of the Chernobyl accident
Oil production, processing, storage and transportation	Sum of refineries, oil harbours and pipelines per NUTS3 region

All hazard maps follow the same classification of hazard intensity in five classes. In cases it was not possible to distinguish between five hazard classes, the same classification range (very low to very high) is kept, with fewer classes in between very low and very high.

Table 2: Hazard classification

Class	Hazard intensity
1	Very low
2	Low
3	Medium
4	High
5	Very high

It is important to keep in mind that the results generated on NUTS3 level are rather generalizing and statistically rough, also because the sizes of the NUTS3 areas vary strongly over the ESPON space. This is especially the case considering the independence of the data sources and the coarse resolution of the data available at the European wide scale. Hence hazards, risks, catastrophes and disasters do not respect political boundaries, a categorisation into administrative areas will always lead to generalisations or exaggerations and thus giving partly deviated images of the reality.

Natural hazards are usually defined as extreme natural events that pose threat to people and their properties. These extreme events occur in closed time spans of seconds or weeks, after which the initial state before the extreme event is reached again. Longer lasting natural processes, such as climate change and desertification, might pose certain threats but do not belong to hazards as such.

The emission from a technological hazard may leak out of a production facility, a deposit, a stockpile, a transport corridor etc. through specific transmission media (water, air, soil) and can harm people, the environment or facilities. To create a risk, a specific damage potential has to exist, which is determined by the type and magnitude of an emission. In the first instance, typical technological hazards focus on very small areas of emission (e. g. chemical production plants, oil pipelines, etc.). However, some hazards have a great perimeter of influence and thus can affect a relatively great part of Europe. Furthermore, it is very difficult and in many cases not possible to define specific threatened areas (weather influence, unknown processes below ground). Because of its rather densely populated area, approximately the entire European territory is threatened by accidents with a regional, local or sub-local level of influence (e.g. major accident hazards).

Whenever a multitude of hazards has to be considered in risk management, the question of weighting the relevance of certain hazards appears.

The Delphi method was adapted for the specific use of hazard weighting and was tested several times in four case study areas (the Dresden Region and the Ruhr District in Germany, The Centre Region of Portugal and Regional council of Itä-Uusimaa in Finland) in the scope of the ESPON Hazards project. To avoid distortion by regional bias, experts with a clear European perspective were chosen, also the geographical provenance of experts was considered. Six of these experts had southern European provenance and six represented central north European areas.

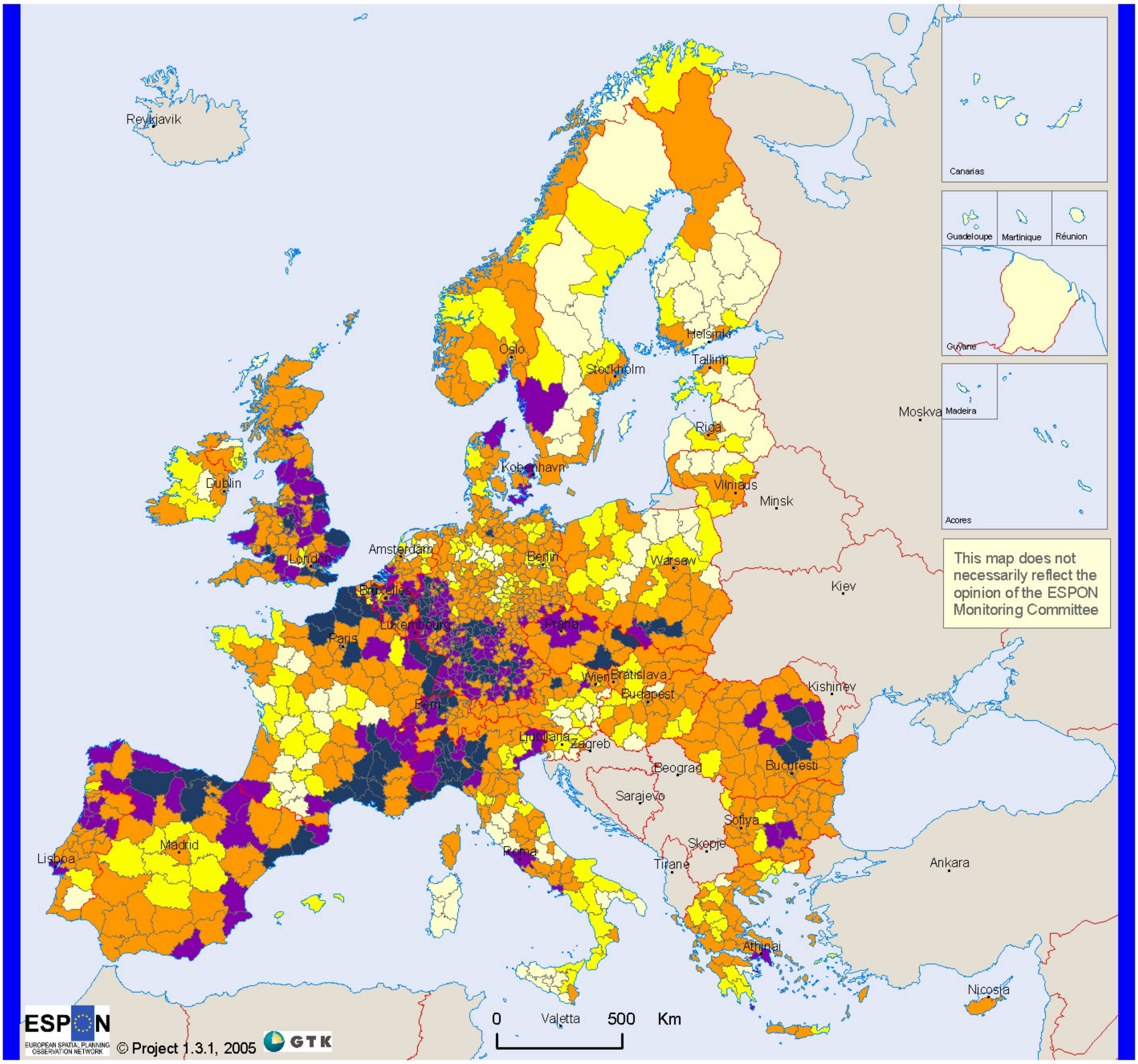
Prior to the enquiry all experts were supplied information concerning the aim of investigation, characteristics of the applied method and the mode of use of results. The investigation comprised three rounds in the period from September to mid of December 2004.

Results of the Delphi survey are represented by more or less calibrated average values of the responses from the expert panel. During each round experts had the possibility to alter the estimation after taking consideration of the average value from the previous round. Ideally, the final estimation represents the so far final 'opinion' on the weight of each hazard.

The biggest emphasis was clearly on natural hazards (73,9 %) with floods (15,6 %), forest fires (11,4 %) and earthquakes (11,1 %) on the top of estimations. Technological hazards in total received 26,1 % with major accidents hazards weighted highest (8,4 %).

The aggregated hazard map (map 1.) shows that the highest hazard classes form a kind of a scorpion-shape covering parts of southern, western, central and eastern Europe. The two arms and the claws of this high hazard scorpion start off on the coastal areas of the United Kingdom and the Iberian Peninsula, respectively, and the head is found in central and southern Germany. The tail is then more scattered towards eastern Europe, and finally turns southwards ending in Greece. Some hotspots are located outside of this "high hazard scorpion", i.e. central Italy and parts of southern Scandinavia. Most of the NUTS3 areas have a medium and some a low aggregated hazard. Besides scattered spots, only few large areas have a very low aggregated hazard, mainly in northern Europe and central-south France.

In the map analysis one has to take into account that the 15 hazards used for these maps are based on current knowledge that is comparable among all EU 27+2 countries. The technological hazards are represented by only 4 hazard types. The maps thus serve as an overview on the entire area, but regional and local analysis always have to take the best available data into account.



Hazard classification

- 0-10 percentile
- 10-25 percentile
- 25-75 percentile
- 75-90 percentile
- 90-100 percentile
- Non ESPON space

Origin of the data: © EuroGeographics Association for the administrative boundaries
Source: ESPON Data Base

This map shows the aggregated hazard typology based on 15 hazard indicators. Every indicator gives the value from 1 to 5 depending on the magnitude of the hazard in the NUTS3 area. For the class "No data" value is 0. These values are then weighted on base of expert opinion (Delphi method questionary). At the end the sum of 15 weighted indicators are classified on base of percentile rank. For instance, NUTS3 areas that belong in 90-100 percentile have their score greater than or equal to 90% of the total of all the summed hazard values.

Map 1. Aggregated hazards

Vulnerability and risk

In order to determine a risk factor, the ESPON Hazards project acknowledges damage potential and coping capacity as the two main sides of regional vulnerability. The definitions of risk and vulnerability are given below. Please also see the glossary in annex 1 for further definitions.

Risk: A combination of the probability (or frequency) of occurrence of a natural hazard and the extent of the consequences of the impacts. A risk is a function of the exposure of assets and the perception of potential impacts as perceived by a community or system. Risk = Hazard potential x Vulnerability

Vulnerability: Vulnerability is the degree of fragility of a (natural or socio-economic) community or a (natural or socio-economic) system towards natural hazards. It is a set of conditions and processes resulting from physical, social, economical and environmental factors, which increase the susceptibility of the impact and the consequences of natural hazards. Vulnerability is determined by the potential of a natural hazard, the resulting risk and the potential to react to and/or to withstand it, i.e. its adaptability, adaptive capacity and/or coping capacity. The overall regional vulnerability is thus measured as a combination of damage potential and coping capacity. The following formula is used: Vulnerability = Damage potential + Coping capacity

In this project overall regional vulnerability is measured as a combination of damage potential and coping capacity. For both damage potential and coping capacity a set of indicators was chosen. In an ideal case, all indicators presented in table 29 of the final report would be used to measure vulnerability. Hence only few data sets were available at EU level, the vulnerability is measure as shown in the figure below. The three dimensions of vulnerability are embedded in either damage potential or separate indicators measure coping capacity and each dimension. The basic criteria for choosing the indicators was that they should cover the range of all three vulnerability dimensions, as well as both damage potential and coping capacity. The indicators listed below are used to measure and compare vulnerability at European level. To determine vulnerability on regional and local level the best needed data sets should be used. For example, in the case study areas of this project appropriate indicators are used according to the region in question.

The following four chosen vulnerability components are hazard independent:

0.1. The (high) regional GDP/capita measures the value of endangered physical infrastructure and the extent of possible damage to the economy, according to insurance company's point of view.

0.2. Population density measures the amount of people in danger.

0.3. The proportion of fragmented natural areas to all natural areas presumes that small and fragmented areas are more vulnerable, since they are likely to be totally destroyed if a hazard strikes.

0.4. The (low) national GDP/capita measures the capacity of people or regions to cope with a catastrophe.

In the ESPON Hazards -project the national GDP/capita was used to indicate coping capacity, since the presumption was that coping capacity is weak in poor countries and strong in rich countries. It was further presumed that there are no marked differences in coping capacity inside a country.

Due to the fact that fragmented natural areas only refer to a specific part of the ecological dimension, the indicator was only given the percentage value of 10. The other three indicators thus received the value of 30%. Figure 1 shows the integrated vulnerability index with the four feasible indicators.

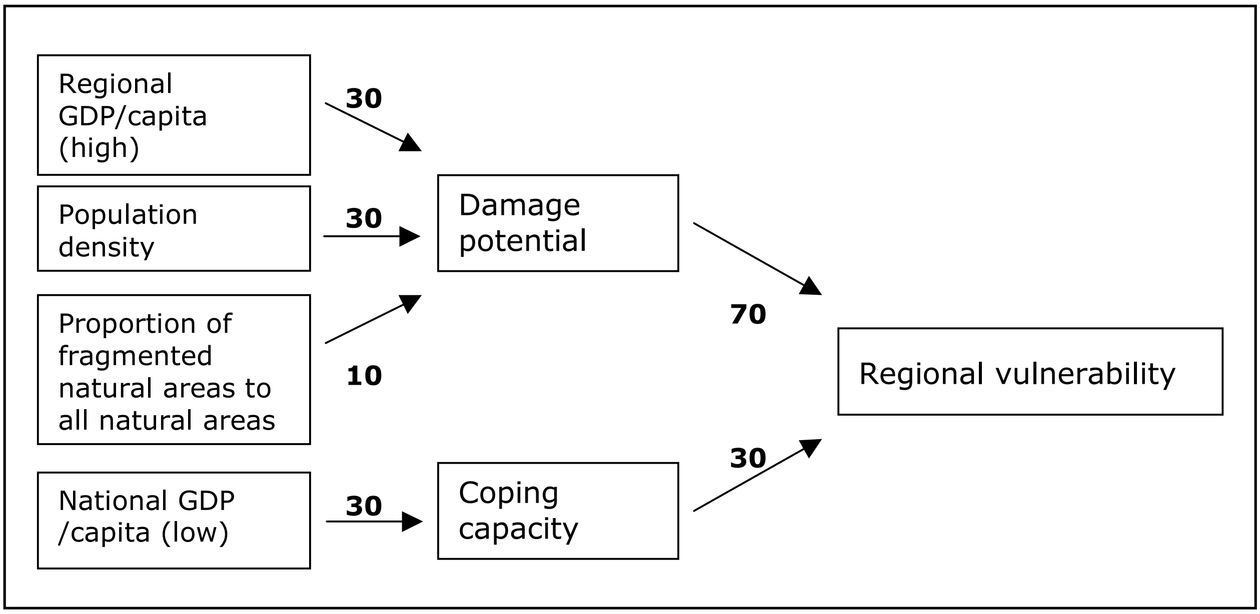
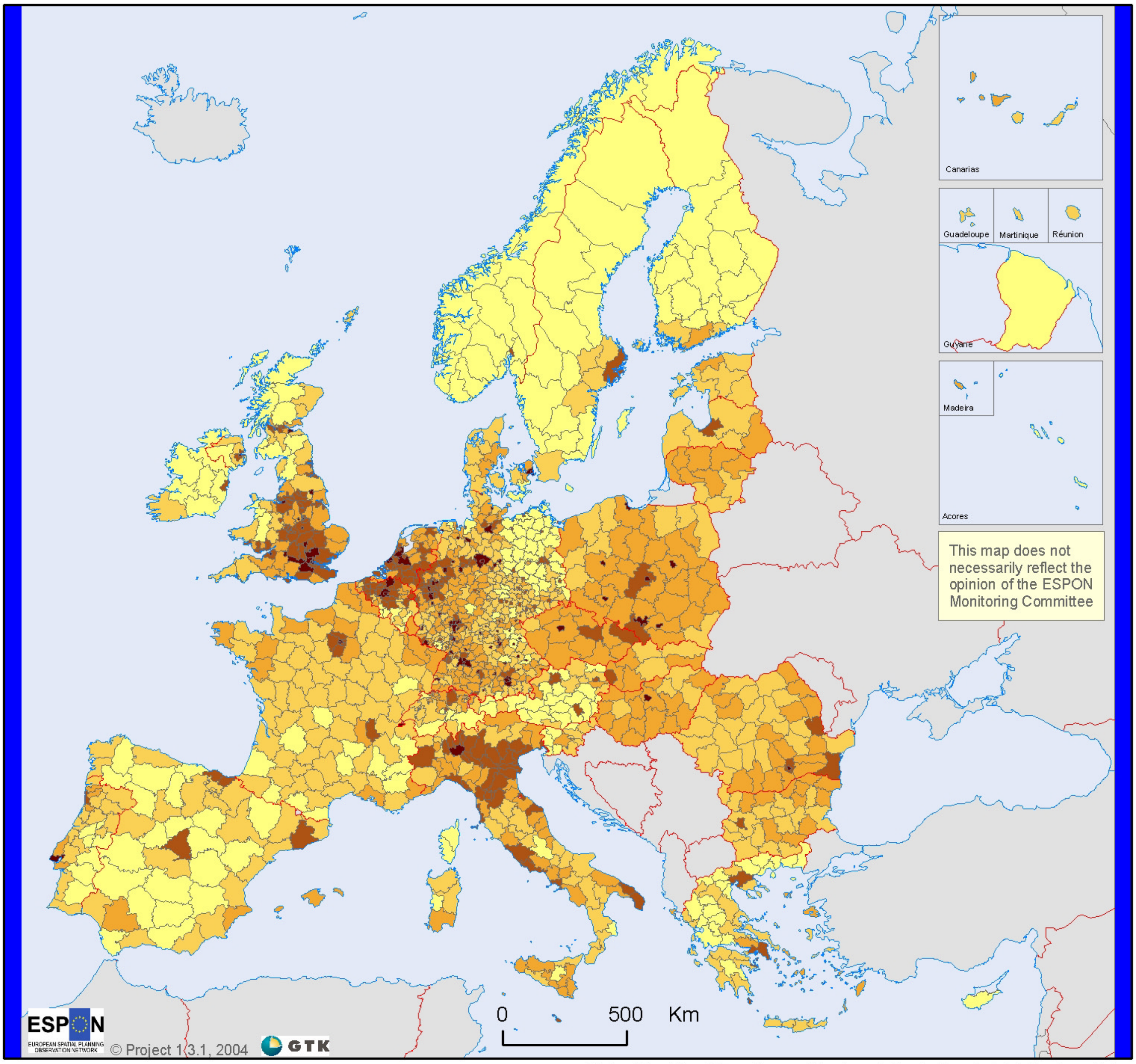


Figure 1: Integrated vulnerability index



Integrated vulnerability

- I (Low vulnerability)
- II
- III
- IV
- V (High vulnerability)
- Non ESPON space

Origin of the data: © EuroGeographics Association for the administrative boundaries
Population density and GDP Eurostat
Fragmented natural areas CLC90 EEA
National GDP 2003 Eurostat
Source: ESPON Data Base

Degree of integrated vulnerability is based on GDP per capita, population density, national GDP (inverse) and proportion of fragmented natural areas to all natural areas equally weighted (30:30:30:10). Because Corine Land Cover data does not cover Norway, Kypros and remote areas these are classified only on base of three first indicators.

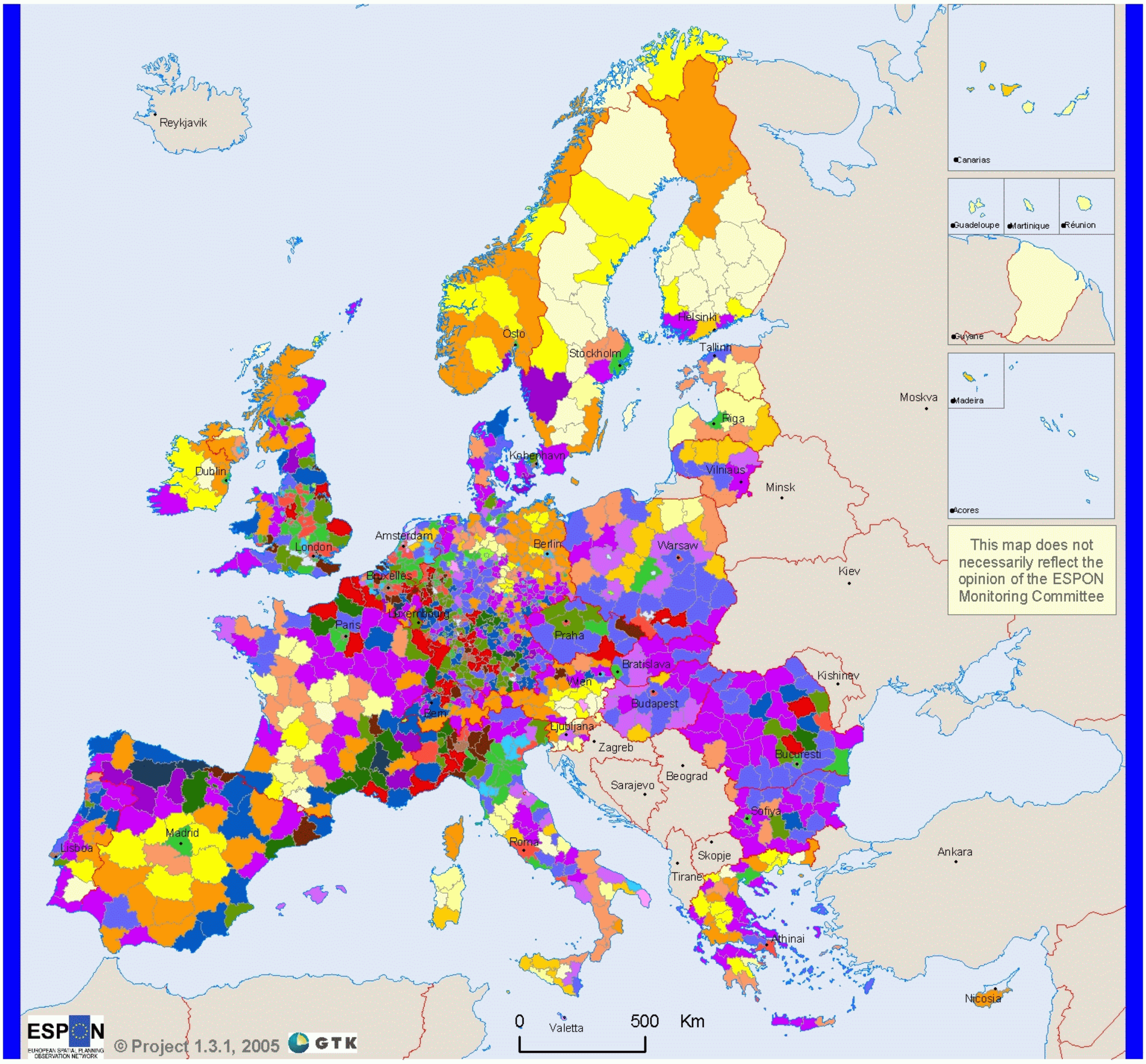
Map 2. Degree of integrated vulnerability

The integrated vulnerability map shows several patterns over the EU 27+2 area. The vulnerability tends to decrease from east to west because of a lower coping capacity, as based on the lower national GDP/capita. Less fragmented natural areas have a lower vulnerability because the nature in larger undisturbed areas can recover faster than that in smaller areas. Densely populated areas with a high regional GDP per capita show the highest vulnerability, as the total amount of people and assets per km^2 poses a higher vulnerability of total damage in case of a disaster. The varying vulnerability in western European countries in comparison to eastern European countries is based on the influence of low coping capacity levels in the latter ones. In consequence, the influence of the existing differences in population density and regional GDP per capita on the integrated vulnerability in western European countries is much greater in comparison with eastern Europe.

The risk maps are more complicated to analyse than the hazard or the vulnerability maps, mainly because of the higher diversification due to the integration of the hazard potential and the vulnerability. Assuming that the low risk classes are 2-4, the medium risk classes are 5-7 and the high risk classes are 8-10, some patterns can be distinguished.

The aggregated risk map (map 3.) again shows a similar pattern as the aggregated hazard map, eventhough the scorpion shape of high risk has moved towards medium risk (classes 6, 7, and 8). The Pentagon Area displays the highest agglomeration of high risk, and the largest parts with low risk are found in northern Europe.

Spatial patterns of hazards were studied by combining individual hazards on NUTS3 level. The hazard interaction map is based on physical processes between hazards. In addition to the development of the overall hazards interaction map, several hazard combinations were studied on European scale, and the distribution of selected hazard types was compared with spatial patterns, e.g. the Pentagon Area or Interreg IIIB regions.



Origin of the data: © EuroGeographics Association for the administrative boundaries
GDP 2000 Eurostat Newcronos Regio
Population density 1999 Eurostat Newcronos Regio
National GDP 2003 Eurostat
CLC90 EEA

Source: ESPON Data Base

Typology of the regions

	Degree of vulnerability				
Intensity of hazard	1	2	3	4	5
1	2	3	4	5	6
2	3	4	5	6	7
3	4	5	6	7	8
4	5	6	7	8	9
5	6	7	8	9	10

Map 3. Aggregated risk

Hazard clusters

Hazard interactions were only considered when the hazard intensities in a certain region were above average (hazard intensity classes IV and V). Each individual hazard was reclassified for the interaction map as follows:

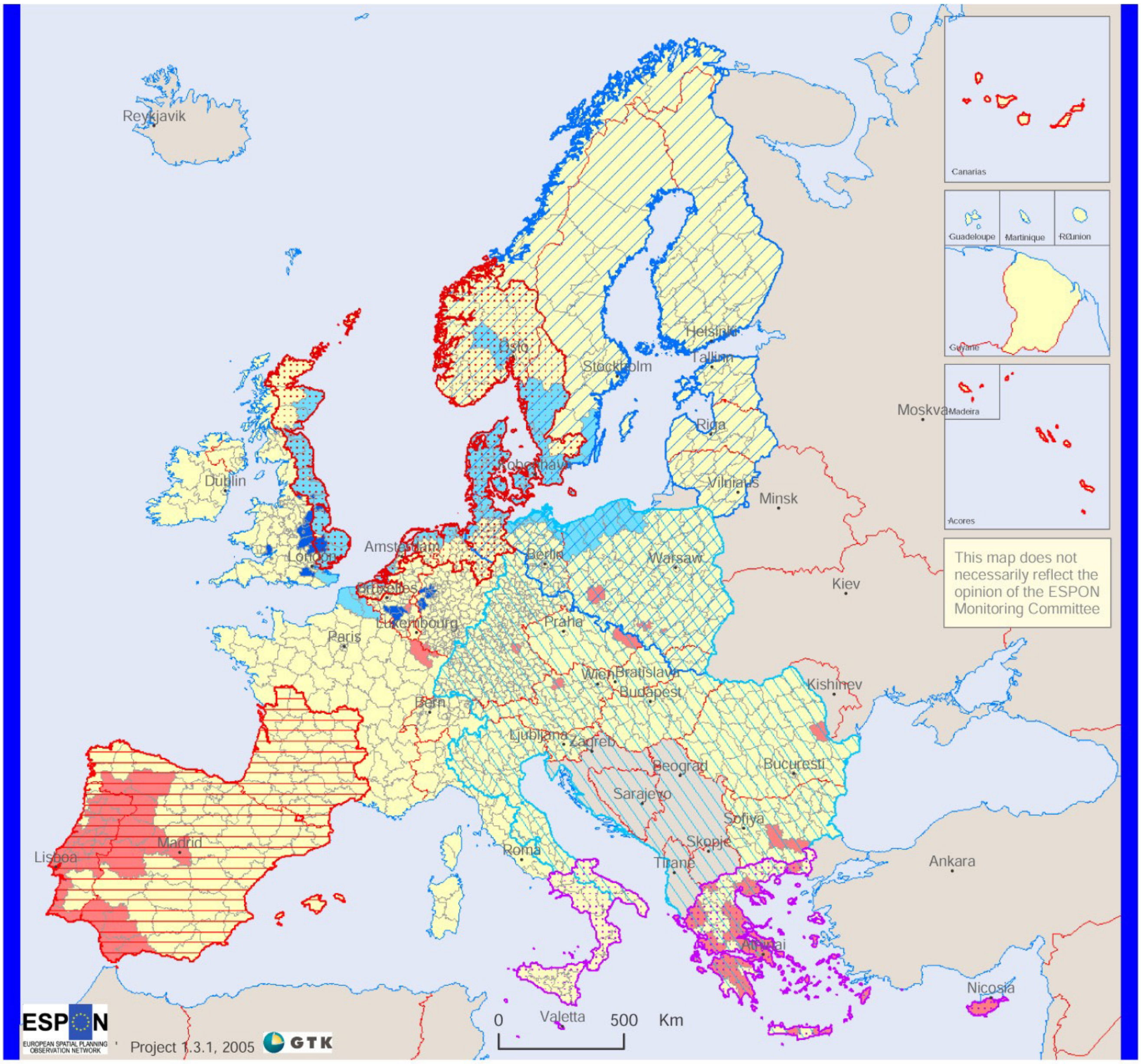
- 1 = hazards intensity higher than average (class IV or V)
- 0 = hazard intensity less or equal to average (class I to III)

Only selected combinations of hazards have physical influence to each other. For example, earthquakes can lead to landslides, but snow avalanches cannot cause forest fires. Altogether 59 possible hazard combinations were studied for all NUTS3 areas. Eight of these physically possible combinations did not occur in any European NUTS3 region. For example, the combination of high volcanic eruption risk and high risk for large river floods was not identified for any region. The most common hazard combinations were plotted on maps. These hazard interaction maps showed clear regional patterns, which can be compared with geographical regions or administrative units.

Main clusters, which could be the basis for special policy recommendations and spatial planning response are:

- Coastal areas, threatened by storm surges/winter storms and floods (mainly in north-western Europe)
- Alpine-areas, threatened by avalanches/land slides, floods
- Mediterranean areas, threatened by forest fires and droughts
- River valleys, threatened by river floods and often technological hazards due to the given concentrations of infrastructure
- Areas that are located above tectonic active zones (threatened by volcanic eruptions and earthquakes, landslides, and tsunamis)
- "Pentagon Area" (cluster of technological hazards), Interreg IIIB regions (see below).

Some of the Interreg IIIB regions show a strong correlation with certain hazard interactions. The North Sea Region is characterized by winter storm, storm surge and flood hazards, continuing into to the southern part of the Baltic Sea Region. The combination of earthquakes and landslides is elevated in the southern part of the CADSES Region. The combination of droughts and forest fires are found in the Interreg IIIB Regions South West Europe and ARCHIMED.



Hazard interaction

- Winter storm - flood interaction
- Winter storm - storm surge interaction
- Drought - forest fire interaction
- Archimed InterregIIIB
- South West Europe InterregIIIB
- North Sea InterregIIIB
- CADSES InterregIIIB
- Baltic Sea InterregIIIB
- Non ESPON space

Origin of the data: ' EuroGeographics Association for the administrative boundaries
Storm surges: Munich Re
Winter storms: Munich Re
Large flood areas ' Dartmouth Flood Observatory
Flood areas ' ESA - Earth observation - Earth online
Rhine Atlas 2001 IKRS-CIPR-ICBR
ARIDE final report (2001)
Forest fires years 1997-2003: ESA
Biogeographic regions: EEA

Source: ESPON Data Base

This hazard interaction map displays hazard intensity values from high to very high hazard of winter storm, storm surge, flood, forest fire and drought potential indicators.

Map 4. Hazard clusters in Interreg regions

Climate change

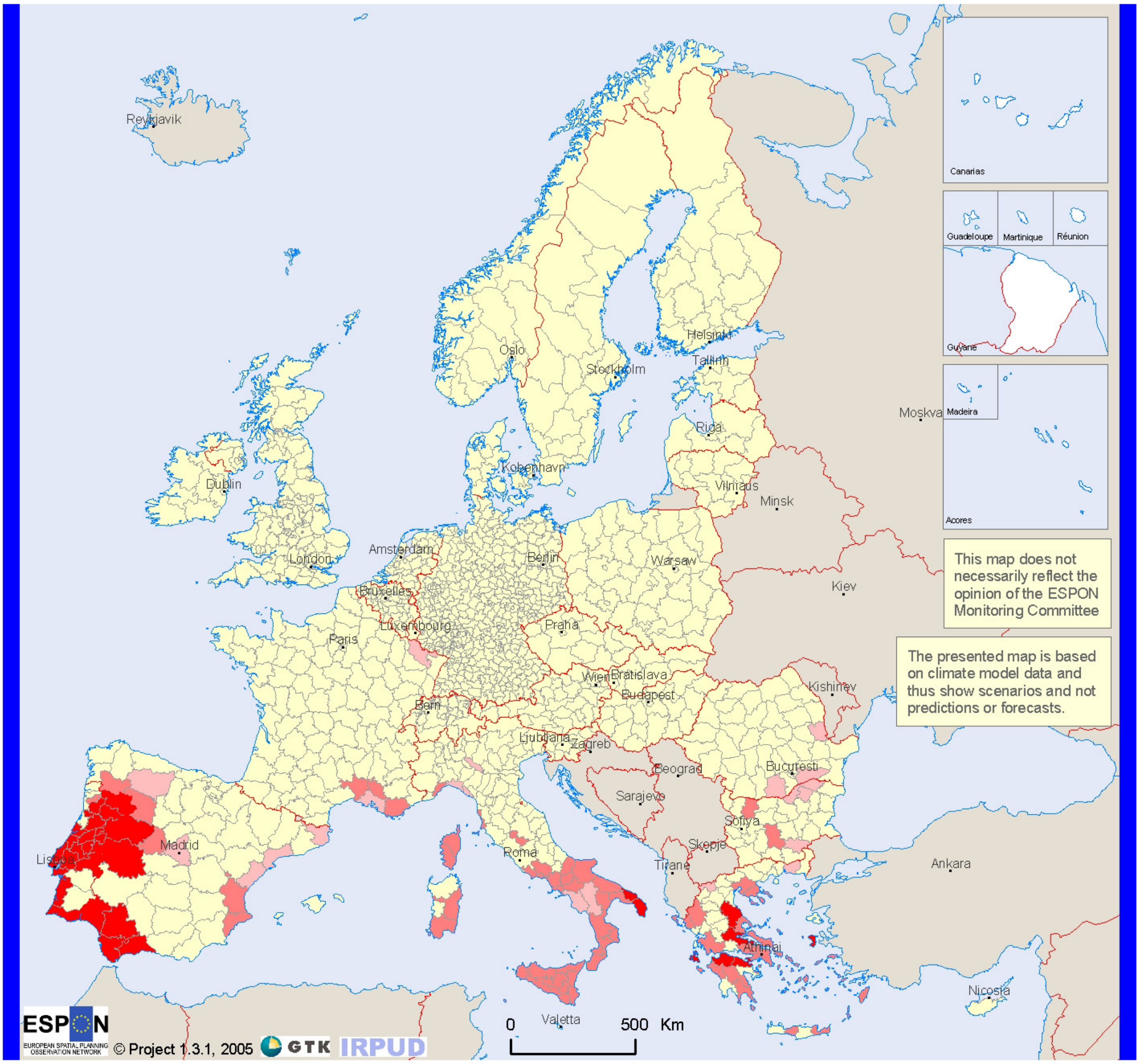
In order to define possible effects of climate change on natural hazards research results of climate models, mainly from the PRUDENCE project, were applied. The result of these models were combined with the hazard maps in order to outline regions that might see an effect of climate change on some hazards. ***The reader must take into account that the presented climate change results and maps are based on climate model data and thus show scenarios and not predictions or forecasts.***

Natural hazards are one major pathway over which climatic extremes may become manifest. Shift in mean values of certain parameters are rarely at all perceivable. Especially in industrialised countries impacts such as the change of general climatic parameters (temperature, precipitation and other) or even certain extremes are rarely experienced directly.

With the possible exception of the July 2003 heat wave in Europe, it has as yet not been possible to attribute either single climate extreme events or perceived trends in climate extremes to an ongoing climate change. Instead, concurrent changes to land use and societal sensitivity usually complicate, or even dominate the picture. According to climate change model results from EU research projects, large parts of Europe will see a shift towards temperature extreme conditions that now occur mainly in the Mediterranean North Africa and the south-western Iberian Peninsula. In a similar way, the present day high extreme temperature climate of France, Germany and Poland will move northwards towards the British Isles, southern Scandinavia, and southern Finland. Large parts of Europe are projected to have a warming of 5-8°C during warm extremes. Least changes are projected for northern Scandinavia and northern Finland, where the warming could be limited to 2-3°C.

The present wintertime cold extreme climate becomes substantially milder, with the conditions of the SW Iberian Peninsula moving into France and Italy, French winter conditions appear in Germany and Poland, as well as in large parts of Central Europe and all the way up to southern Scandinavia. The Mediterranean coastal regions, in particular the Iberian Peninsula has today a long summer dry period that is projected to become even more extended. Large parts of southern Europe may see the summer drought extended by 1-2 months.

A first typology of regions showing natural hazards that might be influenced by climate change focuses on the three selected hazards: drought potential, floods and forest fires. In the case of drought potential the assumption is that a longer dry spells lead to an increase, meanwhile shorter dry spells decrease the drought potential. The flood map depicts those areas with a modelled increase in precipitation and a consequent increasing flood hazard. Regions that have less modelled precipitation therefore show a decreased flood hazard. In the case of forest fires it is also assumed that a longer dry spell leads to an increase in the forest fire potential.



Length of dry spell affecting forest fires

- No impact on forest fire hazard
- High increasing impact on forest fire hazard
- Moderate increasing impact on forest fire hazard
- Low increasing impact on forest fire hazard
- No data
- Non ESPON space

Origin of the data: © EuroGeographics Association for the administrative boundaries
The Prudence project model database
Number of fires 1997-2003: ATSR World Fire Atlas European Space Agency - ESA/ESRIN
Biogeographic regions: EEA

Source: ESPON Data Base

This map represents the connection between change of dry spell length (The Prudence project model database) and forest fire hazard. Only the highest hazard intensities (4 and 5) are chosen.

Map 5. Change of dry spell affecting forest fire hazard

Risk management

Risk monitoring systems may be used to evaluate the outcome of environmental policies, to assist in the development of strategies for hazard prevention and management. They can also serve as research platforms for the development of analytical methods and models on hazards and hazardous processes.

By splitting up "risk" into the elements of hazard potential, damage potential and coping capacity, a framework for monitoring not only risk as a whole but also ideally for monitoring the constitutive elements of risk can be created. Within this framework it is not only possible to monitor the hazards impact on the built up environment and humans but also the vulnerability (damage potential and coping capacity) of an area. Risk monitoring thus has a major role in defining and deciding on response actions like mitigation (structural, non-structural and prevention oriented mitigation) and reaction (preparedness, response, recovery).

The role of the EU Commission regarding the set up and the scaling of monitoring systems on hazards, damage potentials and coping capacities could be to initiate and ensure that appropriate monitoring systems are installed. EU funding sources can be used as a tool to ensure appropriate installation of monitoring systems.

Natural and technological hazards pose challenges for balanced and sustainable development in Europe. Regions are exposed to hazards in varying degrees, placing them in different "risk positions". The EU Policy instruments should contribute to even out these differences as a matter of European solidarity. Consequently, the role of risk management should be understood as an important task for the cohesion policy. Overall, better inclusion of risks related to natural and technological hazards in EU policies is needed for the implementation and monitoring of risk management practices.

Natural and technological hazards do not simply fall in the category of "environmental protection". Rather, they are hybrid phenomena involving complex socio-ecological processes, which bring together multiple institutions and stakeholders and many fields of action such as nature protection, civil protection and security policy. The growing recognition for the need of a risk management perspective is comparable to the historical evolution whereby the "environment" was included on the EU policy agenda. The introduction of the notion of territorial cohesion is important in this respect. It covers the territorial dimension of social and economic cohesion and is closely linked to the fundamental EU objective of "balanced and sustainable development" (Art. 2 EU-treaty). It demands a more integrated approach, from a territorial perspective, to both EU investments directly relevant to the cohesion of the European territory (structural funds/cohesion fund) and other relevant EU policies. An example is that the ESDP calls for an inclusion of hazards into EU policy.

Summary of selected policy recommendations

I. Guiding principles:

1. Risk management should be made an integral and explicit part of EU cohesion policy. This calls for better coordination of policy measures at all spatial scales.
2. Both substantive goals and procedural rules related to vulnerability reduction and risk mitigation could be integrated into policies and programmes

II. EU-level instruments

3. As an addition to existing Structural Fund criteria, coordination of the use of Structural Funds for risk management, by e.g. using criteria relevant to risk and vulnerability to identify a region as eligible to funding through the Structural Fund objectives
4. Ensure the effective implementation of the strategic environmental assessment (SEA) directive. Integrate risk mitigation principles for planning into its implementation (in countries where not yet implemented) (see also chapter 11).

III. Meso-level (national, transnational co-operation, Interreg)

5. National authorities should recognize the upgraded status of risk mitigation in the remodelled cohesion policy for the period 2007-2013 and include principles of vulnerability reduction and risk mitigation in the programme guidelines. Programme guidelines can be changed to this direction already prior to 2007.
6. The implementation of the Strategic Environmental Assessment directive (2001/42/EC) should be ensured by member states, preferably in a uniform fashion across Europe, broadening the scope of all plans and programmes with potential effects on risk and vulnerability. The dimension of *safety impact assessment* should be integrated with other impact assessment methods.
7. Enhance the use of the Water Framework Directive (2000/60/EC) for integrating land use planning and water resources management in support of risk management (not only water quality) purposes, to make use of potential synergies of the Water Framework Directive and of flood risk management plans as elements of integrated river basin management; as mentioned in the Council Conclusions of October 2004.

A handbook for risk assessment and management can complement the EU strategies to reduce spatial risks within the Member States. It therefore has to be strongly connected with the policy recommendations that are discussed above. From an EU point of view, a handbook for risk assessment and management can be seen as a means to an end to encourage European regions to produce risk mitigation plans. Thus, the main interest of the EU would be to guarantee that the necessary measures will be implemented to fulfil the protection goals.

This can be strengthened by installing certain implementation incentives, like e.g.: a) *Funding of the setting up of mitigation plans by the EU:* E.g. funding activities for certain plans or maybe for the exemplary implementation of the SEA directive; b) *Integration of the setup of mitigation plans and their implementation into the INTERREG activities:* There already might be examples of implementation oriented projects among the INTERREG activities; c) *Regional competitions/contests of risk mitigation:* The handbook could be a guidance and provide the criteria for the jury of such a competition. The winning regions would have the chance to have their proposed projects funded by the regional funds.

Data gaps and cooperation with other TPG's and EU institutions

This report is a first approach to present the spatial relevance of natural and technological hazards in the ESPON area. The reader should keep in mind that the data shown in this report is a preliminary approach that is partly based on preliminary data sets. Consequently, the maps enable a first overview on the spatial distribution of hazards in the studied area. This overview is valuable at the current stage as it presents a first integrated approach, including vulnerability and resulting risk patterns. On the other hand it also shows that far more research is needed in the future. Better data sets with improved research methodologies should be used in order to obtain reliable results that can also be downscaled to local levels. The results of this report should not be used for local interpretations, as the data sets can be misleading if used for detailed analysis and often locally better data sets and research results are available.

The Terms of Reference demanded maps and typologies of regions covering the entire ESPON space, i.e. EU 27+2, to be produced between December 2002 and March 2005 with a limited budget. There was no time or resources to carry out own research to obtain full hazard data sets, the Transnational Project Group (TPG) was depending on existing research results. These existing and obtained hazard data sets were then calculated according to the methodology developed by the project to display the spatially relevant hazards of the ESPON space. Even though excellent research results exist in the EU on most of the hazards relevant for spatial development, very few project results cover the entire ESPON space, so that many research results could not be used. One main obstacle for the compilation of data on hazards and vulnerability were thus the large data gaps so that ways and methods had to be found how to extend comparable data sets of all hazards to cover all NUTS3 areas. Therefore most of the data and maps presented in this report are only preliminary results as they are based on the best available data (not best needed) on this scale. The project has worked in four case study areas where regionally best available data sets were used to carry out appropriate hazard research and develop locally relevant risk maps for spatial planning purposes.

The natural hazards coverage (11 indicators) is fair since most of the identified problems are represented. In cases where only poor information could be obtained, simple methods (yes/no, e.g. avalanches), indications for hazards (chemical production plants), and/or questionnaires had to be used (e.g. landslides). In the case of floods and forest fires the data sets are produced on very short observation periods, and the drought potential data set is a first approach on how to display the hazard potential of droughts on the entire EU 27+2 area. At a certain stage in the project it became clear that there are no scientifically sound data sets covering the whole ESPON space available to the project to produce indicators on droughts, floods and forest fires. Nevertheless the European Commission (DG Regio) and the ESPON Coordination Unit insisted on data and maps on these three hazards, too. The reader thus has to take into account that the data sets used for these hazards are at a preliminary stage, especially the drought problem is displayed as a possible approach to display the drought potential.

The technological hazards are underrepresented in relation to the natural hazards, as only 4 indicators were developed. The reason is simply lack of data availability. There is more data on technological hazards available in the EU 27+2 area, but the TPG was denied access to it.

Most of the data were obtained from freely available sources, indicated in each of the maps. Many data requests were sent to international and European research institutions as well as other TPG's but only very few were responded to or the geographical coverage of gained data was poor. In fact, the project only received data sets in case of good personal relationships, all other data requests were left unanswered. The cooperation with other TPG's was very difficult, as all projects worked under extreme time pressure. In the seldom cases that TPG data requests were responded to, these data sets were often incomplete or simply not adequate for the needed purposes. Most of the data sets were therefore collected by the project itself, data developed by other TPG's and used for this report was mostly taken directly from the ESPON data base.

Better data availability and more resources could easily enhance the project's results. In future research approaches on natural and technological hazards all indicators developed by this project should be revised. The main obstacle for indicator development was the required large geographical coverage. Example hazard indicators would have been feasible to produce for selected areas with sound scientific background. Another obstacle was the compulsory reporting on NUTS3 level, as hazards usually do not respect political boundaries, also vulnerability and resulting risk patterns are difficult to produce on man made limitations.

Future research approaches financed by the European Union on such an extensive scale should also ensure a good cooperation between relevant EU funded research institutions and projects. Many indicators could not be developed, or are developed in a preliminary quality eventhough better data would have been available, simply because the data holders refused access.

The Spatial Effects and Management of Natural and Technological Hazards in Europe

ESPON 1.3.1

Co-financed by the European Community through the Interreg III ESPON Programme

The Spatial Effects and Management of Natural and Technological Hazards in Europe

ESPON 1.3.1

Edited by

Philipp Schmidt-Thomé

GEOLOGIAN TUTKIMUSKESKUS
GEOLOGISKA FORSKNINGSCENTRALEN
GEOLOGICAL SURVEY OF FINLAND

This report represents the final results of a research project conducted within the framework of the ESPON 2000-2006 programme, partly financed by the ERDF through the INTERREG III ESPON 2006 programme.

The partnership behind the ESPON programme consists of the EU Commission and the Member States of the EU25, plus Norway and Switzerland. Each country and the Commission are represented in the ESPON Monitoring Committee.

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Foreword

This report presents the results of the project "1.3.1 - The spatial effects and management of natural and technological hazards in general and in relation to climate change", which was conducted within the ESPON 2000-2006 Programme. The project was co-ordinated by the **Geological Survey of Finland (GTK)** in cooperation with the following institutions:

Institute of Spatial Planning (IRPUD), Germany

Center for Urban and Regional Studies/Helsinki University of Technology (CURS/HUT), Finland

Institute of Ecological and Regional Development (IOER), Germany

Swedish Meteorological and Hydrological Institute (SMHI), Sweden

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The content of this report does not necessarily reflect the opinion of the ESPON Monitoring Committee

Abstract

The final report of the ESPON 1.3.1 Hazards project shows the spatial patterns of natural and technological hazards in Europe as an overview on all NUTS3 areas and identifies possible impacts of climate change on selected natural hazards. The approach of the project was to use existing results of hazard research and to combine those in such a way, that the obtained information is comparable over the entire EU 27+2 area. The natural and technological hazards that are relevant for the EU 27+2 area in the ESPON context were selected by specified risk schemes. A so-called spatial filter was applied to ensure that the selected hazards and risks are relevant for spatial planning concerns. For example, floods and major accident hazards have a spatial relevance, meanwhile planning cannot mitigate risks like meteorite impacts or murder.

Not all hazards are equally relevant for the entire EU 27+2 area, as the importance of hazards differs among the territory and the perception of the risk. A weighting system, the Delphi method, was used to develop an integrated European hazard. Before developing an integrated picture of aggregated hazards in Europe, the method was tested in several case study areas. The resulting integrated hazard map shows a pattern of high and very high hazardous areas in the shape of a scorpion that has its head in central and southern Germany, the arms reaching out into the Iberian peninsula and the United Kingdom, respectively, and a tail that covers parts of central-eastern European countries before it turns southwards through accession countries into Greece. In this sense the most hazardous spaces of Europe go well beyond both, the so-called "Pentagon" and the "Blue Banana" areas.

The risk of hazards is a result of the hazard potential and the vulnerability. The integrated European vulnerability is based on a weighted combination of population, GDP (national and regional) and the proportion of fragmented natural areas to all natural areas. The vulnerability tends to decrease from east to west because of a lower coping capacity, as based on the lower GDP/capita. Unfragmented natural areas show a lower trend towards vulnerability, and densely populated areas with a high GDP per capita show the highest vulnerability, as the total amount of people and assets per km^2 poses a higher vulnerability of total damage in case of a disaster. The risk maps reveal a similar "scorpion" pattern of medium risk, meanwhile the highest risk density is found in the "Pentagon" area.

The analysis of hazard cluster maps shows that certain Interreg IIIB regions can be associated with certain hazard agglomerations and also with hazard clusters. These hazard clusters comprise storms, floods and storm surges in the North Sea Region and the southern part of the Baltic Sea Region; drought potential and forest fires in the ARCHIMED and South West Europe regions; as well as earthquakes and landslides in the southern part of the CADSES region. Hazards, which magnitude is assumed to increase with the effects of climate change appear to be most severely affecting areas in the Mediterranean and in central Europe.

Regions are exposed to hazards in varying degrees, placing them in different "risk positions". The EU Policy instruments should contribute to even out these differences as a matter of European solidarity. Consequently, risk management should be understood as an important task for the cohesion policy. Overall, better inclusion of risks related to natural and technological hazards in EU policies is needed. The report therefore presents some policy recommendations and a proposal for a handbook for spatial planning and risk assessment.

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Table of maps

1 Selection of Hazards

The range of existing hazards that affect the development of regions within the European Union is wide. But in the context of the European Spatial Planning Observation Network (ESPON) not all hazards are relevant. Thus, there is a need to identify and select relevant hazards according to certain criteria. The selection of hazards is done in three steps:

1. *Risk type:* First, a list of possible hazards in Europe is compiled. These hazards and the risks they produce are characterized based on their probability, damage extent and other criteria. In this first step some risk types (and with them the causing hazards) are excluded (Chapter 1.1.) because some of them cannot be managed with spatial planning tools and policies.
2. *Spatial relevance:* In a second step the spatial relevance of the hazards is assessed. Only those hazards will be considered that can be spatially located (Chapter 1.2).
3. Finally the selected hazards are classified according to the possible impact of climate change on them (Chapter 1.4).

1.1 First step of hazard selection: risk type criteria

The following risk typology focuses on the risk perspective instead of the perspective of the hazard concept. This broadens the possibility of describing the interactions between hazards on the one hand and the societal reaction and response to hazards (for example aspects of risk perception) on the other hand. Both aspects have to be considered in a risk management process. The German Advisory Council on Global Change (WBGU) suggests the following criteria (Table 1) as a basis for the classification and characterisation of risks. On this basis, risks can be classified into normal, transitional and prohibited areas of risk.

Table 1: Criteria for a typology of risks, Source: WBGU 2000: 55

Criteria	Range of values
Probability of occurrence *P*	0 to approaching 1
Certainty of assessment of *P*	Low or high certainty of assessment of the probability of occurrence
Extent of damage *E*	0 to approaching infinity
Certainty of assessment of *E*	Low or high certainty of assessment of extent of damage
Ubiquity	Local to global
Persistency	Short to very long removal period
Irreversibility	Damage not reversible to damage reversible
Delay effect	Short to very long time lag between triggering event and damage
Mobilization potential	No political relevance to high political relevance

Risks in the *normal area* are characterized as follows (WBGU 2000: 42):

- Low uncertainty about both the probability of occurrence and the associated magnitude of damage,
- in total, a small catastrophic potential,
- in total, a low to medium probability of occurrence,
- low levels of persistency and ubiquity of risk sources or consequences,
- high reversibility of risk consequences should the damage occur,
- low statistical confidence intervals with respect to probability and magnitude of damage,
- no distinct distortions between the group that is exposed to the risk and the group to which opportunities and benefits accrue (distributional equity).

In this case a simple multiplication of the probability and magnitude of possible damage is appropriate. This approach permits to calculate risks and opportunities against each other (WBGU 2000: 43).

Risks in the *transitional* or *prohibited areas* have at least one of the following characteristics:

- uncertainty is high for all risk parameters,
- the damage potential is high,
- the probability of occurrence is high, approaching 1,
- the certainty of assessment is low, but there are reasonable grounds to assume that major damage is possible,
- persistency, ubiquity and irreversibility are particularly high, whereby here too there must be reasonable grounds to assume that damage is possible,
- for reasons of perceived distributional injustice or other social and psychological factors, a major potential for mobilization is to be expected (refusal, protest, resistance).

When risks reach areas that are significantly beyond everyday levels, either the ‘transitional’ or the ‘prohibited area’ is reached (Figure 1). In the transitional area there is a possibility for risk-reducing measures that would shift an existing risk into the normal area. In the prohibited area the risks are so severe that generally a ban should be imposed, unless there is a consensus in society that these risks are to be accepted because of the opportunities that come along at the same time (WBGU 2000: 43 f.).

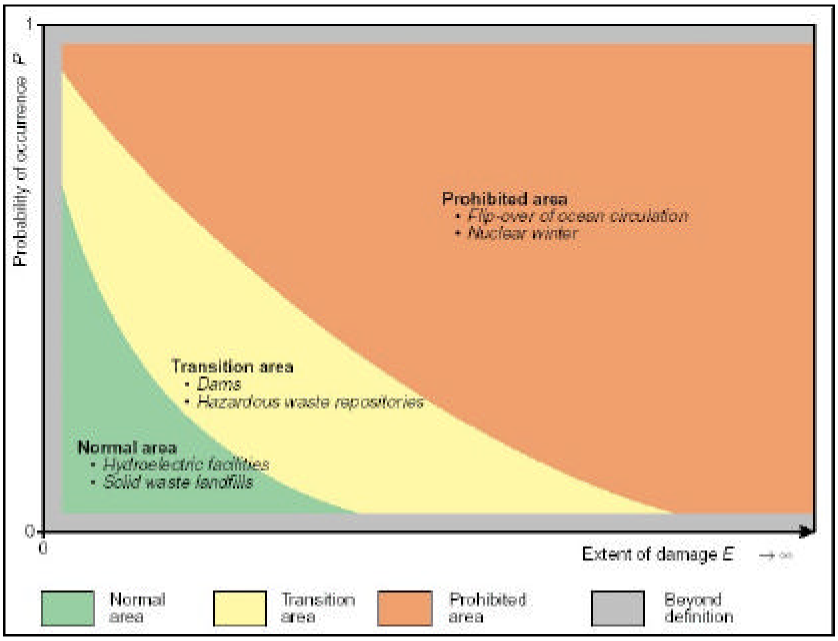


Figure 1: Normal, transition and prohibited areas of risks. Source: WBGU 2000: 44

Combining this display of risks with the criteria of Table 1 allows to identify different types of risks. This risk typology can be used as a first step to select relevant risks for the ESPON Hazards project. The following types of risk are characterised by the different values of the probability of occurrence (and the certainty of its assessment), the extent of damage (and the certainty of its assessment) as well as extreme values of other criteria such as high persistence, long delay of consequences or mobilisation potential (Table 1). On this basis it is possible to distinguish six different types of risks. In short these six types of risks can be described as follows (names are taken from Greek mythology; WBGU 2000: 57 ff.; see Table 2):

- *Cyclops risk type:* For this type of risks the probability of occurrence is largely unknown, but the possible damage is quantifiable. Such risks include natural disasters such as floods, drought or volcanic eruptions and epidemics or cancerogenic substances in low doses, but also the possible breakdown of the North Atlantic Stream ("Gulf Stream") due to a collapse of the thermohaline ocean circulation, caused by anthropogenic climate change.
- *Damocles risk type:* In this type of risks, the possible damage can be very high, but the probability that it occurs is very low. In addition to meteorite impacts, many large-scale technologies can be assigned to this class of risk, such as major chemical works, mega-dams or nuclear power plants.
- *Pythia risk type:* In this risk type, both the possible damage and the probability of its occurrence are uncertain. Examples of Pythia class risks include genetic engineering interventions and the release of transgenic plants.
- *Pandora risk type:* The prime concern in the Pandora risk type is the global dispersal of e.g. chemical substances and their accumulation in organisms. In many cases, the consequences of these risks are still unknown or there are at best assumptions concerning their possible damaging effects. Examples of this risk type include the pesticide DDT or endocrine disruptors.

- *Cassandra risk type:* In the Cassandra risk type, a relatively long period elapses between the causation and occurrence of harm. The long-term consequences of impending global climate change must be assigned to this risk class, as must the destabilization of terrestrial ecosystems due to the human induced change of biogeochemical cycles.
- *Medusa risk type:* In the case of Medusa type of risks the public perceives hazards as being much larger than they really are. An example of this is the concern surrounding the cancerogenic effect of ionizing or electromagnetic radiation in low concentrations, which cannot be statistically proven.

Table 2: Overview of risk types: characterisation and substantive examples. Source: WBGU 2000: 62

Risk type	Characterisation (*P* = probability of occurrence; *E* = extent of damage)
Cyclops	*P* is unknown; Reliability of estimation of *P* is unknown *E* is high; Certainty of assessment of *E* tends to be high
Damocles	*P* is low (approaching 0); Certainty of assessment of *P* is high *E* is high (approaching infinity); Certainty of assessment of *E* is high
Pythia	*P* is unknown; Certainty of assessment of *P* is unknown *E* is unknown (potentially high); Certainty of assessment of *E* is unknown
Pandora	*P* is unknown; Certainty of assessment of *P* is unknown *E* is unknown (only assumptions); Certainty of assessment of *E* is unknown Persistence is high (several generations)
Cassandra	*P* tends to be high; Certainty of assessment of *P* tends to be low *E* tends to be high; Certainty of assessment of *E* tends to be high Long delay of consequences
Medusa	*P* tends to be low; Certainty of assessment of *P* tends to be low *E* tends to be low (exposure high); Certainty of assessment of *E* tends to be high Mobilisation potential is high

These six types of risks allow classifying the risks and attributing them to the areas of risk (Figure 2). The classification is not final as risks can evolve in the course of time from one class to another. For example, further research and a longer period of experience or the use of risk management tools might move a Pythia type risk to the Cyclops type and from there towards the normal area (WBGU 2000: 63).

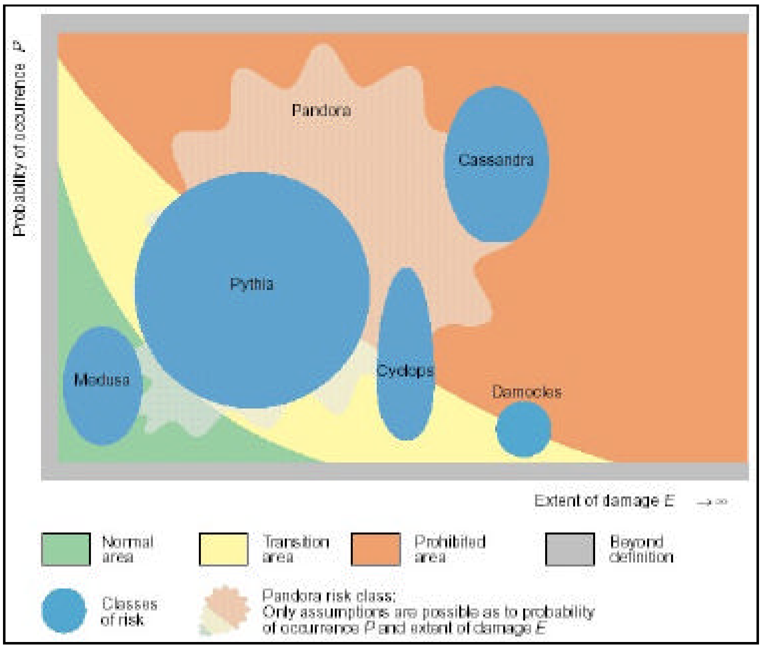


Figure 2: Types of risks and their location in the normal, transition and prohibited areas. Source: WBGU 2000: 62

This typology of risks can serve as a rationale for selecting the hazards to be investigated within the ESPON Hazards project (see also Table 4, column "Risk type"):

- *Medusa:* The risk type of Medusa is characterised by a high public sensitivity (mobilisation potential) and thus can be tackled with improved risk communication. Hence it would not require a spatial planning response.
- *Pythia, Pandora and Cassandra:* These types of risks mainly belong to the prohibited risk area and are characterised by a high degree of uncertainty in regard to probability and damage potential or by a long time lag in regard to consequences. These characteristics make clear that these types of risks cannot be tackled by risk management in terms of spatial planning responses (although they might have negative spatial effects) but by integrated political and societal measures. Therefore, the risk types of Pythia, Pandora and Cassandra will not be further investigated within the ESPON Hazards project.
- *Cyclops and Damocles:* Spatial planning responses are mainly relevant for the risk reduction of the risk types of Cyclops and Damocles. Therefore only these risk types will be taken into consideration in the ESPON Hazards project.

The risks of a long-term climate change as such belong to the Cassandra type of risks. Thus, the risk of climate change as such and its management will not be considered in this project. However, climate change influences the frequency and magnitude of several natural hazards like extreme weather events, floods or storms. These hazards belong to the risk types of Cyclops or Damocles and are therefore considered in the ESPON Hazards project.

1.2 Second step of hazard selection: Spatial relevance

The categorisation of risks into certain types does not yet enable to extract those risks from the great number of possible risks that are relevant for the ESPON Hazards project. For example, murder, drug abuse or road accidents definitely belong to the main risks in western societies. But risks like these do not have any spatial relation. Therefore, the second step for the selection of risks excludes non-spatial risks by a certain risk filter.

The *spatial filter* screens risks according to their spatial character. The spatial character is defined by spatial effects that might occur if a hazard turns into a disaster. Of course, *every* hazard has a spatial dimension (disasters take place somewhere). However, the occurrence of spatially relevant hazards is limited to a certain disaster area which is regularly or irregularly prone to hazards (e.g. river flooding, storm surges, volcanic eruptions). Spatially non-relevant hazards occur more or less anywhere (e.g. flash floods, car accidents, meteorite impacts).

Table 3 shows the results of the spatial filter. Only those hazards will be considered further that have a specific spatial relevance (+ = high or 0 = low) whereas hazards without spatial relevance (- = none) do not pass the filter (see Table 4, column "Spatial filter").

1.3 Selection of ESPON relevant hazards

Table 4 evaluates existing risks on the basis of the risk typology and the spatial filter. The aim is to select those risks that are of relevance within the ESPON Hazards project.

On the basis of the criteria discussed in the chapter above, table 3 lists the hazards that are of high relevance for the ESPON Hazards project:

Table 3: Selected natural and technological hazards

Natural and technological hazards	Indicators
Avalanches	Areas that have reported landslide/avalanche potential (derived from several sources)
Drought potential (based on recorded rainfall scarcity)	Amount of observed droughts 1904 –1995
Earthquakes	Peak ground acceleration
Extreme temperatures	Hot days Heat waves (7-day maximum temperature) Cold days Cold waves (7-day minimum temperature)
Floods	Large river flood event recurrence (1987 – 2002)
Forest fires	Observed forest fires per 1000 km^2 (1997 – 2003); Biogeographic regions
Landslides	Questionnaire, Expert opinion of geological surveys of Europe
Storm surges	Approximate probability of storm surges
Tsunamis	Areas that have experienced tsunamis Areas in close vicinity to tectonically active zones
Volcanic eruptions	Known volcanic eruptions within the last 10 000 years
Winter and tropical storms	Approximate probability of winter/tropical storms
Technological hazards	**Indicators**
Air traffic hazards	Civil commercial airports Amount of passengers per year
Major accident hazards	Number of chemical production plants per km^2 per NUTS3 region
Nuclear power plants	Location of nuclear power plants Distance from nuclear power plants, based on fallout experience of the Chernobyl accident
Oil production, processing, storage and transportation	Sum of refineries, oil harbours and pipelines per NUTS3 region

Table 4: Evaluation and selection of risks on the basis of risk type and spatial filter. Source: ESPON Hazards project

	Risk type (first step of risk selection)				**Spatial filter** (second step of risk selection)	**Selection results** (relevance for ESPON Hazards)	
	Characterisation of risk						
Risks / Hazards	Probability *P*	Extent of damage *E*	Extreme value of certain criteria	**Risk type**	Specific spatial relevance: + = high, o = low, - = none	**ESPON-relevance?**	**Reason for exclusion**
Volcanic eruptions	unknown	high	---	Cyclops	+	yes	---
River floods	unknown	high	---	Cyclops	+	yes	---
Storm surges	unknown	high	---	Cyclops	+	yes	---
Avalanches	unknown	high	---	Cyclops	+	yes	---
Landslides	unknown	high	---	Cyclops	+	yes	---
Earthquakes	unknown	high	---	Cyclops	o	yes	---
Droughts	unknown	high	---	Cyclops	o	yes	---
Forest fires	unknown	high	---	Cyclops	o	yes	---
Winter storms	unknown	high	---	Cyclops	o	yes	---
Extreme precipitation (heavy rainfall, hail)	unknown	high	---	Cyclops	o	yes	---
Extreme temperatures (heat waves, cold waves)	unknown	high	---	Cyclops	o	yes	---
Hazards along transport networks	high	low	High ubiquity	Cyclops	-	no	Spatial filter
Hazards from the collapse of thermohaline circulation (breakdown of the North Atlantic Stream)	unknown	high	---	Cyclops	-	no	Spatial filter
Nuclear early warning systems and nuclear, biological and chemical weapons systems	unknown	high	---	Cyclops	-	no	Spatial filter
Epidemics (e.g. AIDS infection)	unknown	high	---	Cyclops	-	no	Spatial filter
Cancerogenic substances in low doses	unknown	high	---	Cyclops	-	no	Spatial filter
Mass development of anthropogenically influenced species	unknown	high	---	Cyclops	-	no	Spatial filter
Hazards from nuclear power plants	low	high	---	Damocles	+	yes	---
Major accident hazards	low	high	---	Damocles	+	yes	---
Hazards from hazardous waste deposits or the storage of nuclear waste or ore minig stockpiles	low	high	---	Damocles	o	yes	---
Hazards from the marine transport of hazardous goods (oil etc.)	low	high	---	Damocles	o	yes	---
Hazards from oil production, processing, storage and transportation, including major oil spills	low	high	---	Damocles	o	yes	---
Air traffic hazards	low	high	---	Damocles	o	yes	---
Meteorite impacts	low	high	---	Damocles	-	no	Spatial filter
Terrorism, war, crime	unknown	unknown	---	Pythia	o	no	Risk type
Instability of the West Antarctic ice sheets	unknown	unknown	---	Pythia	o	no	Risk type
Self-reinforcing global warming (runaway greenhouse effect)	unknown	unknown	---	Pythia	-	no	Risk type
Release and putting into circulation of transgenic plants	unknown	unknown	---	Pythia	-	no	Risk type
BSE/nv-CJD infection	unknown	unknown	---	Pythia	-	no	Risk type
Certain genetic engineering interventions	unknown	unknown	---	Pythia	-	no	Risk type
Dispersal of persistent organic pollutants (POPs)	unknown	unknown	High persistence	Pandora	-	no	Risk type
Endocrine disruptors	unknown	unknown	High persistence	Pandora	-	no	Risk type
Long-term consequences of human-induced climate change	high	high	Long delay of consequences	Cassandra	o	no	Risk type
Destabilization of terrestrial ecosystems due to human induced change of biogeochemical cycles	high	high	Long delay of consequences	Cassandra	o	no	Risk type
Electromagnetic fields	low	low	High mobilisation potential	Medusa	o	no	Risk type

1.4 Spatial relevance and climate relation of selected hazards

One of the main tasks of the ESPON Hazards project is to assess the impact of climate change on hazards and their spatial impact. Therefore, those hazards with relevance for the ESPON Hazards project are structured along the criteria of spatial relevance and climate relation (see Table 5 below).

Table 5: Climate relation and spatial relevance of hazards; grey shaded boxes show climate change related hazards. Source: Based on Fleischhauer 2004, p. 118

Spatial relevance \ Climate relation	High/Medium	Low/non-existent
High	Avalanches Floods, flash floods Landslides Storm surges	Major accident hazards (chemical plants) Nuclear power plants Volcanic eruptions
Medium (hazards with no spatial relevance have not passed the spatial filter, see above)	Droughts Extreme temperatures Forest fires Winter storms	Air traffic accidents Earthquake Oil production, processing, storage and transportation Tsunami

In consequence, only some of the selected hazards will also be important for the context of climate change in the ESPON Hazards project (see Chapter 7.5). These hazards are shown in the grey shaded boxes in Table 5.

2 Hazards and Risks in European Regions

Hazards are natural extreme events or technological accident phenomena that can lead to threats and damages to the population, the environment and/or material assets. The origin of hazards can be purely natural (e.g. earthquakes) or technological (e.g. accidents in a chemical production plant), as well as a mixture of both (e.g. sinking of an oil tanker in a winter storm and subsequent coastal pollution). Natural extreme events usually become a hazard when human beings or material assets are threatened. All so-called natural hazards occur on a more or less regular basis, as they are phenomena that belong to natural processes. As being part of natural processes they do not pose any threat to the natural system itself, as the nature is used to recover from natural hazards and adapt its life forms to it. In extreme cases when humans influence natural hazards, e.g. arson in the case of forest fires, these hazards are not purely natural any longer and can cause severe damages to the nature itself.

Technological hazards pose threats to human assets and the nature, as they can have impacts and pollutions that do not belong to natural processes. Also, technological hazards can have very long lasting unnatural effects (e.g. oil spills and nuclear fallout).

The focus of this report lies on representing the natural and technological hazards in administrative regions, on NUTS3 level, of the ESPON space (EU 27+2, i.e. the EU member states, its accession countries (Bulgaria and Romania) and associated countries (Norway and Switzerland)). Since all of the EU 27+2 regions are populated and bear human assets, all natural and technological phenomena that can be hazardous to human life, properties, and the nature are defined as hazards.

Many datasets used for this report can still be improved both in terms of precision and completeness. The best example of high data precision and coverage is the earthquake hazard map that is derived from globally homogeneous earthquake data produced by the Global Seismic Hazard Assessment Project. Other hazard maps are more complicated because their main data sources are based on observations and not hazard mapping (e.g. major river floods). In the field of technological hazards representative data sets were difficult to obtain and all hazards that are developed so far are preliminary examples that require further input. All hazard maps follow the same classification of hazard intensity in five classes. In cases where it was not possible to distinguish between five classes, the same classification (very low to very high) is kept, with less classes in between very low and very high.

Table 6: Hazard classification

Class	Hazard intensity
1	Very low
2	Low
3	Medium
4	High
5	Very high

It is important to keep in mind that the results generated on NUTS3 level are rather generalizing and statistically rough. This is especially the case considering the independence of the data sources and the coarse resolution of the data available at the European wide scale. Hence hazards, risks, catastrophes and disasters do not respect political boundaries, a categorisation into administrative areas will always lead to generalisations or exaggerations and thus giving partly deviated images of the reality.

In the following sub-sections, natural and technological hazards in European regions are identified and analysed. The description of each hazard follows a common structure, starting with a characterisation of the hazard, followed by a description of the main aspects of management of the risk. Then, the development of each hazard map is explained and finally analysed. The linkage between natural and technological hazards and policies is provided in the section on policy recommendations

2.1 Natural hazards

Natural hazards are usually defined as extreme natural events that pose threat to people, their property and their possessions. These extreme events occur in closed time spans of seconds or weeks, after which the initial state before the extreme event is reached again. Longer lasting natural processes, such as climate change and desertification, might pose certain threats but do not belong to hazards as such. Most natural hazards arise from the normal physical processes operating in the Earth's interior, at its surface, or within its enclosing atmosphere.

Further research activities in the EU on all kinds of natural hazards are summarized on the web page of the European Mediterranean Disaster Information Network (EU-MEDIN). EU-MEDIN promotes the sharing of disaster-related information and data, research, results, knowledge and expertise. The initiative aims at harmonising methods to improve pre-disaster planning as well as hazard, vulnerability and risk assessments. www.eu-medin.org

2.1.1 Avalanches

Hazard characterisation

An avalanche is a mass of snow, ice and debris sliding down a mountainside. The parameters describing the possibility of having avalanches are quite similar to those for landslides, i.e. slope steepness, depth of snow cover, volume of weak layers in the snow (ice) cover, water saturation, and other effects (wind, seismic activities, etc.). According to a study of several hundred avalanches 90% of the avalanches with (fatal) accidents were triggered by the victims, only 6% are of natural causes and 4% of unknown causes (McCammon, 2000).

Risk management

The European Avalanche Services maintains a website that includes regularly updated maps and reports on avalanches in the Alpine Regions and the Pyrenees. The website also displays many links to other avalanche information websites in Europe and overseas. Many tour operators and skiing resorts maintain their own websites with regularly updated information on the snow conditions and the avalanche hazard. Most European skiing and hiking areas have very detailed and strict avalanche surveillance and warning systems. In these skiing and hiking areas the zones that are safe to use for recreational purposes are clearly marked with signs and maps. Most avalanche accidents in skiing and mountaineering accidents therefore happen to persons that move out of the secure areas and have little knowledge or experience on the hazard, or that take the risk deliberately.

Avalanche hazard map

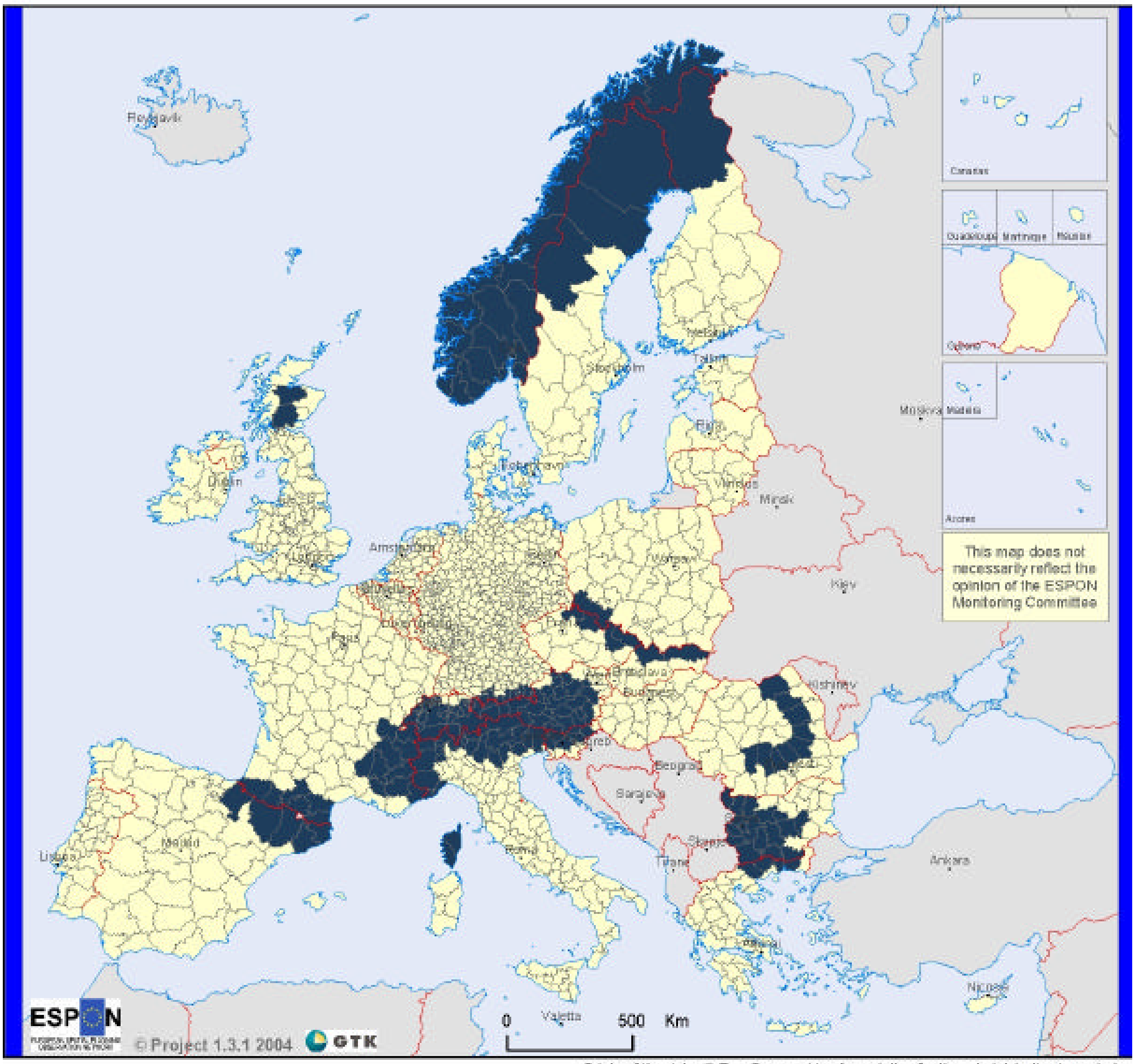
Avalanches are very local phenomena that occur only along certain slopes and valleys. The avalanche hazard map displays those NUTS3 areas in which avalanches may occur. The map does not display a general local frequency or probability, as this is not feasible due to changing weather conditions, i.e. avalanche maps have to be updated regularly. One must bear in mind that avalanches are a natural hazard that is restricted to valleys and slopes that are not representable on a European scaled NUTS3 level map.

Table 7: Avalanche hazard classification

Areas with no (or unknown) avalanche potential	1 Very low hazard
Areas with avalanche potential	5 Very high hazard

Map analysis

All NUTS3 regions with an avalanche hazard bear major skiing resorts. Since people moving in avalanche-prone areas trigger most avalanches with losses of human life, reliable data was difficult to obtain on avalanches in those mountain regions that do not belong to the major tourist areas. The avalanche hazard might therefore appear exaggerated in areas that have lower mountains and less snow than others, as it depicts areas with existing information on avalanches (e.g. Scotland). Areas that might bear higher possible hazards of avalanches and do not have extensive tourism might therefore not be represented. The map shows that the avalanche hazard is widespread among all European mountain regions famous for winter sport activities.



Avalanche hazard

- No avalanches
- Avalanches
- Non ESPON space

Origin of the data: © EuroGeographics Association for the administrative boundaries
European Avalanche Services
USGS GTOPO30 DTM

Source: ESPON Data Base

The European Avalanche Services covers the data of United Kingdom, Spain, France, Italy, Slovenia and Austria. Information about the other countries where obtained from the USGS GTOPO30 digital elevation model and questionnaires.

Map 1. Avalanches

2.1.2 Droughts

Hazard characterisation

Droughts are usually distinguished into 3 types Moneo and Iglesias (2004): 1) Meteorological droughts, (levels of precipitation); 2) Hydrological droughts (water levels in rivers, lakes, reservoirs and aquifers) and 3) Agricultural droughts (availability of water for crops).

Since the ESPON Hazards project was not able to obtain comparable drought data on any of these drought types for the entire ESPON space it was not possible to develop a drought indicator. Instead, data on scarcity of precipitation in large catchment areas were used to develop an indicator for drought potential (see map below) in order to somehow point out the potential hazards of droughts in European Regions. It is also important to stress that here it is assumed that the spatial development is affected strongly by the economical effects caused by any of the drought types mentioned above.

Droughts and long dry periods have led to serious power failures in Europe and in consequence to great economic losses in the industrial sector and tourism. Meanwhile most drought assessments concentrate on the effect on the vegetation and estimate economical losses of agricultural production, the drought risk should also take the effects on the producing industry and the service sector into account. The European countries' agricultural GDP share is well below 5%, in most of the countries it is less than 3%. Therefore in Europe drought impacts on the industry and service sector are more harmful to the economy than agricultural losses. The 2003 drought in Europe accounted for almost 1/3 of the economic natural hazard losses (Munich Re, 2004).

The long-term drought effect on groundwater and surface water levels have a strong impact not only on agriculture but also on power production, etc. Nuclear power plants, for example, might have to run on lower production rates because their cooling systems depend on rivers or lakes. Most of the hydropower plants in areas affected by droughts suffer from reduced energy production due to lower water levels; this is especially crucial for an economy in a country like Norway that is depending on hydropower (Cherry et al.). Other countries in northern Europe that have a high consumption of hydropower also experience the economical effects of rising electricity prices during droughts (Acher, 2002). Droughts usually have long-term impacts, as the water reservoirs, both surface and subsurface, need several raining periods in order to restore. Dreadful is a combination of a drought and a heat wave. The power support is not only getting shorter due to the effects mentioned above, it is additionally stressed by the need for cooling systems that themselves demand a lot of energy. Additionally, power plants might have to shut down because the cooling water taken from lakes, rivers or the sea might be too warm to be used.

Risk management

The effects of droughts have to be analysed and assessed on regional or local scale. Meanwhile failing groundwater recharge in a certain period does not necessarily have long lasting ecological effects, an accumulation of many events over several years can affect the entire ecological system. It is also important to take the dependency of, e.g. a groundwater system on annual recharges into account. Regions with very shallow aquifers require a steady recharge meanwhile deeper and larger aquifers can cope easier with drier years, simply because they store much more water. In Europe the man made impact on droughts is considerable. There are several examples of water resource mismanagement, such as over pumping of aquifers, sealing of areas increasing surface runoff and restricting groundwater recharge, overuse of water in dry areas and intensive agriculture in places where extensive agriculture would be more appropriate, and many more. Since climate conditions that lead to droughts are extremely difficult to predict and droughts are usually not recognizable until it they are already well advanced, the drought hazard can only be managed by the sustainable use of water resources. Water should be stored in times when it is abundantly available in order to ensure enough supply during a drought.

Map of precipitation deficits in regional basins 1904-1995 as potential drought indication

The inhomogeneous topography, climate and vegetation of Europe make it very difficult to compare the drought hazard on European scale. E.g. agricultural droughts are dependent on local circumstances (vegetation types, plant water demands, etc.); and meteorological droughts might expand beyond areas of hydrological droughts. Hydrological droughts are those that could best describe the impact on power production and industry, which are the major reason of economical damage by droughts.

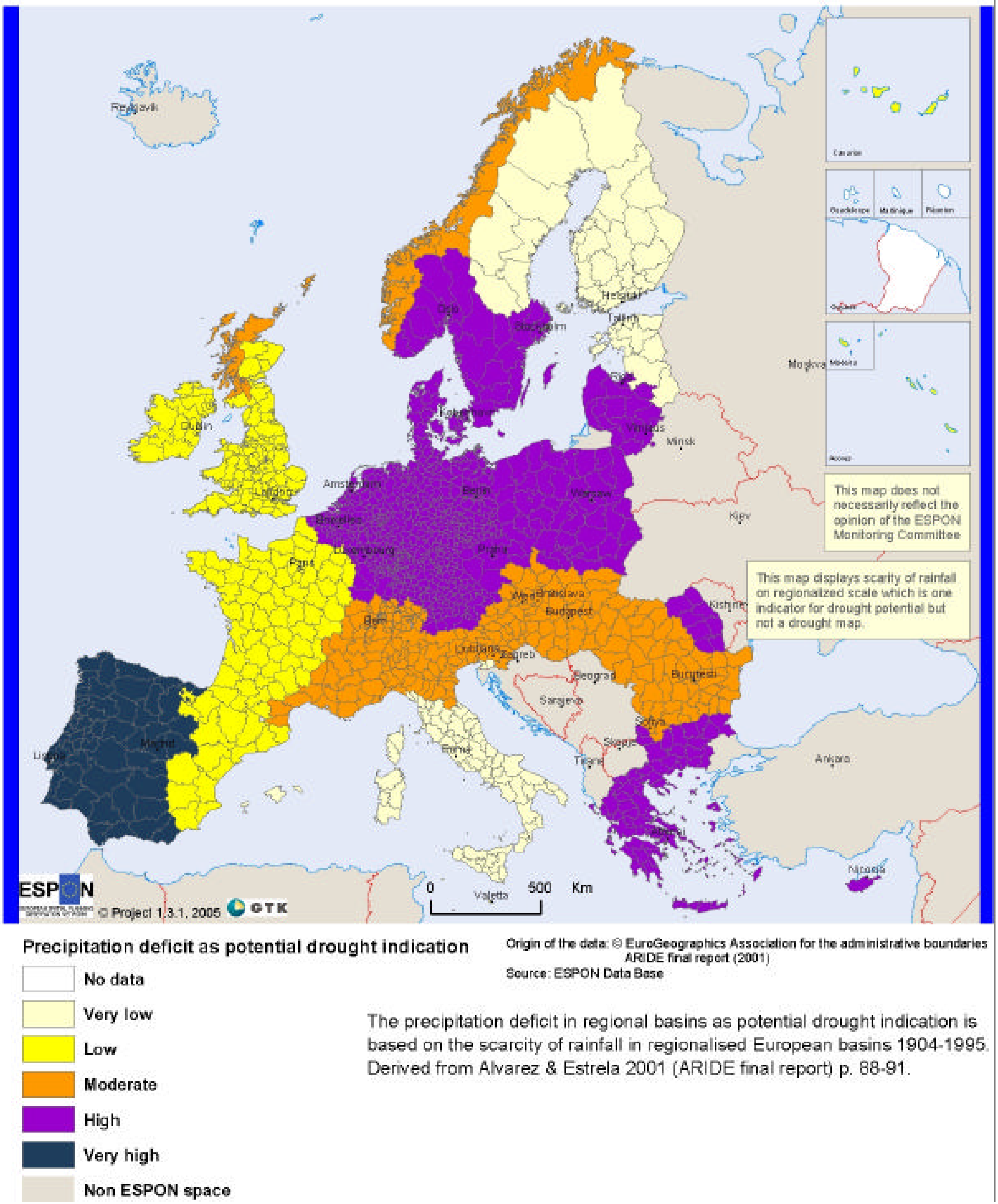
Since the ESPON Hazards project did not get hold of appropriate data sets for making such a hydrological drought map, it focussed on the report of Alvarez and Estrela (2001). This report presents a map of European regions based on a clustering process. A table in this report mentions large drought events in Europe based on scarcity of precipitation. Because of non-availability of data, other drought aspects were not taken into account in this table. The ESPON Hazards project merged the table and the map and displays the resulting recorded droughts on NUTS3 level. This approximately 100 year long record does not predict future areas that might be hit by droughts. Since the map is based on historically reported drought events, the data accuracy is variable. Therefore the map is applicable as a general overview map on past large drought events in Europe. The resulting potential drought hazard is calculated from the amount of recorded droughts per NUTS3 level during the last century.

Table 8: Precipitation deficit as potential drought indication

Amount of observed precipitation deficits 1904-1995	Class
2	1 Very Low
3-5 (no area with 4 droughts)	2 Low
6	3 Medium
7	4 High
8	5 Very high

Map analysis

The map shows interesting patterns and issues drought potential on a European scale. For example, Norway has problems with water deficiency because the country's economy is strongly depending on hydropower. Eventhough Norway has some of the rainiest places in Europe small negative deviations in precipitation can lead to energy problems because the water reservoirs are not refilled appropriately (Cherry *et al.*). The map also shows that the Mediterranean area has a wide variety of the drought potentials. Meanwhile Portugal and western Spain have the largest drought potential in Europe, eastern Spain appears to have generally a lower potential. Some areas in southern Europe that are usually associated with droughts appear less dramatic in this map. The reason for this lies in stronger local effects of agricultural droughts, as these might partly be related to the adequacy of agricultural systems and related water scarcity. A problem in this map are the severe jumps of two classes in some areas, e.g. in northern Europe. Also southern Italy appears to have a low drought potential, eventhough it is surrounded by areas with a higher drought potential. The reason for this might be that the drought problem in southern Italy is not directly related to precipitation deficits but to other reasons not displayed here. As mentioned above, the data and map shown here represent an indicator for drought potential. The data are gathered over a long time period with scarce information and shown on clusters of European regions. Due to the existing limitations of the map, its results are not used as a basis for specific policy recommendations on droughts in particular. The map shown is only to be used as one indication of many in the drought hazard discussion and much more research is needed for the production of a drought hazard map for Europe.



Map 2. Precipitation deficit as drought potential indication

2.1.3 Earthquakes

Hazard characterisation

Earthquakes are seismic movements of the solid earth that are mainly caused by tectonic activities. Most of the world's earthquakes occur in areas where large tectonic plates meet but they may also occur within plates themselves. Earthquakes can also occur by other impacts, such as collapse of cavities underground. Man made explosions, example for tunnelling works, can also create local earthquakes. Therefore earthquakes can occur in all terrestrial and submarine areas. Earthquakes can trigger other hazards, such as landslides, tsunamis and avalanches.

Risk management

Minimization of the loss of life, property damage, and social and economic disruption due to earthquakes depends on reliable estimates of the seismic hazard. National, state, and local governments, and the general public require seismic hazard estimates for land use planning, improved building design and construction, including adoption of building construction codes. The EN1998 Eurocode 8: "Design of structures for earthquake resistance" intends to regulate earthquake proof building design in Europe (Lubkowski and Duan, 2001).

Earthquake hazard map

The peak ground acceleration data from the Global Seismic Hazard Assessment Project (GSHAP) were used to produce an earthquake hazard map covering the whole of Europe. The GSHAP project was designed to provide global seismic hazard framework as a resource for any national or regional agency for further detailed studies. One of the main goals of GSHAP was to produce a homogeneous seismic hazard map for horizontal peak ground acceleration representative for stiff site conditions, for the probability level of an occurrence or exceeding of 10% within 50 years. The peak acceleration is the maximum acceleration experienced by the particle during the course of the earthquake motion. Acceleration is chosen, because the building codes prescribe how much horizontal force building should be able to withstand during an earthquake. This force is related to the ground acceleration. The peak ground acceleration is described as percentage of the earth's gravity g (see table 9).

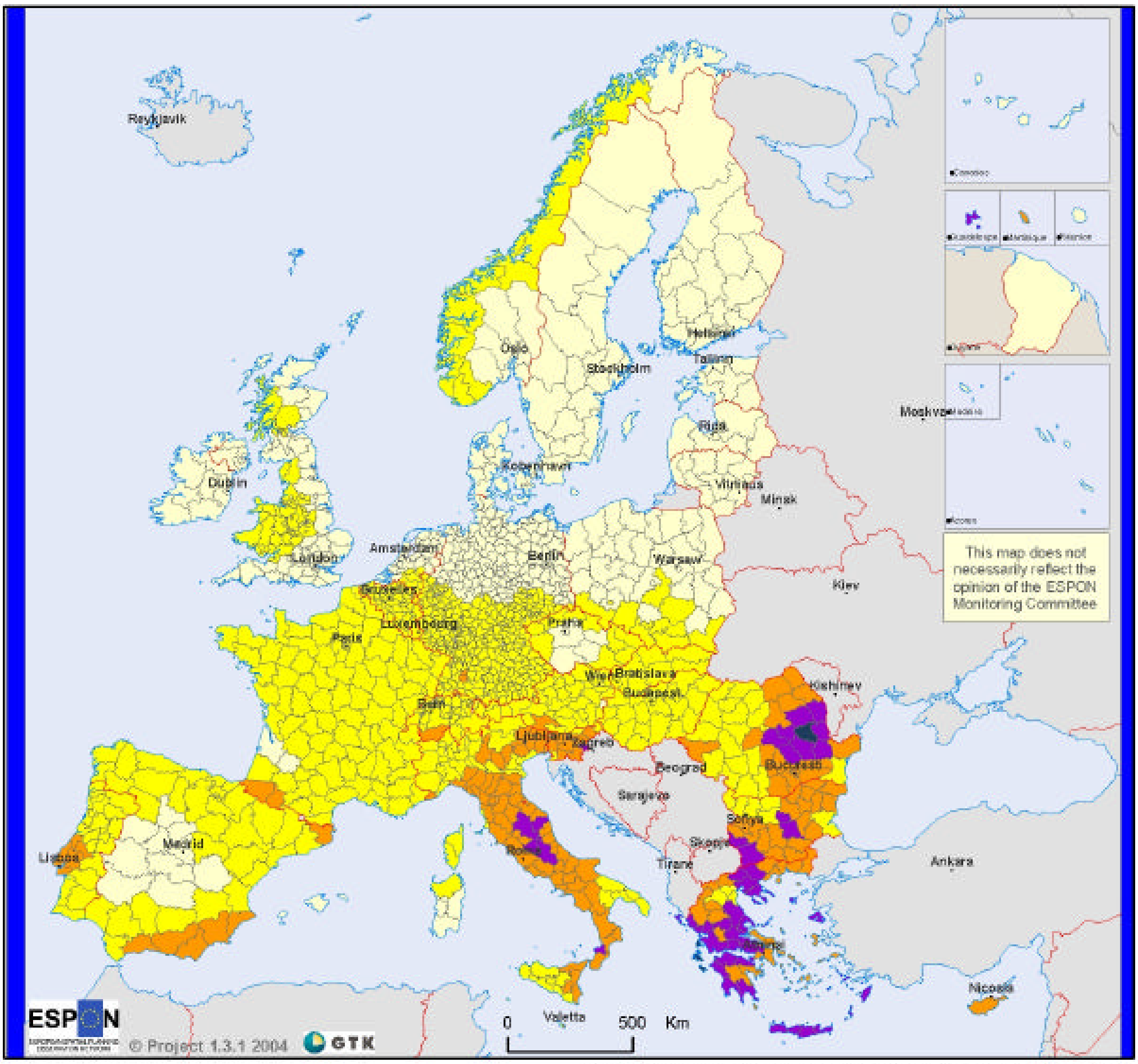
To create the hazard potential classification in five classes, the mean value of the grid points inside the NUTS3 boundaries were calculated. This method will lower the effect of the peak values in the area. This classification of the GHASP project was turned to five classes by the ESPON Hazards project:

Table 9: Earthquake hazard classification

Peak ground acceleration	
0-4% g	Very low hazard
4-14% g	Low hazard
14-24% g	Medium hazard
24-40% g	High hazard
> 40% g	Very high hazard

Map analysis

The highest earthquake hazard is concentrated in south-eastern areas of Europe, e.g. Greek, Italy and Romania. With the theory of plate tectonics, it has become evident that most earthquakes occur along the margins of plates, where one plate comes into contact with another, developing shear stresses. There are, however, examples of significant earthquakes apparently not associated with the plate boundaries. The earthquake activity zone affecting in continental Europe is sometimes called the "Mediterranean and trans-Asiatic" zone. Earthquakes in this zone have foci aligned along mountain chains. These active zones have not changed significantly through human history (Radu and Purcaru, 1964).



Earthquake hazard potential

- Very low hazard
- Low hazard
- Moderate hazard
- High hazard
- Very high hazard
- Non ESPON space

Origin of the data : © EuroGeographics Association for the administrative boundaries
Pga data © Global Seismic Hazard Assessment Program

Source: ESPON Data Base

The hazard classification is based on the average value of the peak ground acceleration (pga)/acceleration of gravity (%) in a NUTS3 region.

Map 3. Earthquakes

2.1.4 Extreme temperatures

Hazard characterisation

Extreme temperatures are significantly higher or lower than the average temperature of a regional climate. Summers can be significantly hotter or colder than average, and winters can be colder or warmer than average. The strong climatic differentiation of EU 27+2 from Mediterranean to sub-artic climate does not allow single extreme temperature figures for the entire continent. Mostly extreme temperatures are described as an excess of the average temperatures in a climate zone or a typical regional climate.

Extreme heat can lead to strong health impacts that mostly affect the oldest and the youngest population. Power plants might get problems because cooling water taken from rivers, lakes or the sea might be too warm and the plants have to run on lower energy output. This can lead to problems in power support, because production energy and households at the same time consume more energy to run own cooling systems. Finally, power cuts can have extreme impacts on the producing industry and thus on the economy of an entire country.

Extreme cold leads to a stronger use of heating systems, which can then lead to a shortage of energy and even power cuts. Extreme cold can also physically damage heating systems (cracking of pipelines, tubes). In cases of severe shortage of heating, extreme cold can lead to serious health damages or fatalities.

Risk management

Hence extreme temperatures cannot be forecasted on a long-term basis and cannot be directly mitigated, they can only be managed by proper disaster plans that regulate the behaviour of authorities and emergency facilities in case of a heat or cold wave. For example, the use of energy can be controlled in case of low energy availability and emergency plans can regulate the use of hospitals, supply of needed goods, etc.

Extreme temperatures hazard map

The extreme temperature map is based on data from the Swedish Meteorological and Hydrological Institute (SMHI) Rossby Centre's Regional Atmosphere-Ocean Model (RCAO). The data is based on a grid of 50x50km from the time span 1961-1990. The four equally weighted factors are in the following table 10:

Table 10: Classification of extreme temperature

Hot days	The 99th percentile of daily temperatures in NUTS3
Heat waves (7-day maximum temperature)	The 90th percentile of annual maximum 7 day average temperature in NUTS3 region
Cold days	The 1st percentile of daily temperature in NUTS3 region
Cold waves (7 day minimum temperature)	The 10th percentile of annual minimum 7 day average temperature in NUTS3 region

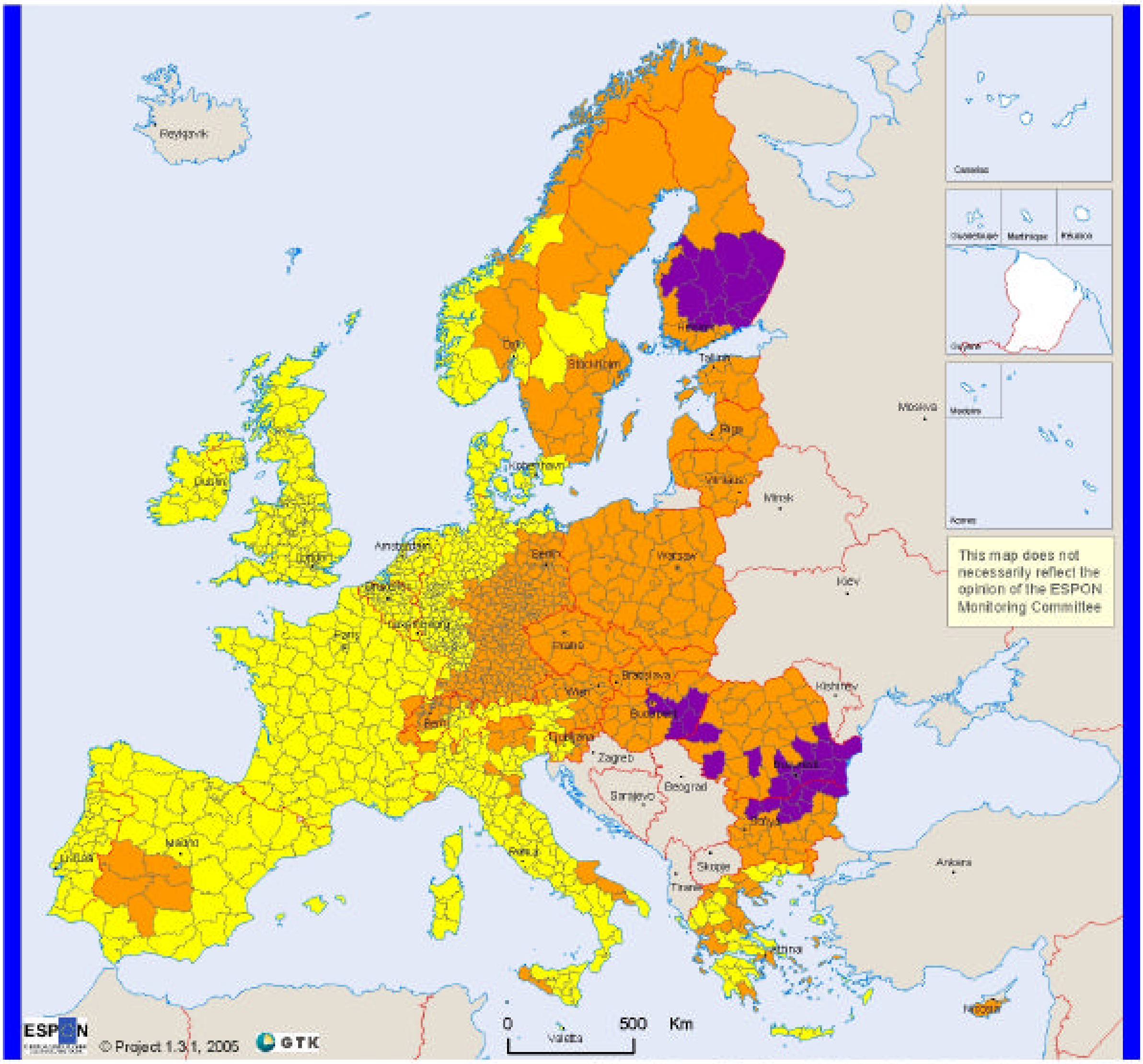
All four factors are classified in ordinar scale with five classes. The extreme temperature hazard indicator classification is based on the mean value of these four factors. The mean values of each NUTS3 region are classified in three categories. The hazard values "very low hazard" and "very high hazard" are not represented in this scale, because there are no such exceptional areas in EU 27+2 where both, extreme coldness and extreme heat appear in the same area.

Table 11: Extreme temperature hazard classification

Mean = 2-2.75	2 Low hazard
Mean = 2.75-3.25	3 Moderate hazard
Mean = 3.25-3.50	4 High hazard

Map analysis

The extreme temperatures index map of Europe shows a general trend of an increasing extreme temperature hazard from west to east. Also northern Europe shows a higher hazard than southern Europe. The reason for these trends is that the more continental the climate, the extremer the temperature differences. More continental climates anyhow show stronger annual temperature amplitude than marine influenced climates. This effect might grow in connection with climate change. Northern Europe might show a higher hazard of extreme temperatures due to a quicker effect of climate change observed in the Arctic than so far presumed (Hassol, 2004), i.e. areas that are closer to the Arctic might respond quicker than areas located further way from it.



Extreme temperature hazard

- Low hazard
- Moderate hazard
- High hazard
- No data

Origin of the data: © EuroGeographics Association for the administrative boundaries
Rossby Centre RCAO model
Source: ESPON Data Base

This map shows the mean of four indicators (hot days, heat waves, cold days and cold waves).

Map 4. Extreme temperatures

2.1.5 Floods

Hazard characterisation

Floods are high-water stages where water overflows its natural or artificial banks onto normally dry land, such as a river inundating its floodplain. Floods occur at more or less regular intervals in riverbeds and floodplains. Besides storm surges the two main types of flood are river flood and flash flood. Further, there are a few special types like ice flood, backwater, groundwater rise, lake-level rise, and glacial lake outburst floods (Munich Reinsurance Company, 2000). During wintertime, ice blocks may dam rivers causing sudden extensive flooding, and the formation of frazil ice inside freezing rivers in the winter may lead to floods in places where it prevents discharge (Finnish Environment Institute, 2004). Floods occur as natural phenomena when the river runoff is so strong, that the riverbed is too small to contain the water masses. Floods are most regular in Europe in springtime, when the winter snow and ice is melting. Strong floods happen irregularly, in so-called re-occurrence intervals of 10, 50 or 100 years. But these intervals are only statistical averages as for example the Rhine/Mosel catchment areas were hit by 100-year return period floods in the end of 1993 and the beginning of 1995. Heavy summer rainfalls can also lead to floods, as happened for example in 1997 in the Oder and 2002 in the Elbe basins. Floods have become an increasing problem for the built up environment since human beings have started to change, straighten and even relocate river beds with their natural flood prone areas and by settling in low lying areas close to rivers. Also increased soil sealing leads to a higher flood hazard, as rainwater runs off directly into the streams and the water mass inflow to rivers is no longer delayed by natural soil retention.

Flash floods are the fastest-moving types of floods. A flash flood is a specific type of flood that appears and moves quickly across the land, with little warning. Heavy rainfall concentrated over an area, thunderstorms, hurricanes and/or tropical storms cause most flash flooding. Dam failures can also cause flash flood events. When a dam or levee breaks, a gigantic quantity of water is suddenly discharged downstream, developing strong destructive forces.

Flash floods can contribute to river floods, or can be caused by river floods, for example if an embankment collapses. Flash floods can happen all over the European territory but are mostly bound to catchment areas and are thus integrated into the map of large river floods in Europe.

Risk management

The most important part of flood risk identification and management is the flood-prone area (extent) delineation. Flood-prone areas are those areas subject to inundation as a result of flooding with certain frequency. The determination of flood prone area requires considerable collation of historical data, accurate digital elevation data, discharge data and number of cross-sections located throughout the watershed (Lear J. *et al*.). In Europe this complex kind of data is available only from certain case study areas. So far flood prone area mapping in Europe does not follow a cohesive approach, there are several approaches in different catchment areas or riverbeds. In addition to taking past flood events into account, it could be possible to derive river flood prone areas in European regions by river catchment area elevation modelling.

In a future cooperation of European research institutions it might be possible to develop a flood prone area map of European regions based on digital terrain models, river runoff, flood data and climate models.

Large river flood events recurrence map in Europe

This report presents the first aggregated large river flood map of Europe, based on the recurrence of floods in the time span of 1987-2002. The regional flood hazard for this 15-year period is displayed on NUTS3 level. The methodological approach focuses on areas that have actually been affected by floods and does not take local or regional flood prone area mapping into account.

Since the ESPON hazards project could not get hold of data to produce a flood map based on probability calculations, historical data were used to show the spatial patterns of the flood problem. The resulting large river flood map is mainly based on the "Global Active Archive of Large Flood Events", of the Dartmouth Flood Observatory. The Observatory detects, maps, measures, and analyzes extreme flood events world-wide using satellite remote sensing. The Flood Observatory is located under Dartmouth College in Hanover USA and its work is partially supported by NASA Earth Science Enterprise grant. The Global Active Archive of Large Flood Events does not yet completely cover the time period 1987-2002, for instance the delineated flood areas from the years 1989, 1990, 1991, 1995 and 1996 are still missing. Some of the missing floods were completed from other sources (Rhine Atlas, 2001 and Envisats online data sets). The flood events archive is under supplement work and the aim is to add the data from missing years continuously.

The Dartmouth Flood Observatory digitised flood areas have been changed by the ESPON Hazards project to a relatively coarse raster size (25km x 25km) to avoid detailed interpretation. Representing this data on NUTS3 level therefore shows a generalized overview on the EU 27+2 territory. In this “Flood hazard recurrence” map the average value of the registered large flood events was calculated for each NUTS3 area.

The recorded floods do not show the magnitude of a single flood but the extent of a flooded area. Since the used data does not give any information on the depth of inundation, and this kind of data does not exist for the ESPON space, the flood reoccurrence map shows the amount of floods per NUTS3 level regardless of its magnitude. One can argue that a single catastrophic flood like the one occurred in the Elbe basin in 2002 has a great societal impact. But this was a single event that broke most historical flood records of the area. It thus has a low probability of reoccurrence and consequently a low impact on spatial development. Areas that are flooded regularly on the other hand, have to take the high water stages into account in the spatial development plans, even if the water levels do not always lead to major destructions and fatalities. Regular floods, even with low water levels, can be of a far greater challenge for spatial development than a single record catastrophic event.

The ESPON hazards project is well aware that this time scale is rather short for a flood map, but it is the only data set available covering the ESPON space. The map should therefore be used as an overview on areas that have had more floods than others in a 15year time scale. This overview is interesting for a Europe wide comparison but should not be used for local interpretations.

Table 12: Major river flood hazard classification

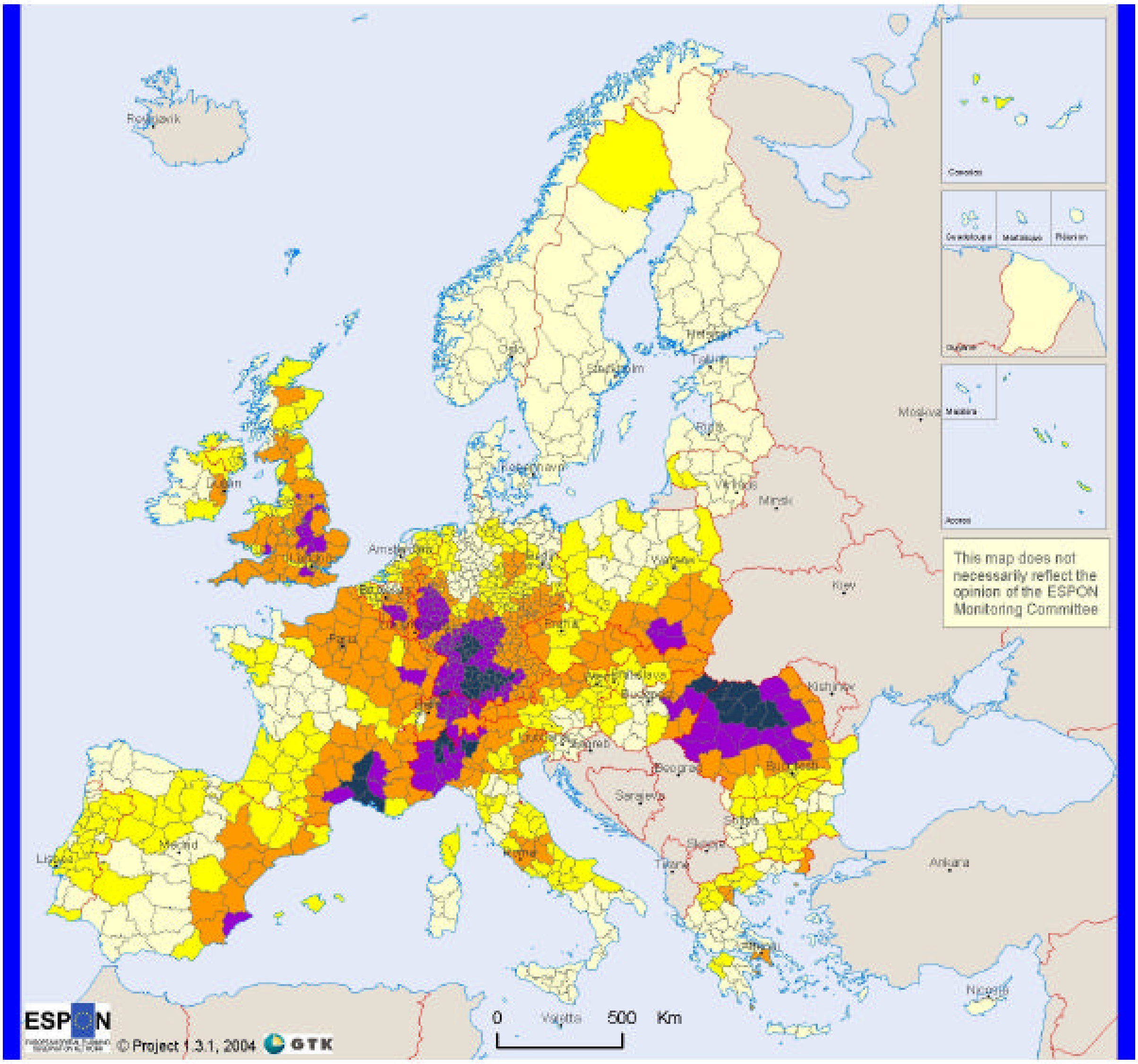
Number of observed floods per NUTS3 level	Hazard classes
0	1 Very low hazard
1*	2 Low hazard
>1 - <=2	3 Moderate hazard
>2 - <=3	4 High hazard
>3	5 Very high hazard

*This classification is synthetic and points out the recurrence of large flooding events in Europe, meanwhile the magnitude of single flood events is not taken into consideration.

Map analysis

Based on map 5 the highest amount of large flood events between 1987 and 2002 are concentrated in north-western Romania, south-eastern France, central and southern Germany and in the east of England. As explained above, the source data were obtained through satellite images and the mapped areas may not coincide to 100% with areas that have actually experienced floods. Also the observation period is rather short to have actual statistical significance. Another problem with the data is the lack of flood magnitude information. The big 100-year return period flood events could not be distinguished from the more frequent ones. The authors are aware of the limitations of the flood indicator used in this project. However, there are no statistically significant long-term data sets covering the EU 27+2 area available at the moment.

Eventhough this kind of map is actually not usable as a flood prone area map, as it displays the past events and does not forecast possible future events, it gives a representative picture of the flood hazard. This was shown for example in the floods that have hit southern France in 2004, as the flood hazard map depicts this area as one with a high flood hazard.



Flood recurrence

- Very low
- Low
- Moderate
- High
- Very high
- Non ESPON space

Origin of the data: © EuroGeographics Association for the administrative boundaries
Large flood areas © Dartmouth Flood Observatory
Flood areas © ESA - Earth observation - Earth online
Rhine Atlas 2001 IKRS-CIPR-ICBR

Source: ESPON Data Base

This map displays the hazard recurrence based on average number of large flood events on NUTS3 regions 1987-2002. The first class "Very low hazard intensity" includes the regions without large flood events.

Map 5. Floods

2.1.6 Forest fires

Hazard characterisation

Forest fires (wild fires) can cause considerable damage in environmental terms, e.g. by the destruction of fauna and flora, and can cause human casualties. They also have serious economic implications on forestry, infrastructure and private property.

Forest fires are natural phenomena (e.g. self ignition, lightning, etc.) that are very important for the natural living process of a forest. They lead to a natural cleaning process of forests, as e.g. excessive dead wood is burnt. The suppressing of forest fires can lead to the production of excessive biomass and dead wood that lead to unnatural conditions, leading to more catastrophic forest fires than in natural forests due to the abundance of fuel.

Risk management

Forest fire is a complex phenomenon that is difficult to model and manage. There are many factors that co-exist for the ignition of forest fire. These include human factors (population density, road density), topographic variables (slope steepness and direction), meteorological variables (temperature, precipitation) and vegetation variables (land cover type, moisture content, availability of fuel). The major problem is that a large amount of forest fires are caused by human action, e.g. arson, which is difficult to model or predict in any form. According to the Global Forest Fire Assessment 1990-2000 of the FAO, forest fires caused by humans in the Mediterranean basin reach 90-95%, meanwhile natural causes represent only a small percentage of all fires (from one to five percent, depending on the country).

The trend of increasing fire occurrences in the south-eastern European countries, fire damages and fire severity is a consequence of the changing rural and urban space due to the economic transition. Unprecedented numbers of catastrophic fires and areas affected by fire have been observed since 1991 (Goldammer, 2002).

The spread of forest fires and the behaviour of the fires are investigated in many case study regions. These research activities help to foresee the development of a fire under certain meteorological conditions and according to the topography. The knowledge achieved from this research has helped to limit the extent of fires and to protect human lives.

Until the end of 2002 the European Commission has given Commission Regulation (EC) No 804/94 laying down certain detailed rules for the application of Council Regulation (EEC) No 2158/92 as regards forest-fire information systems. The new Regulation (EC) No 2152/2003 (November 2003) also focuses on studying forest fires and it states that it will incorporate the earlier regulations.

Forest fire map

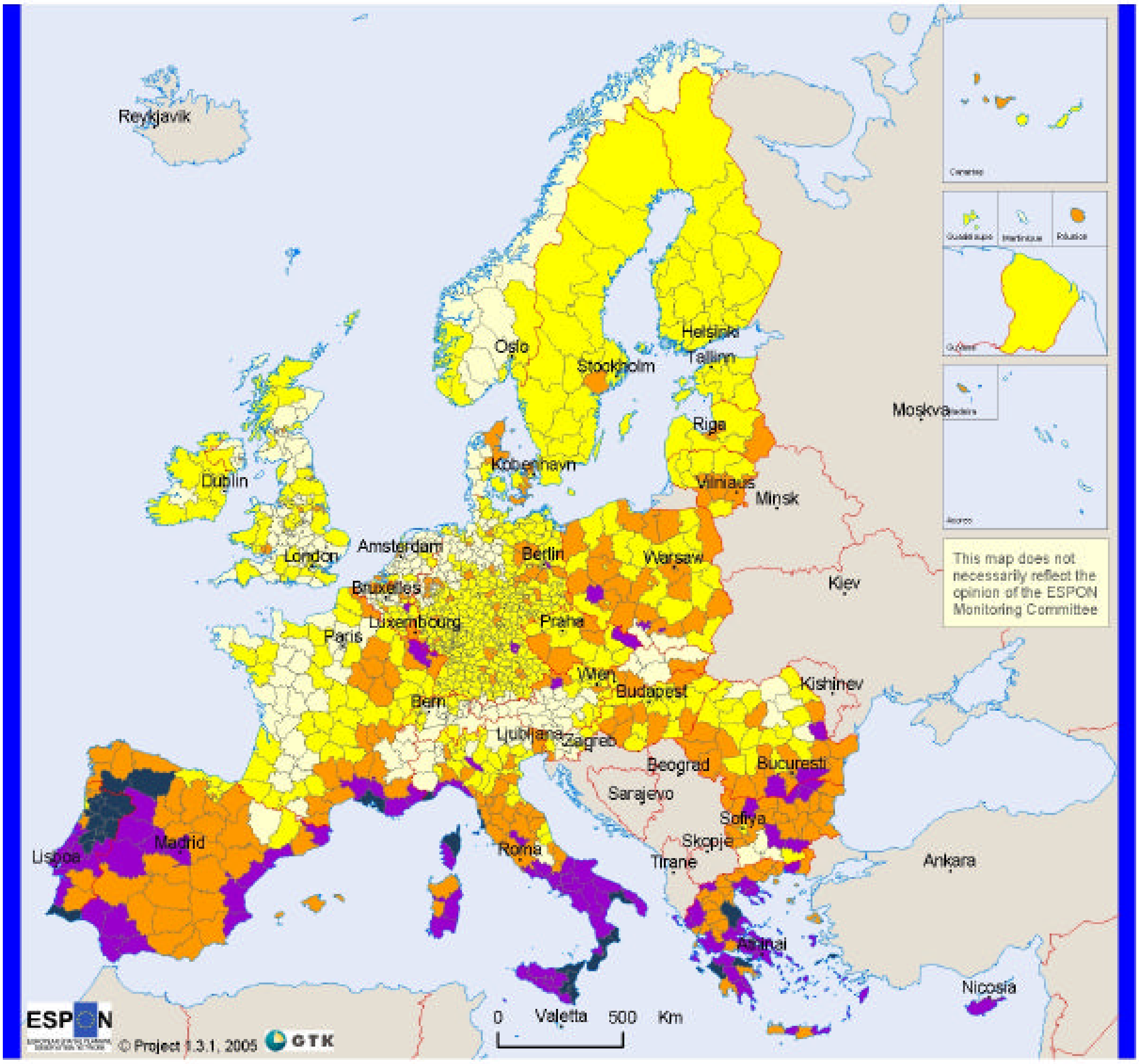
There is extensive research on forest fire forecasting in the EU but currently no forest fire potential maps are available at EU scale yet. The forest fire hazard map developed by the ESPON Hazards project is a combination of vegetation zones and observed forest fires (ATSR World Fire Atlas, 1997 to 2003). The amount and density of observed forest fires gives a good overview on the distribution of fires on European level but the short observation period does not allow too detailed conclusions on the actual hazard on regional level. The main limitations of the used database are that only night time fires are detected and the repeat cycle of the satellite is three days. Fire temperature and extension are not taken into account, either. The vegetation zones, which are regulated by climate and the relief, play a major factor for the physical potential of forest fires. A combination of these two factors leads to a valuable overview on the forest fire hazard on European scale. Most fires have been observed in the Mediterranean vegetation zone. The amount of observed fires then gradually lessens over the vegetation zones to the lowest observed amount in the artic and alpine vegetation zones. Following the ESPON Hazards project's methodology, the European vegetation zones (EEA, 2003) were categorised into five classes, according to the amount of observed forest fires. The lowest class are alpine and artic regions, the second class the Atlantic, the third Boreal, the fourth Continental, Steppic and Pannonian, and the fifth Mediterranean. The observed forest fires (ATSR World Fire Atlas) were also categorized into five classes, according to the amount of forest fires per 1000 km^2 within years 1997 to 2003. The forest fire hazard classification on NUTS3 level is based on the sum of the vegetation zone class and the forest fire class. According to this classification, the highest forest fire hazard for alpine regions is medium (in case of high density of forest fires but low vegetation class) and the lowest forest fire hazard in the Mediterranean vegetation zone is also medium (in case of a low density of forest fires but a high potential). This straightforward classification scheme gives a very representative picture of the existing forest fire hazard, according to several interviewed forest fire experts.

Table 13: Forest fire hazard classification

Observed forest fires per 1000 square kilometres	Hazard class	Biogeographic regions	Hazard class	**Resulting sums**	**Resulting forest fire hazard classes**
No forest fires	1	Alpine and Arctic	1	**2-3**	**1 Very low hazard**
1	2	Atlantic	2	**4-5**	**2 Low hazard**
2-5	3	Boreal	3	**6-7**	**3 Medium hazard**
6-10	4	Continental, Black Sea, Pannonian and Steppic	4	**8-9**	**4 High hazard**
>10	5	Mediterranean	5	**10**	**5 Very high hazard**

Map analysis

The forest fire hazard map shows that the areas with the highest potential for forest fires lie in the Mediterranean, partly Romania and Bulgaria and in some hot spots in central Europe. The large areas with the highest hazard lie in central-northern Portugal and in north-western Spain, due to bcal habits of slash and burn practices that are a dreadful combination with the high forest fire potential.



Forest fire hazard

- Very low
- Low
- Moderate
- High
- Very high
- Non ESPON space

Origin of the data: © EuroGeographics Association for the administrative boundaries
Number of fires 1997-2003: ATSR World Fire Atlas European Space Agency - ESA/ESRIN
Biogeographic regions: EEA
Source: ESPON Data Base

The classification of the forest fire hazard is based on a combination of the numbers of observed fires per 1000 sq. km 1997-2003 (ATSR) and the map of biogeographic regions in Europe (EEA).

The number of observed fires per 1000 sq. km 1997-2003:
1 = No fires
2 = <1 fires
3 = 1-5 fires
4 = 5-10 fires
5 = >10 fires

Biogeographic regions:
1 = Alpine and Arctic
2 = Atlantic
3 = Boreal
4 = Continental, Black sea, Pannonian and Steppic
5 = Mediterranean

Map 6. Forest fires

2.1.7 Landslides

Hazards characterisation

The term landslide includes a wide range of ground movement, such as rock falls, deep failure of slopes, and shallow debris flows. Although gravity acting on a slope is the primary reason for a landslide, there are other contributing factors, such as erosion processes, water saturated soils after rainfalls and snowmelts, heavy loads deposited on slopes, e.g. by snowfall or from ashes of volcanic eruptions and seismic activities. Human activities can cause landslides because of artificial slope constructions (roads, stockpiling, mining, etc.) and by other activities, such as deforestation.

The term landslide comprises many geotechnical subterms that all have different causes and effects. Also, different European regions use varying terms for similar phenomena in European languages. For e.g. the Geological Survey of Bavaria, Germany, distinguishes between 6 different types of mass movements. The ESPON Hazards project uses the general term "landslide" to express the hazard of gravity forced movement of material on a slope that could lead to potential structural damages and accidents.

Risk management

In the case of landslides it is most difficult or even impossible to assess return periods or probabilities of occurrence. Estimations for landslide probability due to meteorological conditions (rainfalls, etc.) are possible for all areas sensitive to landslides. Also the probable occurrence of earthquakes can be estimated. Although the physical cause of many landslides cannot be removed, local geologic investigations and good engineering practices, as well as effective enforcement of appropriate land-use management regulations can reduce landslide hazards. Landslides are local phenomena that should be managed by large-scale studies.

Landslide hazard map

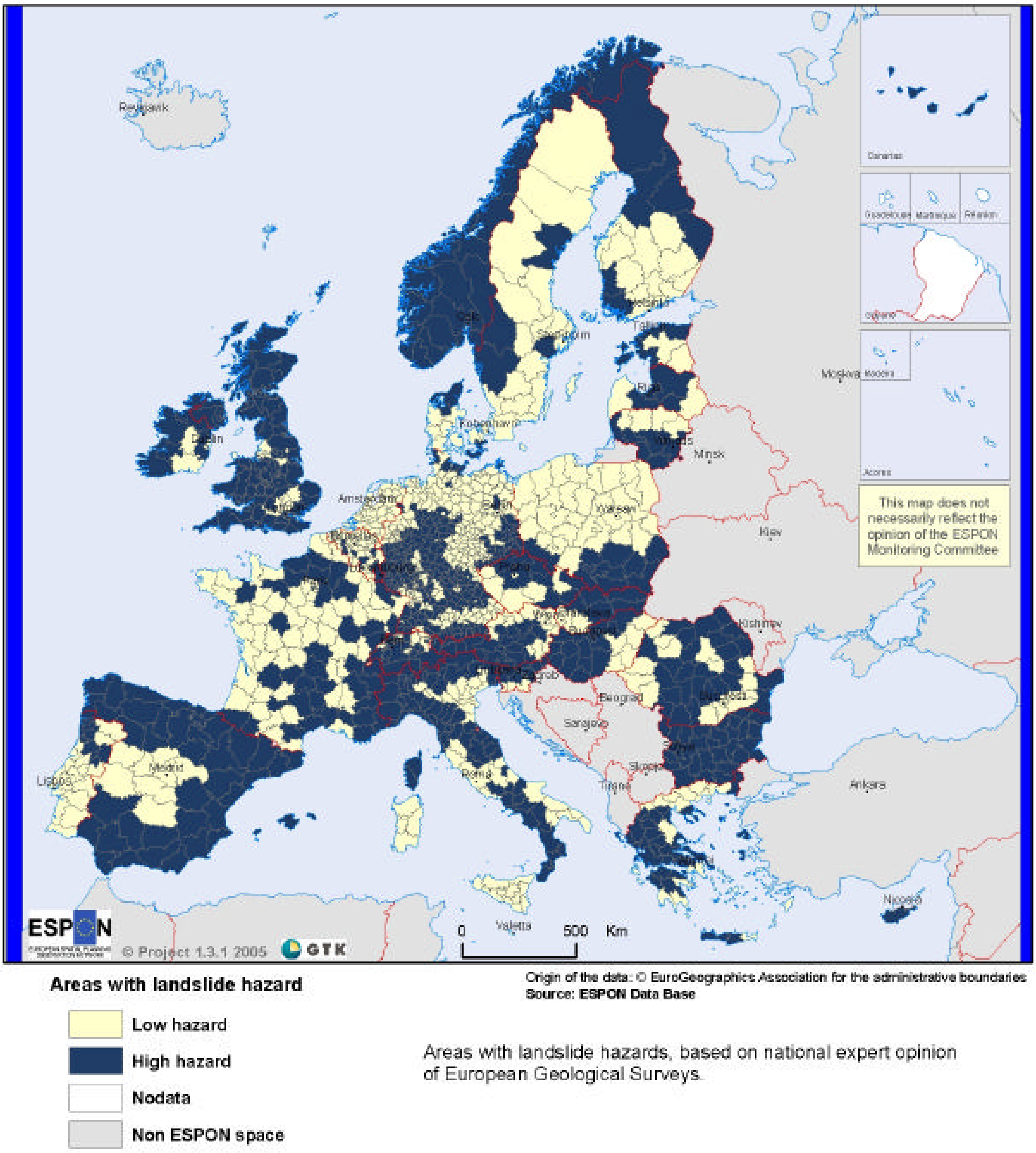
NUTS3 levels are too coarse for pinpointing areas sensitive for landslides. In order to develop a first overview map on the problem of landslides in European regions, the ESPON Hazards project developed a questionnaire that was sent to all geological surveys of Europe. Based on expert opinion, the geological surveys were asked to mark those NUTS3 areas of their respective country or region that have the possibility of landslide hazards in general terms. In order to keep the comparability of simply displaying the landslide hazard, probability and risk factors were excluded. Some regions included so-called man made landslide problems, for example in open pit mines.

Table 14: Landslide hazard classification

No or unknown landslide potential	1 Very low hazard
Landslide potential	5 Very high hazard

Map analysis

The landslide hazard in the European regions map gives an overview on the landslide hazard but does not assess in any detail neither in which parts of the regions landslides occur nor the causes of landslides (e.g. geology, relief, construction, etc.). A striking point in the map is the large extent of the landslide hazard in European regions, showing that even though the total amount of losses due to landslides in Europe is not economically very significant (Munich Reinsurance Company, 2004), the hazard itself is rather widespread over the entire European territory.



Map 7. Landslides

2.1.8 Storm surges

Hazard characterisation

Storm surges occur mainly in Northern Europe and have led to devastating impacts until the 1960's. Since then improved coastal zone management enables to keep the damages of storm floods low. Storm surge is seawater that is pushed toward the shore by the force of the winds of a strong storm. This rise in water level can cause severe flooding in coastal areas, particularly when the storm tide coincides with the normal high tides. In northern Europe many coastal areas lie just above or even below the mean sea level and the danger from storm tides is very high. Storm surges can appear in may European areas (see map 8), but due to the high winter storm probability the North Sea shoreline is especially exposed to this hazard.

Risk management

The North Sea coast has experienced severe storm surges throughout human history, the largest recent devastating surges hit the Netherlands in 1953, killing 2100 people, and the German North Sea coast and Hamburg in 1962, killing over 300 people. Better coastal management and the erection of stronger sea walls have since then protected the coastal areas from such catastrophes, eventhough the coast has been hit by stronger winds and higher water levels in the years 1973, 1981 and 1990 (strongest recorded storm surge so far) (Junge, 2005). Nowadays many of the North Sea territories have Integrated Coastal Zone Management (ICZM) plans that clearly define the land use in coastal zones, the coastal protection measurements and the hazard management facilities (Ministry of the Interior of Schleswig-Holstein, 2003). Many European coastal regions without an imminent storm surge hazard still despise of such ICZM plans.

Storm surge map

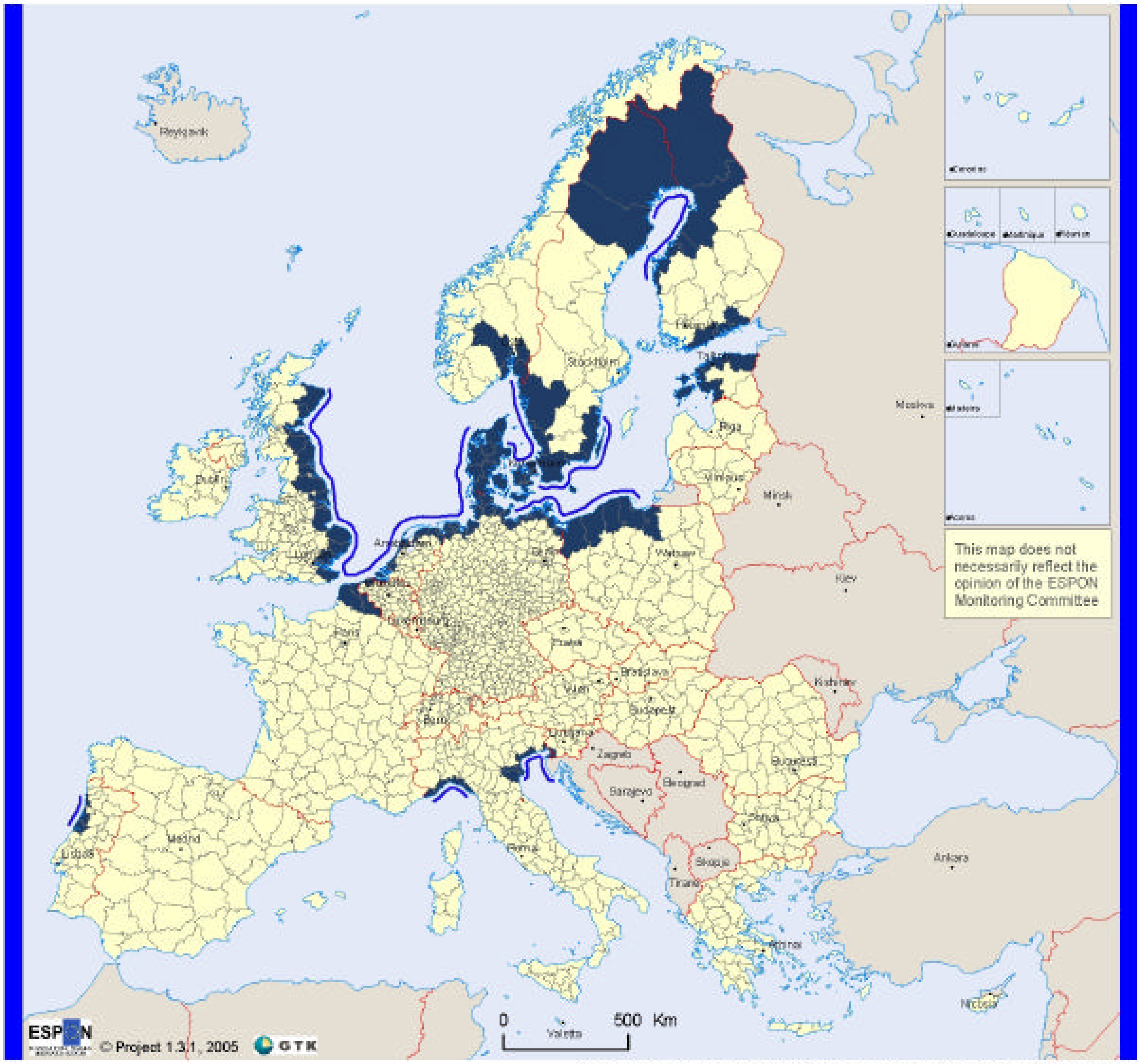
In the case of storm surges coastal morphologies (e.g. lowlands versus cliff coasts) and coastal protection measurements (e.g. sea walls) play an important role in the actual threat that surges pose to the coastal areas. The existing data sets do not yield enough information for such a classification on the entire EU 27+2 area. Therefore storm surges are represented as a general hazard in areas where they might occur.

Table 15: Storm surge hazard classification

No or very low storm surge probability	1 Very low hazard
Medium or high storm surge probability	5 Very high hazard

Map analysis

Since storm surges are often closely linked to winter storms, the very high hazard area is mainly located in the areas where winter storms occur.



Storm surge hazard

Storm surge

Occurence of storm surges NUTS 3

ESPON space

Storm surge hazard

Non ESPON space

Origin of the data: © EuroGeographics Association for the administrative boundaries
Storms surges © Munich Reinsurance Company

Source: ESPON Data Base

This map presents the approximate probability of having storm surges in Europe.

Map 8. Storm surges

2.1.9 Tsunamis

Hazard characterisation

Tsunamis are seismic waves caused by earthquakes, large landslides, volcanic activities and meteorite impacts. The term derives from the Japanese expression for "large harbour wave". Tsunamis are characterized by large wavelengths and velocities of approximately 700km/h in deep waters, depending on the seismic activity and the location the wave is triggered. The wavelength causes a slowing down of these waves in shallower waters to around 100km/h. The high wave length of these waves make them nearly unnoticeable on the ocean, but when they reach the shoreline they build up wave heights up to 30m and more. When these waves hit the shoreline they can cause severe damages, both because of their destructive energy and the extensive floods. An additional hazard is the re-treating water when the tsunami floodwater runs back into the sea (National Oceanic and Atmospheric Administration).

The destructive force of a tsunami could be observed in East and South East Asia on December 26, 2004. According to information from the Deutsche Welle the official death toll of this tsunami has reached 300 000. (DW-World, 22.02.2005).

In Europe tsunamis can mainly occur in the Mediterranean Sea with short travel times and thus very short early warning possibilities. The most devastating tsu-namis in Europe occurred in Sicily (1693), Lisbon (1755), Calabria (1783), and Messina (1908), each of them causing more than 50.000 casualties. These are only examples, as there have been many more tsunamis throughout the Euro-pean history. One of the most recent tsunamis in Europe hit the Balearic Islands in 2003 after a submarine landslide caused by an earthquake in Algeria (Hébert, 2003) . The runups of this tsunami were rather small, up to 2 metres and caused no injuries. Nevertheless, this incident and the short estimated travel time of the tsunami (20-30min) shows that tsunamis maintain to be a potential hazard all over the Mediterranean, also in areas not marked in the World Map of Natural Hazards (Munich Reinsurance Company, 1998).

Risk management

As it is impossible to forecast earthquakes, it is also virtually impossible to fore-cast tsunamis; it is only possible to outline potential impact areas. These poten-tial impact areas are derived from geologically active zones that bear earthquake and volcano hazards. But not every earthquake, volcanic eruption or landslides necessarily trigger tsunamis. The Pacific Tsunami Warning Center (PTWC), in-stalled in Hawaii records all earthquakes in the Pacific, issuing tsunami warnings in case of major earthquakes. Even though the technology involved in the PTWC is very high, this system has not recognised larger tsunamis that led to many casualties, e.g. in Nicaragua (1992) and Papua New Guinea (1998). 75% of all tsunami warnings issued by the PTWC were false warnings (http://www.globalsecurity.org/).

The tsunami hazard map

The tsunami hazard map was derived from several international data sources (see reference list in the map). In addition to data from the World Map of Natural Hazards (Munich Re, 1998), 236 tsunami runup data points of Europe and adjacent areas were extracted from the tsunami Event Database of the National Geophysical Data Centre. 102 of these entries show no records of the run-up height. 103 data points have runup heights less than 3 metres. These tsunami events, especially those occurred in the north of Europe (mostly in Norway), are associated with (submarine) landslides or snow avalanches. 31 runups have heights of more than 3 metres, with a maximum of 50 metres. Tsunamis with high runups in the Mediterranean are mainly associated with earthquake and volcanic activities, including submarine landslides. Although many data points were received from the referred websites, there are still data missing because there is no unified tsunami recording in Europe.

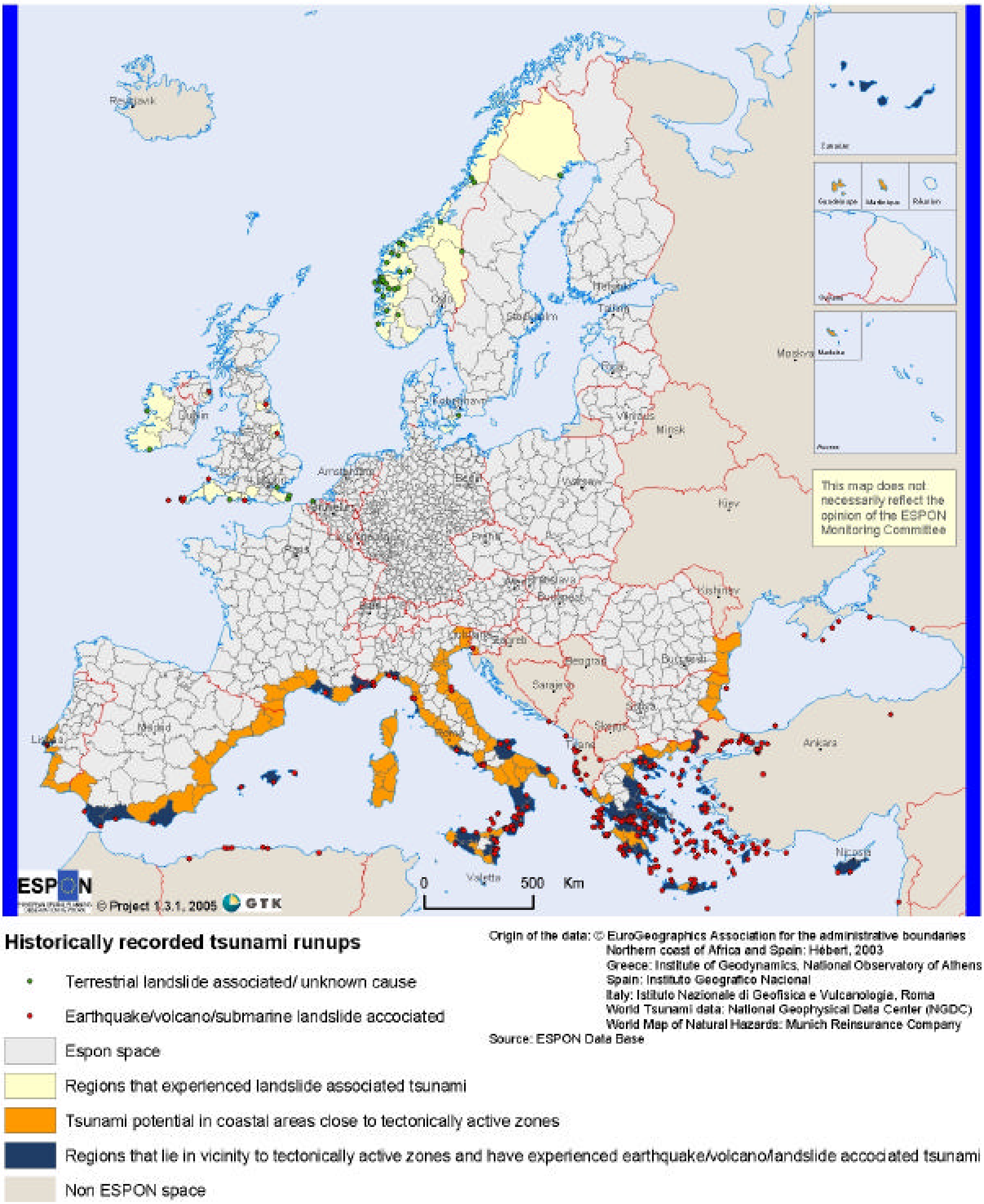
The tsunami hazard was modified from the data sources by categorising the hazards into 2 groups: the tsunami hazard area (solid line) and the probable tsunami hazard area (dashed line). The Mediterranean is entirely marked as tsunami prone because of the tectonic activities. The tsunami that occurred in East Asia in December 2004 showed that areas that were so far not noticed as tsunami hazardous (World Map of Natural Hazards) but lie in the vicinity to active fault zones (Myanmar, Thailand and Malaysia) should be included into tsunami prone areas. In northern Europe, that does not have as many tectonically active zones as the Mediterranean, those NUTS3 areas with experienced tsunami runups are marked as potential reoccurrence areas.

Table 16: Classification of the tsunami hazard

Areas that have experienced tsunamis that resulted mainly from gravitational landslides (terrestrial landslides)	1 Very low hazard
Areas in close vicinity to tectonically active zones	3 Medium hazard
Areas in close vicinity to tectonically active zones that have already experienced tsunami runups from earthquakes, volcanoes and/or resulting (submarine) landslides	5 Very high hazard

Map analysis

Tectonically induced tsunamis occur in Europe mainly in the Mediterranean and the Black Sea. There are several geological and historical records of tsunamis (see above). The most endangered zones lie in close vicinity to the main volcanoes or along seismically active zones. Tsunamis caused by (submarine) landslides have mainly occurred in Norway, but also in some other areas in Europe. Often it is difficult to distinguish if an earthquake caused a tsunami or if an earthquake triggered a (submarine) landslide that then caused a tsunami. In general it can be concluded that tsunamis are possible along all shorelines that lie in tectonically active zones and/or in areas where (submarine) landslides are possible. Even though no devastating tsunamis have occurred in Europe in the last 100 years, the potential hazard is still high.



Map 9. Tsunamis

2.1.10 Volcanic eruptions

Hazard characterization

A volcanic eruption is considered in this report as the arrival of solid products at the Earth's surface in the form of either the explosive ejection of fragmental material or the effusion of initially liquid lava. This definition excludes energetic, but non-ash-bearing steam eruptions.

Major volcanic eruptions are destructive but their occurrence in Europe is quite low. There is a connection between volcanic activity and plate movements. Often, volcanic activity on convergent plate boundaries is explosive and on divergent plate boundaries effusive. However, volcanoes may also be found in the middle of plates. These volcanoes are called hot spots, e.g. Hawaiian island chain, and they can even cause the plates breaking apart, e.g. East African Rift. Hot spot volcanic activity is always effusive. (Munich Reinsurance Company, 2000)

Risk management

The damages that volcanic eruption causes are ash fall, lava flows, gases (sulphur oxides and nitrous oxide), hot ash clouds, lahars and volcanic earthquakes. Volcanic eruptions can also cause tsunamis and/or climate change (the ash that is thrown out in large eruptions may reach into the Earth's upper atmosphere blocking out the sun's rays and cooling the earth's atmosphere). Ash fall and tsunamis are capable causing damage over a relatively large area, the others (except climate change) usually only threaten areas that are close to the volcano. These phenomena are easier to consider. Still, the geographical extent of ash fall mainly depends on wind direction and strength and is difficult to estimate. (Munich Reinsurance Company, 2000)

Volcano hazard map

The volcano hazard map is based on all volcanoes with known eruption dates in Europe within the last 10 000 years that are marked on the Volcanic Eruption Map of Munich Re, compiled by the Global Smithsonian Institute. The hazard intensity classification is based on Munich Reinsurance Company's classes.

Table 17: Classification of the volcano hazard

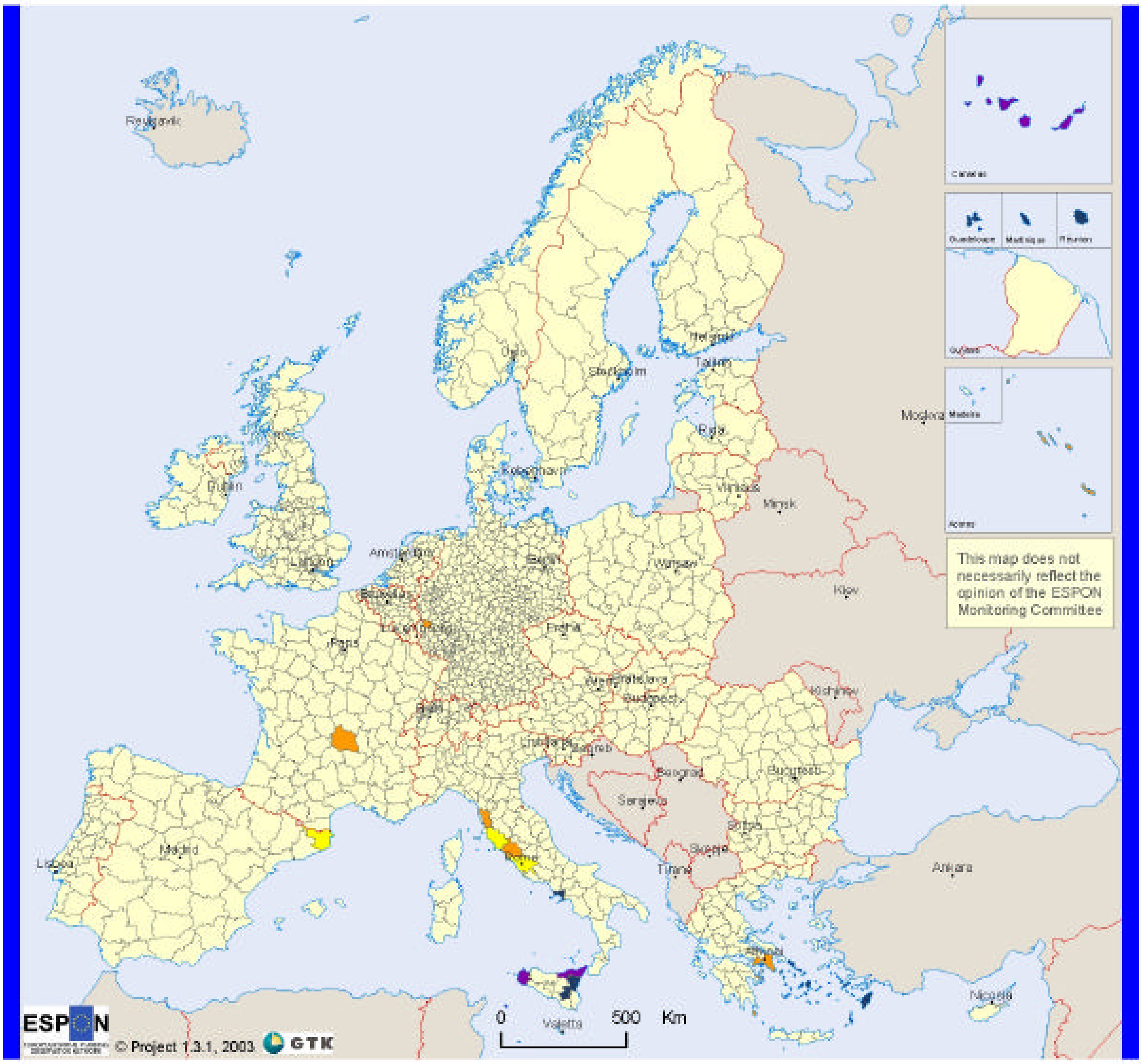
No eruptions	1 Very low hazard
The status of Holocene eruption is uncertain or Holocene activity is only hydrothermal	2 Low hazard
Last eruption before 1800 AD	3 Medium hazard
Last eruption after 1800 AD	4 High hazard
Volcanoes that are identified as being particularly dangerous by the International Association of Volcanology and Chemistry of the Earth's Interior (IAVCEI).	5 Very high hazard

The original data on volcanic eruptions is in point format. The number of eruptions in each NUTS3 area has been investigated and the hazard intensity value has been calculated for the whole NUTS3 area. The largest intensity value of an area determines the hazard intensity value of the studied NUTS3 area.

Map analysis

The highest volcanic eruption hazard is concentrated in southern Europe, i.e. Italy, Greece and in the overseas territories. It must be considered that several Greek islands are clustered into NUTS3 levels, i.e. every island is not its own NUTS3 area. Therefore the volcanic hazard is also displayed on islands that are not volcanic.

In western Germany, The West Eifel volcanic field in the Rhineland district has been active at the end of the Pleistocene and beginning of the Holocene. In central France, the Massif Central has been an active volcanic field in the beginning of the Holocene. In Spain, the Quaternary Olot volcanic field has been active 11.500±1100 years BP (Global Smithsonian Program).



Known volcanic eruptions

- No eruptions
- The status of eruption is uncertain
- Last eruption before 1800 AD
- Last eruption after 1800 AD
- Particularly hazardous vulcanoes
- Non ESPON space

Origin of the data: © EuroGeographics Association for the administrative boundaries
Volcanic eruptions: Smithsonian Institute, Global Volcanism Program
Risk classification: Munich Reinsurance Company
Source: ESPON Data Base

This map displays regions with known volcanic eruptions during the last 10 000 years. The risk classification is based on the time when the last eruption has been occurred. The most dangerous volcanoes are identified by International Association of Volcanology and Chemistry of the Earth's Interior (IAVCEI).

Map 10. Volcanic eruptions

2.1.11 Winter and tropical storms

Hazard characterisation

According to the Munich Reinsurance Company, storms are world wide the highest reason for economic losses by natural hazards. Most of these storms occur in tropical and subtropical regions, such as tropical cyclones. Tropical cyclones occur only in European overseas territories, meanwhile tornados also occur locally in Europe, but these are seldom and difficult to predict. The most relevant storms for Europe are the so-called regional storms, i.e. winter storms. These regional storms are also the highest cause for economic and insured losses in Europe. (Munich Reinsurance Company, 2004)

Winter storms are the result of differences in temperature between the polar air masses and the air in the middle latitudes in autumn and winter. These extratropical cyclones generally have less destructive power than tropical cyclones or tornadoes, but they are able to provide damaging winds over a wide area, and also can cause wave damages in coastal areas.

Winter storms can have such associated effects as storm surges (result of prolonged onshore winds), floods, avalanches, landslides, high seas/waves (depending on the duration and intensity of a storm), snow pressure (heavy snowfalls) and coastal erosion (wave action and suction on the shoreline).

Risk management

Winter storms are climate related hazards that are quite difficult to predict in advance. Their probability of occurrence is the highest in northern Europe near the coastline (e.g. Great Britain, Norway, Denmark, the Netherlands and Germany) and the occurrence as well as the magnitude of winter storms gets lower inland (e.g. Sweden, Finland, Baltic countries).

The damages caused on buildings by winter storms are usually dominated by damage to roofs, windows and facades. The damages on nature, like felling of trees due to strong wind or heavy snowfalls, can also be massive. Falling trees can damage the infrastructure, e.g. roads and power lines. Reducing the occurrence of winter storms is not possible, but it is possible to reduce the extension of damages caused by storms to a certain degree by proper maintenance of assets.

Winter and Tropical Storm map

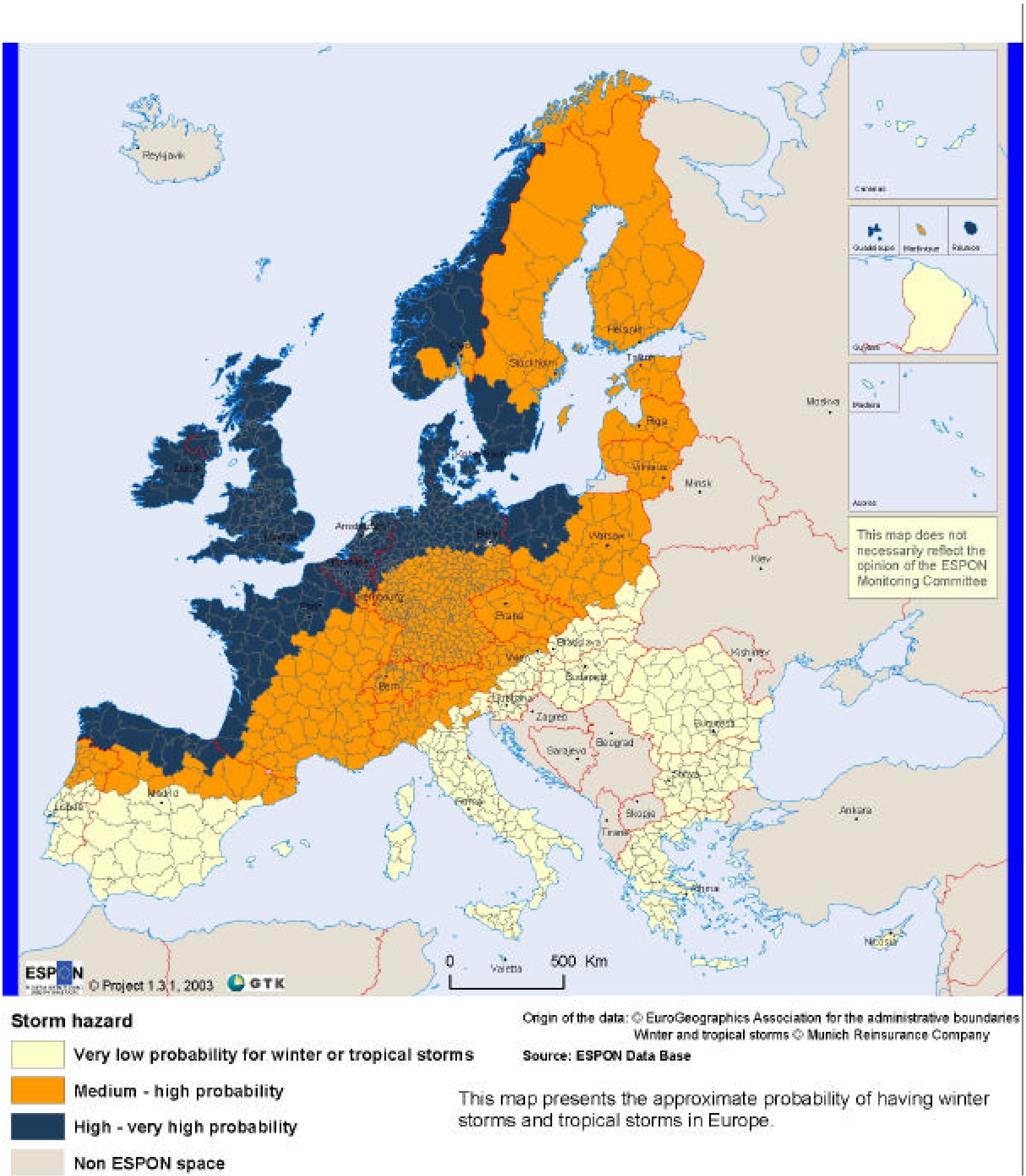
The winter storm and storm surge data are available from the World of Natural Hazards CD-Rom (Munich Reinsurance Company, 2000). The storm hazard is represented according to the probability of occurrence, as reported by the Munich Reinsurance Company.

Table 18: Storm and storm surge classes

No or very seldom winter (tropical) storm probability	1 very low hazard
Medium to high winter (tropical) storm probability	3 medium hazard
High to very high winter (tropical) storm probability	5 Very high hazard

Map analysis

The winter and tropical storm hazard map shows that the areas in Europe that are more exposed towards the northern Atlantic experience the highest threat of winter and storm surges. Tropical storms occur only in the overseas territories. The winter storm and storm surge hazard gradually lessens towards southeast Europe as the climate changes from Atlantic influenced towards more continental. The more continental climate zones experience extremer temperatures (hotter summers and colder winters) than the marine influenced ones but they do not have the direct impact of winter storm surges from the northern Atlantic Ocean.



Map 11. Winter storms

2.2 Technological Hazards

The field of technological hazards is more complicated than the one of natural hazards. The emission from a technological hazard may leak out of a production facility, a deposit, a stockpile, a transport corridor etc. through specific transmission media (water, air, soil) and can harm people, the environment or facilities. To create a risk, a specific damage potential has to exist, which is determined by the type and magnitude of an emission. In the first instance, typical technological hazards focus on very small areas of emission (e. g. chemical production plants, oil pipelines, etc.). However, some hazards have a great perimeter of influence and thus can affect a relatively great part of Europe. Furthermore, it is very difficult and in many cases not possible to define specific threatened areas (weather influence, unknown processes below ground). Because of its rather densely populated area, approximately the entire European territory is threatened by accidents with a regional, local or sub-local level of influence (e.g. major accident hazards).

The following table gives an impression about the interrelationship between hazards and emissions, respectively influence. The table lists the types of emission that are generally possible and indicates their relevance for the selected types of technological hazards:

Table 19: Technological hazards and types of emission

Type of emission / Type of hazard	Toxic gases	Toxic substances in a liquid form	Shock wave	Ionized radiation	Non-ionized radiation	Kinetic energy
Nuclear power plants	+	+	+	+	+	+
Major accident hazards. Hazards from production plants with hazardous production processes or substances (large-scale chemical works, weapons, fireworks ore processing plants, etc.)	+	+	+	+	+	+
Oil storage and transport	-	+	-	-	-	-
Air traffic hazard	-*	-*	+	-*	-*	+

*Depending on the freight transported in the aeroplane, e.g. the El Al Boeing 747-200F Jumbo Jet that crashed into a housing area in Amsterdam in 1992 allegedly carried weapons that led to gaseous emissions after impact.

2.2.1 Air traffic accidents

Hazard characterisation

The hazards of aeroplane accidents in airport entry lines are part of planning schemes in many regional plans in Europe. Nevertheless, the protected areas in airport entry lines cover only several hundreds of meters to a few kilometres in the extensions of runways. These areas mostly cover the very final landing approach of an aeroplane and are mainly designed because of noise protection and air traffic security; but they do not necessarily always take airplane crash statistics into consideration. To determine the real risk of airplane crashes in entry lines to airports or close to airports the ESPON Hazards project carried out a detailed study on worldwide civil airplane crash statistics since 1970. The airplane accident data were downloaded from the online aviation accident database. Accident data were analysed in the time span 1970 to 2004 because the airplane security has advanced strongly since then. The accidents have decreased from over 300 in the 70's to approximately 250 in the 80's and 90's. The maximum number of accidents was found in the year 1970, with a total of 38 planes. Since the late 90's the amount of plane crashes stabilized to approximately 22 per year (see annex 3).

The maximum number of airplane accidents is found in North America, 253 planes (28% of total) and the minimum is in Australia and New Zealand, 10 planes (1% of total). 131 (14%) of the total number of plane crashes were found in Europe; see figure 3. The study took all worldwide crashes into account, as the goal of the investigation is to determine the most dangerous flight phases.

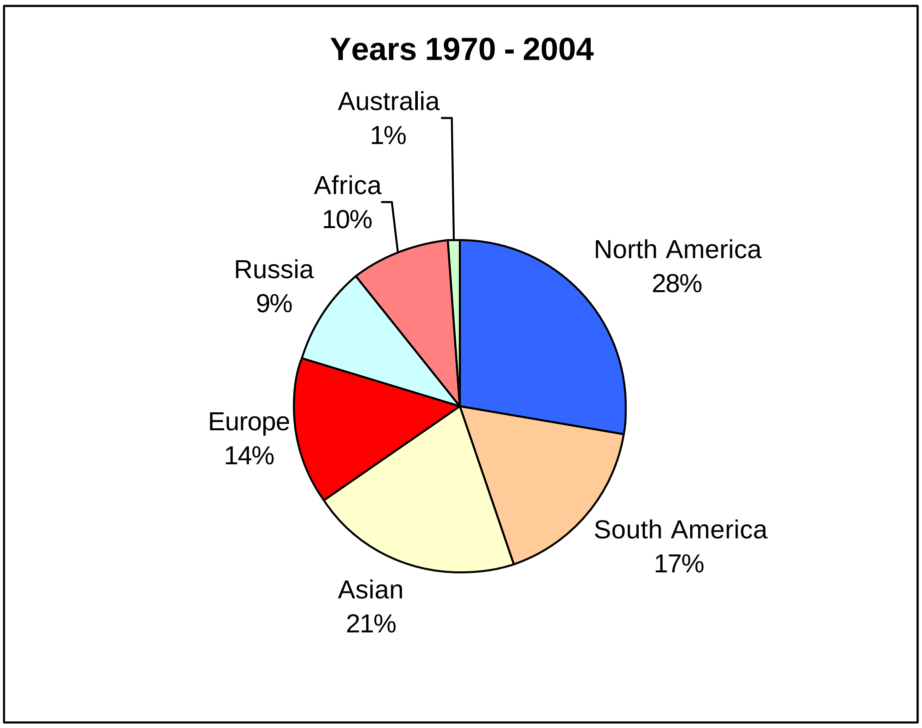


Figure 3: Amount of plane crashes per continent in %, 1970-2004. Source: Aviation accident database.

The results of the study reveal that the most dangerous flight phases are those of approach, landing or take off. 80% of all crashes that occur during landing, final approach or take off occur in a distance of 5km around airports. The process of take off has shown the highest accident rate with 358 planes, followed by the numbers of 336 and 219 planes from the processes of approach to land and landing, respectively. The accidents that occurred in this radius were not always restricted to the designated flight lines, e.g. because pilots tried to return to an airport after technical problems. Plane crashed en route were excluded of the further studies because they make up only 20% of the total accident rate. Also, crashes en route are ubiquitous and thus do not pass the spatial filter developed by this project (see chapter 1.2).

The risk of military airplane accidents was not taken into account in this study, as there is no reliable information on military aircraft safety and amount of flights per military air base in the EU 27+2 area.

Risk management

The risk of airplane accidents can be ensured by rigid safety standards on the technological and maintenance standards of airplanes, standards on the air traffic guidance systems and safety procedures before take off. The European Airline Safety Agency (EASA) ensures the highest possible safety standards for aviation in the European Union.

Hazard map on air traffic accidents

The plane crashes were summarized into groups, depending on the away from the airports (for details see tables in annex 3). Then accidents were categorized according to 1) approach to land, 2) landing and short of the runway, and 3) take off.

Map 12 displays all commercial airports in EU 27+2 and categorizes them into five classes according to the total annual volume of passengers in 2003. Data were selected from the European civil commercial airports. Figures of the passenger traffics are mostly from 2003, in some cases older data sets between 1996 and 2002 were used.

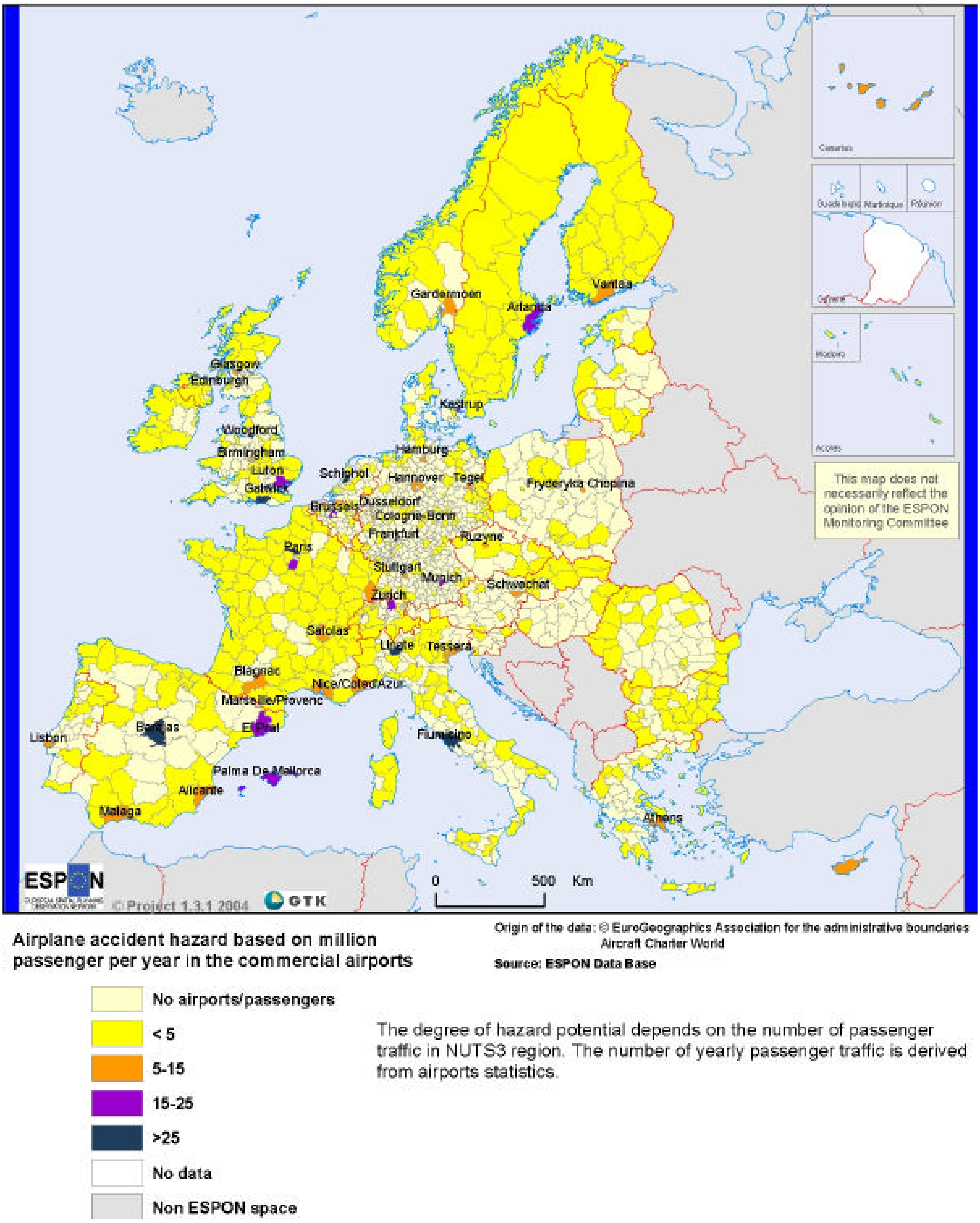
The air traffic hazard is based on the calculated main risk radius of 5km around airports. The hazard itself is based on the amount of passengers per year, i.e. the higher the amount of traffic, the higher the hazard. Other categories that could influence the hazard, i.e. safety standards, morphology, night flights, nearness to other airports, etc. were not taken into account. Based on these five classes, the hazard of airplane crashes on NUTS3 level is the total sum of passengers.

Table 20: Classification of airtraffic accident hazard per NUTS3 level

No airports	1=Very low
<5 millions passenger/a	2=Low
5-15 millions passenger/a	3=Medium
15-25 millions passenger/a	4=High
>25 millions passenger/a	5=Very high

Map analysis

The hazard map on air traffic accidents shows that the highest hazards are b-cated around the major air traffic hubs. Northern European countries have an elevated hazard because they have a relatively higher density of civil airports than average, meanwhile eastern and southern European countries have a less dense airport structure.



Map 12. Air traffic

2.2.2 Major accident hazards (chemical plants)

Hazard characterisation

The hazard type "major accident hazard" represents a wide range of different hazards. The most important similarity of these hazards consists in their origin as an emission from an industrial facility, e.g. specific harmful substances being distributed out of a production area. The most threatened areas are the industrial facility and its employees itself. In addition, the area around the facility is threatened by an emission from the facility to the wider area. The possible impact of a major accident is nearly impossible to forecast, as it depends on the type of accident, the physico-chemical components, the transporting media (air/water), the current weather conditions, the speed of recognition and reaction, etc. Also the timing of an accident may largely influence the hazard, i.e. season (e.g. vacation) weekday or weekend as well as the time (amount of traffic on the street, school children in schoolyards, etc.

Risk Management

Within the European Union the Council Directive 96/82/EC (SEVESO II) aims at the prevention of major accidents involving dangerous substances and the limitation of their consequences. The provisions contained within the directive were developed following a fundamental review of the implementation of the Council Directive 82/501/EEC (SEVESO I). In particular, the plant management was identified as the major area where new provisions seemed necessary on the basis of an analysis of major accidents that have been reported to the EU Commission since the implementation of SEVESO I. Failures of the management system were shown to have contributed to the cause of over 85% of the accidents reported. Against this background, requirements for management policies and systems are contained in the SEVESO II Directive. The directive sets out basic principles and requirements for policies and management systems, suitable for the prevention, control and mitigation of major accident hazards.

Example map on major accident hazards, chemical production plants

The example map on major accident hazards is synthetic, as it displays the number of chemical production plants per km^2 per NUTS3 level, regardless of the substances handled, the size of the plant or the particular safety record of a plant. The chemical plants hazard potential in NUTS3 regions is based on the density of chemical plants classified in five categories:

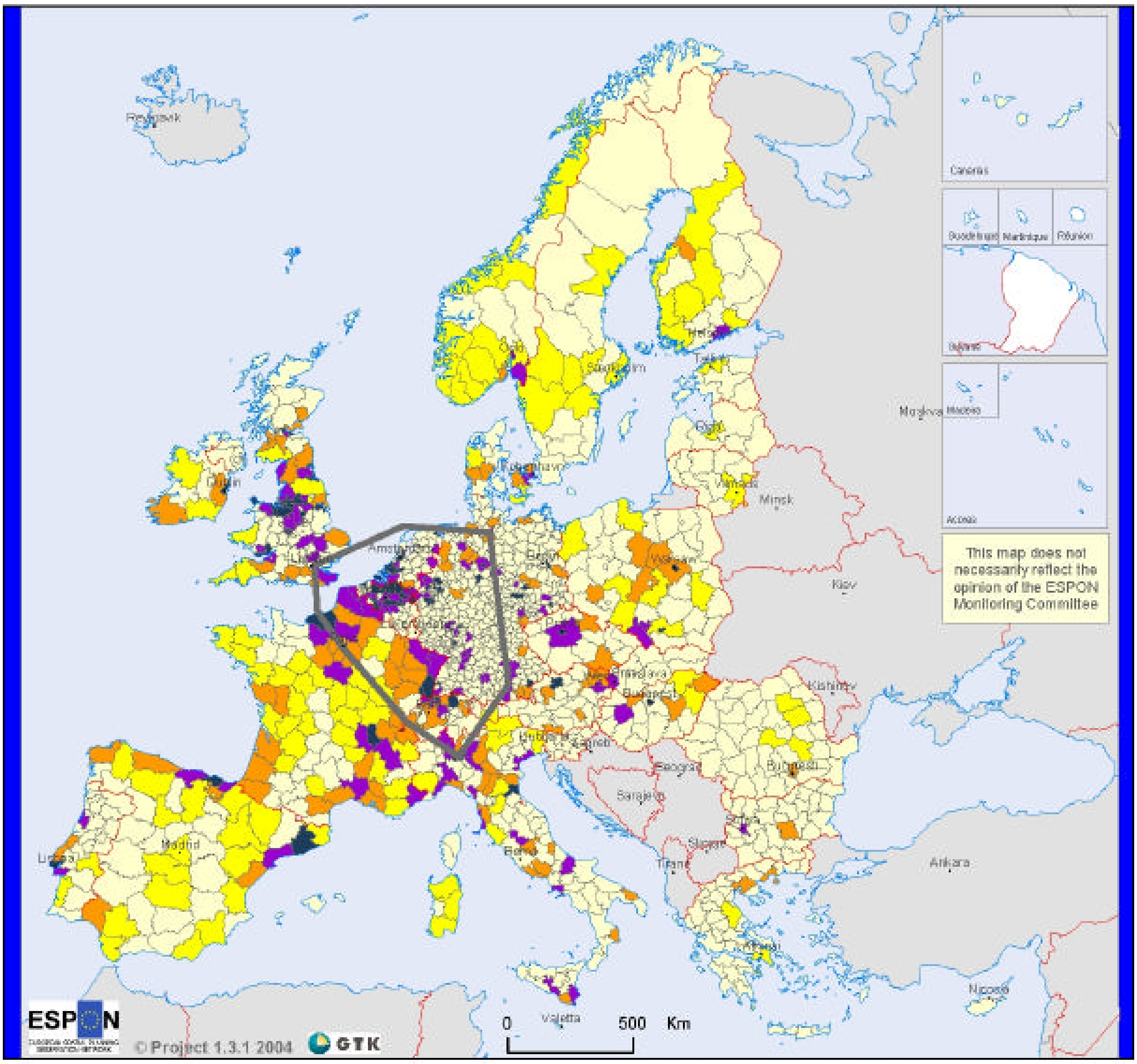
Table 21: Classification of chemical plant hazard

Share of chemical plants/km^2/NUTS3 regionl	Density (hazard) class
[Share]=0	1=Very low
[Share>0and<0,000318	2=Low
[Share]=0,000318-0,000830	3=Moderate
[Share]=0,000831-0,002535	4=High
[Share]=0,002526-0,066781	5=Very high

The map focuses on chemical production plants, as, among the categories of The European Pollutant Emission Register (EPER) database, these pose the highest theoretical risk of a major accident hazard. Data from EU 27+2 countries that are not yet available from the EPER database were collected from the KOMPASS database. The hazard is classified into five classes, according to the amount of chemical production plants per km^2 per NUTS3 region. The size of the production plants is not taken into account, as theoretically any kind of accident in a chemical plant can lead to severe threats for human beings and the living environment.

Map analysis

The example map on major accident hazards, the chemical production plants, shows that there is a strong clustering of this hazard in the so-called “Pentagon Area”. As chemical plants are rather specialised sections of industrial productions, large areas of Europe, especially in the north and the east do not have any hazard from these plants. Most European areas have just a minor hazard and few areas in or adjacent to the “Pentagon Area” experience a medium hazard.



Major accident hazard based on density of chemical plants (NUTS3)

- Very low density
- Low density
- Moderate density
- High density
- Very high density
- No data
- Non ESPON space
- Pentagon

Origin of the data: © EuroGeographics Association for the administrative boundaries
European Pollutant Emission Register (EPER)
http://www.kompass.com

Source: ESPON Data Base

The degree of hazard potential depends on the number of chemical plants per km2 in NUTS3 region.

Map 13. Chemical plants (as an example for major accident hazards)

2.2.3 Nuclear power plants

Hazard characterization

The technological hazard related to nuclear power plants (NPPs) is special in many respects and needs to be treated accordingly. Firstly, the consequences of a large-scale nuclear accident have a big spatial extent, making all of Europe exposed to possible nuclear fallout. Secondly, the theoretical frequency of occurrence (probability) of such an accident is extremely small, less than once in two million years (Fortum, 1999). Because of this, a simple calculation of averaged annualized losses caused by even a major nuclear power plant accident would result in negligible hazard intensity estimates throughout Europe. However, NPPs have to be taken into account in spatial planning considering that the time frame of planning is completely different from such million-year projections and keeping in mind the Chernobyl accident in Ukraine in 1986.

The Chernobyl accident was detectable in practically every country of the northern hemisphere. The largest particles, primarily fuel particles, were deposited within 100 km of the reactor. Small particles were carried by wind to large distances and their deposition depended on local rainfall. Meteorological conditions varied frequently during the 10 days of the accident, causing significant variation in the dispersion of the contamination. The most highly contaminated area was the 30 km zone around the reactor where ground depositions exceeded 1500 kBq/m^2. The far zone of contamination ranges from 100 to 2000 km around the reactor. There, local rainfall produced three spots of especially high contamination. Areas outside the former Soviet Union were affected as the radioactive plume moved across Europe. Initially the wind was blowing to northwest over Fennoscandia, the Netherlands, Belgium, and the United Kingdom. After that the plume moved south and much of Central Europe, Northern Mediterranean and the Balkans. Altogether, most countries in Europe received some deposition of radionuclides. (OECD NEA, 2002)

Risk management

The most important risk management aspect for nuclear power plants is the reduction of the probability of occurrence of hazardous events in the nuclear facilities themselves. Indeed, the nature of nuclear power and the great damage potential has lead to the adoption of extensive, independent, multi-layered safety practices at the installations. The tendency is towards simple safety features that are directly based on laws of physics and are not dependent on electricity, pumps etc.

In addition to the safety procedures at nuclear facilities, risk management is achieved by mitigating the effects of possible radioactivity releases from NPPs. Besides spatial planning responses, nuclear emergency plans have been developed at different administrative levels ranging from individual power plants and municipalities to national plans.

Nuclear power plants hazard map

The nuclear power plant hazard map follows a synthetic approach based on the areas contaminated by the Chernobyl accident in 1986. Because of the overregional nature of the hazard, nuclear power plants of the non-ESPON space are included. The locations of nuclear power plants in Europe were identified using the online Nuke Database System created by the Nuclear Training Centre in Ljubljana (Slovenia) in NUTS3 level (Nuke Database System).

Since the Chernobyl accident is the only example of an exploding nuclear power plant in human history, the presented risk assessment for Europe's power plants is developed according to the experiences made after the accident in 1986. The areas around nuclear power plants are classified according to those areas most affected into the zones 1 (30km radius) and 2 (300km radius), i.e. the areas that have to be evacuated and those of mandatory resettlement, according to the International Communications Platform on the Longterm Consequences of the Chernobyl Disaster (Chernobyl.info). Zone I covers all areas in a 30km distance of the Chernobyl nuclear power plant. All territories belonging to Zone II are approximately within a distance of 300km from the nuclear power plant. These areas were directly affected by the explosion, without influence of local wind patterns during the accident. All NUTS3 levels falling into this radius are marked as "directly" and "indirectly" affected areas.

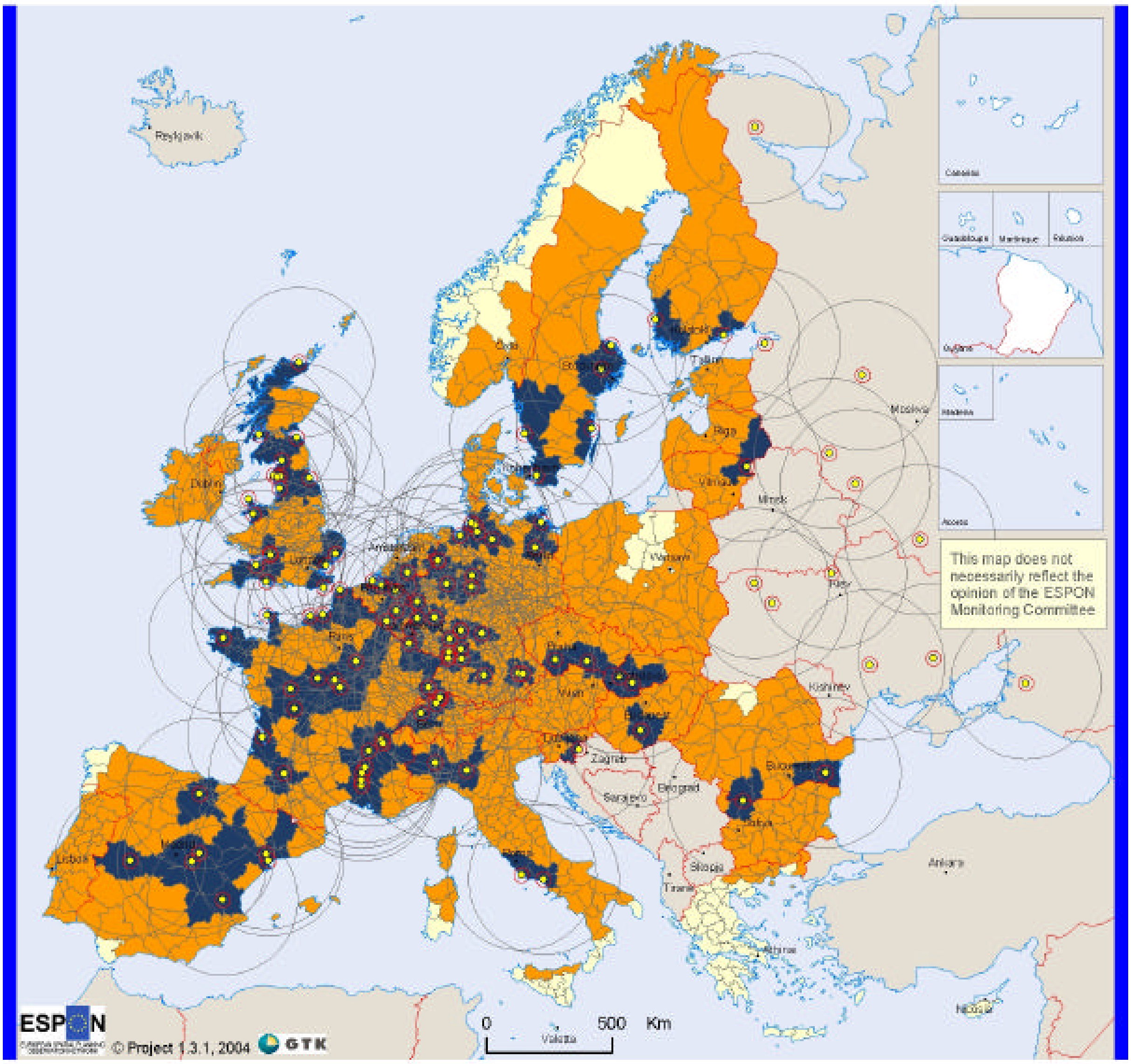
Table 22: Nuclear power plant hazard classes

Regions that do not intersect 300km radius	1 Very low hazard
Regions that intersect 300km radius	3 Medium hazard
Regions that intersect 30km radius	5 Very high hazard

Map analysis

The map is a theoretical synthetic approach because accidents in nuclear power plants have a very low probability (see above). It is doubtful that the contamination, in case of an accident, would follow exactly the same patterns as in 1986. Nevertheless, the Chernobyl accident is the only major accident so far and the map shows its extent on a European level. An inclusion of major wind patterns in Europe is not feasible in this theoretical approach. The "indirectly affected areas" 300km zone chosen is the extent of major contamination around Chernobyl without taking atmospheric conditions into account.

An analysis of the map shows that there are only few areas in the marginal extremes of Europe that are not in the range of a theoretical "indirectly affected area" in the case an accident similar to the Chernobyl incident occurred. Many countries that do not have any power plants are also in the potentially affected zones. The map displays the high amount of nuclear power plants in Europe with a strong agglomeration in the "Pentagon Area".



The potential hazard of radioactive contamination on NUTS 3 level

Origin of the data: © EuroGeographics Association for the administrative boundaries
Nuclear power plants © Nuke Data Base System, Ljubljana, Slovenia
Eurostat GISCO

Source: ESPON Data Base

- Nuclear power plant
- Area to be evacuated (radius 30km)
- Area with a possible severe caesium 137 contamination (radius 300km)

Distance of a nuclear power plant

- Areas outside 300 km radius
- >30 km and <300 km (indirectly affected areas)
- <30 km (directly affected areas)
- No data
- Non ESPON space

The potential hazard of radioactive contamination in case of a nuclear fallout (based on experiences made after the Chernobyl accident in 1986).

Map 14. Nuclear power plants

2.2.4 Oil processing, transport and storage

Hazard characterisation

All activities in oil production, processing, transport and storage pose hazards of contaminating the environment. Large tanker accident oil spills are the most catastrophic single pollution events, but the environment is constantly threatened by smaller accidents and general dispersion of oil. Offshore activities and refineries are an important source of oil pollution for the North Sea, but are of less significance for the Baltic and Mediterranean Seas where offshore activity is much lower. Much of the Black Sea is severely polluted with oil, especially near ports and river mouths, mainly due to heavy traffic and de-ballasting and bilge discharges (ITOPF, 2005).

Oil processing plants, storage facilities and pipelines pose a permanent hazard because of the large amount of oil on a single spot. Data series from 1974-2004 suggest that discharges from offshore activities and refineries add up over 50 % of the total incidence of oil spills (ITOPF, 2005). A more detailed overview of different causes for oil spills is shown in the table below:

Table 23: Incidence of spills by cause, 1974-2004. Source: ITOPF, 2005

	< 7 tonnes	**7-700 tonnes**	**> 700 tonnes**	**Total**
OPERATIONS				
Loading/discharging	2817	327	30	3174
Bunkering	548	26	0	574
Other operations	1177	55	1	1233
ACCIDENTS				
Collisions	167	283	95	545
Groundings	232	214	117	563
Hull failures	573	88	43	704
Fires & explosions	85	14	30	129
Other/Unknown	2176	144	24	2344
TOTAL	7775	1151	340	9266

Risk Management

It is apparent that most of the oil spills result from routine operations such as loading, discharging and bunkering that normally occur in ports or at oil terminals. Thus there is a specific increased risk for those locations. The majority of these operational spills are small, with some 92% involving quantities of less than seven tonnes (ITOPF, 2005). Suitable strategies against large tanker accidents comprise double hull tankers, pilots on board, emergency anchor places, surveillance of shipping routes and strict maintenance regulations.

Oil processing, transport and storage hazard map

The overview map on oil production, processing, storage and transportation displays the main European maritime oil terminals, refineries, storage tanks and pipelines (CONCAWE, World Port Index). The hazard map on oil transportation, storage and processing is produced on NUTS3 levels. Therefore oil platforms and shipping routes are no eligible source of information. Currently there is no information available on exact shipping routes and amounts, neither on types of transported oil.

The hazard map assumes that the larger an oil terminal the higher the hazard, due to the higher amount of transported and handled oil. The same principle accounts for refineries and pipelines. The hazard map categorizes the NUTS3 levels according to the amount of oil terminals, pipelines and refineries into classes. The risk of terrestrial oil pollution by other means of transportation than pipelines (e.g. road) cannot be displayed because it is ubiquitous among the dense European infrastructure (see spatial filter for hazards, chapter 1.2) and is therefore included in the lowest class. The resulting hazard on NUTS3 level is determined by the aggregation of one or more attributes per NUTS3 level.

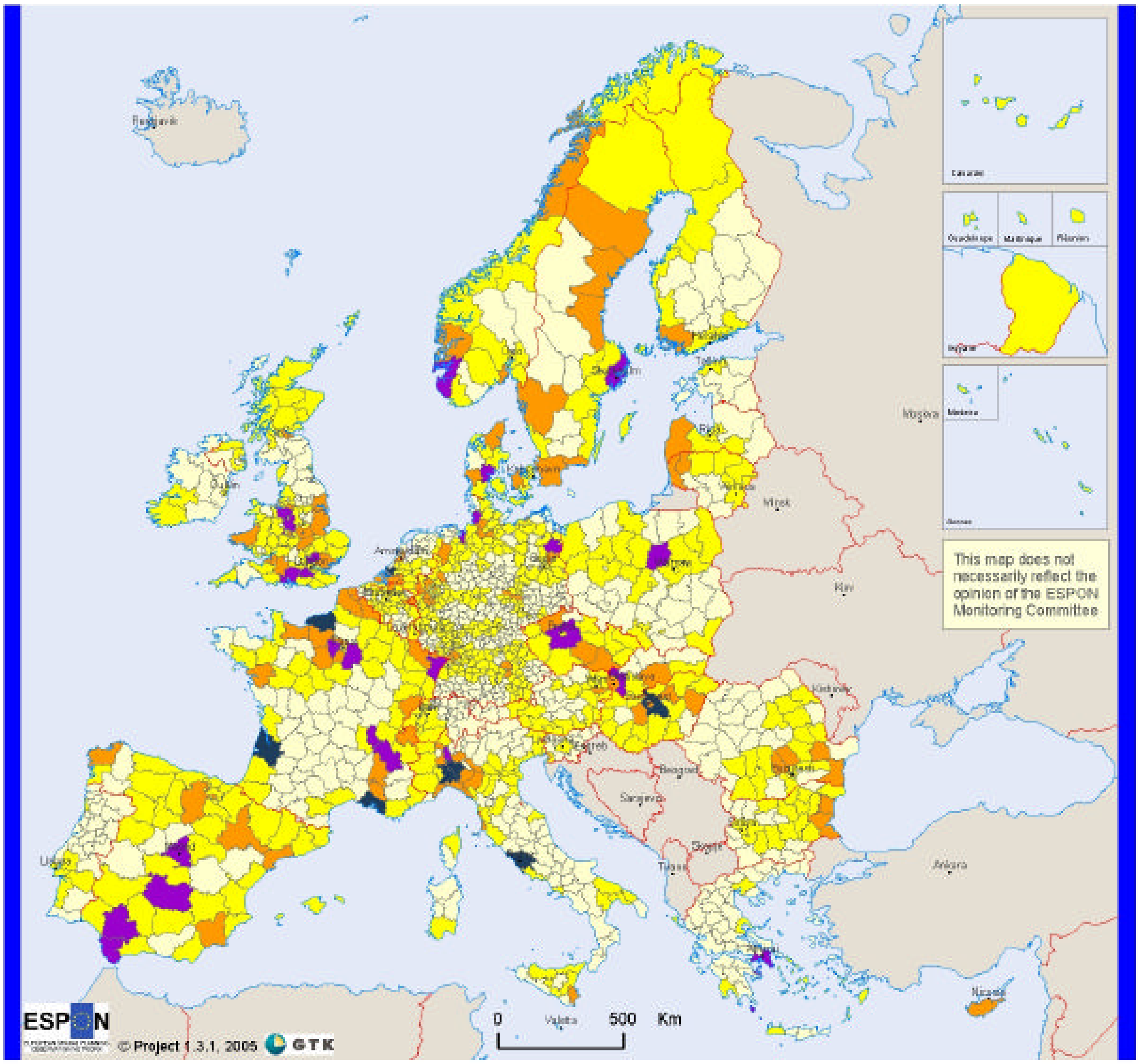
Table 24: Oil processing, transport and storage map classification

Sum of refineries, oil harbours and pipelines	Hazard class
0	1 Very low hazard
3	2 Low hazard
4-6	3 Medium hazard
7-10	4 High
11-16	5 very high hazard

Map analysis

The oil processing, storage and transport map shows that the hazard from oil contamination is rather widespread in the European territory, which is also based on the economies dependency on oil. But not all coastal areas have oil-handling facilities. Meanwhile the entire coast of the United Kingdom poses mainly a medium to very high hazard, large coastal areas in Italy have no hazard.

The map is a synthetic approach, as it focuses on the installations on the land and not on offshore operations nor on the main shipping routes of tankers. The map assumes that the more onshore facilities, the higher is the hazard, as most accidents happen during handling in ports (ITOPF, 2005). Nevertheless, some potentially threatened areas by oil tanker accidents en route are well represented, e.g., in the North Sea, the Baltic Sea, the Mediterranean and the Black Sea. The Oresund (water course between Denmark and Sweden) is one of the heaviest frequented areas by oil transport in Europe and shows a high hazard. Also the Channel is marked with a high hazard. The north-western coast of Spain has a high hazard too, which was sadly shown by the Prestige oil spill in 2002 (ITOPF, 2005). Unfortunately the adjacent areas in Portugal and France that also suffered from the spill are not represented because they dispose of oil terminals, refineries and/or pipelines. The Bretagne is a difficult example, as this region has been hit by large oil spills even though there is no oil handling facilities close by.



Oil as tecnological hazard

- Very low
- Low
- Moderate
- High
- Very high
- Non ESPON space

Origin of the data: © EuroGeographics Association for the administrative boundaries
Refineries, oil depots and pipelines © CONCAWE
Oil terminals © World port index 2000

Source: ESPON Data Base

This map displays the volume of oil production and transport related activities in Europe. Each NUTS3 region has been given a sum of the following activities: amount of refineries, depots, oil terminals and pipelines. Residual NUTS3 regions are classified as very low hazard, indicating the ubiquitous hazard of oil pollution due to transportation by road, rail or ship.

Map 15. Oil transport, storage and handling

2.3 Data gaps and future research

The reader should keep in mind that the data shown in this chapter is a preliminary approach that is partly based on preliminary data sets. Consequently, the maps enable a first overview on the spatial distribution of hazards in the studied area. This overview is valuable at the current stage as it presents a first integrated approach, including vulnerability and resulting risk patterns. On the other hand it also shows that far more research is needed in the future. Better data sets with improved research methodologies should be used in order to obtain reliable results that can also be downscaled to local levels. The results should not be used for local interpretations, as the data sets can be misleading if used for large scaled analysis and often locally better data sets and research results are available.

The Terms of Reference of this project demanded maps and typologies of regions covering the entire ESPON space, i.e. EU 27+2, to be produced between December 2002 and March 2005 with a limited budget. There was no time or resources to carry out own research to obtain full hazard data sets, the project group was depending on existing research results. The data sets that could be obtained were then calculated according to the methodology developed by the project to display the spatially relevant hazards of the ESPON space.

The main obstacle for indicator development was the required large geographical coverage. Example hazard indicators would have been feasible to produce for selected areas with sound scientific background. Another obstacle was the compulsory reporting on NUTS3 level, as hazards usually do not respect political boundaries, also vulnerability and resulting risk patterns are difficult to produce on man made limitations.

Eventhough excellent research results exist in the EU on most of the hazards relevant for spatial development, very few project results cover the entire ESPON space, so that many research results could not be used. One main obstacle for the compilation of data on hazards and vulnerability were thus the large data gaps so that ways and methods had to be found how to extend comparable data sets of all hazards to cover all NUTS3 areas. Therefore most of the data and maps presented in this chapter are only preliminary results as they are based on the best available data (not the best needed) on this scale.

In the case of floods and forest fires the data sets are produced on very short observation periods, and the drought potential data set is a first approach on how to display the hazard potential of droughts on the entire EU 27+2 area. At a certain stage in the project it became clear that there are no scientifically sound data sets covering the whole ESPON space available to the project to produce indicators on droughts, floods and forest fires. Nevertheless the European Commission (DG Regio) and the ESPON Coordination Unit insisted on data and maps on these three hazards, too. The reader thus has to take into account that the data sets used for these hazards are at a preliminary stage, especially the drought problem is displayed as an approach to show the drought potential.

The technological hazards are underrepresented in relation to the natural hazards, as only 4 indicators were developed. The reason is simply lack of data availability. There is more data on technological hazards available in the EU 27+2 area, but the project group was denied access to it.

Most of the data were obtained from freely available sources, indicated in each of the maps. Many data requests were sent to international and European research institutions as well as other ESPON projects, but only very few were responded to or the geographical coverage of gained data was poor. In fact, the project only received data sets in case of good personal relationships, all other data requests were left unanswered. Most of the data sets were therefore collected by the project itself.

Better data availability and more resources could easily enhance the project's results. In future research approaches on natural and technological hazards all indicators developed by this project should be revised.

Future research approaches financed by the European Union on such an extensive scale should also ensure a good cooperation between relevant EU funded research institutions and projects. Many indicators could not be developed, or are developed in a preliminary quality eventhough better data would have been available, simply because the data holders refused access.

3 Weighting of Hazards - Application of the Delphi Method

Risk management with relation to spatial areas in most cases faces the problem of dealing with multiple hazards. Multi-hazard cases can be described as settings where a multitude of hazards need to be included in risk assessment of a certain area. A multi-hazard perspective is essential for all those stakeholders who have to consider the *entirety of risks* and who at the same time are responsible for a certain area.

Institutions and persons dealing with spatially relevant risks are spatial planning authorities (regional planning, comprehensive land use planning), insurance and re-insurance companies and emergency response managers. The importance of the task of risk mitigation is underlined by manifold international (e.g. International Strategy for Disaster Reduction, ISDR), supranational (e.g. EC structural funds), national and regional activities realised and supported in the last years.

Whenever a multitude of hazards has to be considered in risk management, the question of weighting the relevance of certain hazards appears. The answer is not necessarily easy to reach because all normatively determined weighting factors face the same problem: due to lacking impartial and scientifically justified data it is methodologically hardly possible to justify either of the weighting factors. The main reason for this is that beside the impartial risk analyses 'risk' also depends on certain values that are societally determined (Schanze, 2005). Accordingly, risk cannot only be discussed on a factual level. Therefore, it is of greatest interest to find a certain form of weighting in risk assessment. This has several advantages.

- Weighting can produce a common understanding of the severity of hazards compared with another as part of risk assessment and basis for risk mitigation.
- Purposeful variation of weighting factors can be used for simulating different risk profiles in dependency of different conditions, including risk perception. In this way they can be used for formulating alternative scenarios regarding risk management.
- Regular iteration of weighting can allow the surveillance of the development of risk perception and thus illustrate changes over time.

Weighting of hazards can be accomplished by deriving weighting factors empirically, commonly based on loss data (damages) from historic events (e.g. by using insurance data such as Munich Reinsurance Company, 2000, 2004). Their proportion to each other may indicate the proportion of the real relevance. Nonetheless, this procedure does not address all problems. First, rare (very infrequent) hazards can be overlooked in case no event has been recorded in the past. Second, data sets of, e.g. casualties and economic losses are not necessarily complete and may have large gaps. Third, as the most crucial aspect, the exclusive consideration of loss data neglects differences in the perception of vulnerability. The latter can vary considerably between stakeholders (e.g. authorities and citizens) or between different societies. Finally, there is a general problem that is not likely to be solved, because monetary loss data only assesses the monetary values whereas other aspects of loss like psychic stress etc. are hardly quantifiable (e.g. Penning-Rowsell *et al.*, 2000).

Concluding, a weighting procedure should consider the 'subjective factor' in risk perception by going beyond factual information. A possible way is the use of feed back methods such as the Delphi method as a tool to generate weighting factors in multi-hazard cases that are relevant in the context of spatial planning (see e.g. Hollenstein, 1997, p. 82ff; Lass *et al.*, 1998, p. 23). The Delphi method was adapted for the specific use of hazard weighting and tested several times in four case study areas in the scope of the ESPON Hazards project (Annex 2). In this utilisation, the Delphi method should be seen as an assuming, embedded methodological tool for deriving weighting factors for the assessment of the overall risk of a certain area.

3.1 The Delphi method

The Delphi method is a study method of generating ideas and facilitating consensus among individuals disposing of special knowledge in a certain field of interest. Unlike survey research, which insists on a random sample that represents all parts of the population, a Delphi study carefully selects individuals who have knowledge necessary to analyse a specific problem. Concerns of the method are typically mono-dimensional, uncertain issues that cannot be confirmed by impartial information. The Delphi method, developed by Helmer (1966) has become widely accepted by a broad range of institutions, government departments, and policy research organisations (see Turoff and Linstone, 1975; Cooke, 1991; Scholles, 2001). It was originally conceived as a way to obtain the opinion of experts without necessarily bringing them together face to face.

The Delphi method is based on a structured process for collecting and synthesising knowledge from a group of experts through iterative and anonymous investigation of opinions by means of questionnaires accompanied by controlled opinion feedback (Evalsed, 2003). The feedback is provided to encourage the recasting of individual opinions in the light of the summary of opinions given (e.g. the average or median of estimation or other statistical measures). The procedure is usually repeated three to four times. The aim is to reach convergence of opinions to produce an applicable result. Figure 4 shows an idealised convergence process. Due to the usually high degree of uncertainty of investigated issues, in reality convergence may not follow a linear path as suggested in the figure. Especially from first to the second round experts may use the chance to more or less fundamentally recast the initial estimation.

The method has been used in hazard related investigations in the past. Deyle *et al.* (1998, p. 122) used it for the evaluation of the use of hazard assessment in land use planning and management. Other applications where run for the prediction of future trends in safety management (Adams, 2001 p. 26) and food safety (Henson, 1997 p. 195). Joel Goodmen (Turoff and Linstone, 1975 p. 93) included hazard related aspects when conducting a policy-type Delphi on coastal zone development. However, few papers show close relationship to the topic of weighting multiple hazards. Most relevant investigations where done by Karlsson and Larsson (2000) using the Delphi method for the development of a fire risk index and Lass *et al.* (1998) investigating the risk distribution for Germany. Karlsson and Larsson (2000) acquired weights and grades in numerical format regarding several so called risk parameters. Lass *et al.* (1998) asked for distribution of percentages for a selected number of risks. The latter applications also pave the way towards generating consensus numerically.

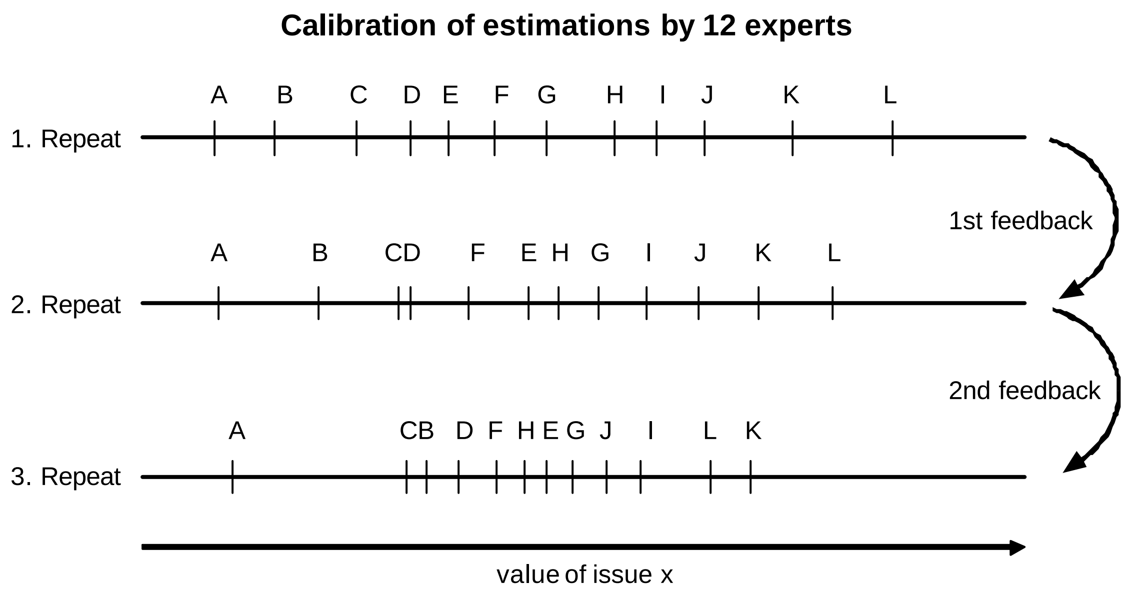


Figure 4: Idealised process of calibration of individual estimations by use of the Delphi method (Hollenstein, 1997, p. 83)

Regarding the application of the method various advantages and disadvantages are discussed. Probably the most important criticism the method faces refers to its often improper application rather than the method in general. Application problems can embrace the use with unsuitable issues (e.g. not uncertain or too complex), the integration of unqualified or too biased experts, mistakes in the implementation process (incomplete information, inappropriate feedback), or the over-interpretation of results. Understandingly, avoidable mistakes should be left undone to emphasise the advantages of the method.

The method is in the first instance useful for a subject with a high level of uncertainty. This applies for risk assessment. While frequency, magnitude and consequences of occurring hazards are uncertain per se, also each individual in a certain area can be expected to perceive differently the importance of hazards and vulnerability. In the public debate about risks it is not possible to speak about the separation of objective notions like risk analysis on the one hand and subjective risk perception on the other hand (WBGU, 2000 p. 38–39). A wide variety of opinions exist regarding each single hazard or risk and possible option for their mitigation. Therefore, each risk related decision is subject to societal discourse. In this light, the main goal of the Delphi method is the creation of a certain consensus among individuals holding special knowledge on the issue of interest as basis for transparent risk related decision making.

Another advantage of the Delphi method is that it avoids problems commonly encountered in face-to-face communication. Problems include communication barriers between individuals with different attitudes, positions etc., dominance of key persons, travel and meeting costs and other aspects.

3.2 Weighting of natural and technological hazards

A) Approach

For the accomplishment of the weighting procedure an approach has been chosen encompassing the following steps:

1. Identification of the weighting question
2. Choice and definition of hazards and preparation of the tool for analysis
3. Choice of experts
4. Carrying out the Delphi survey
5. Analysis of results and success control
6. Transformation of results to the synthetic risk assessment / risk map

Steps one to five are described below. The transformation of results and their application for producing aggregated hazard maps are shown at the end of this chapter.

B) Identification of the weighting question

Matter of weighting is the expert's professional and personal view on the relative importance of the selected hazards. The central question posed to the experts was on *"How hazardous (potentially effective) is one hazard compared with another under average European conditions".*

With *'hazardous'* was meant a hazard's potential to cause harm under European conditions, avoiding defining the issue closer to minimise restrictions to personal perception of the issue. This question first requests the expert's knowledge on multiple hazards. Second it requires that experts set aside regional bias, but try to oversee the general situation in Europe. Third, and most importantly, it appeals to the experts' perception of *hazardousness* of certain hazards.

The uncertainty of the issue lies in various aspects. The area of the European Union is highly diverse in terms of natural settings, distribution of urban areas, industries and hazardous goods, the availability of damageable values, cultural backgrounds and not least the individual perception of hazards and risks. Also the distribution and characteristics of hazards is highly variable from place to place. At the same time the enormous increase of losses (Munich Re, 2004) from even average events urges for action at the European level. Here, generalised information is necessary to set up a European policy addressing multiple risks (see background of the ESPON Hazards project). Methodological advancement and generation of sufficient impartial information, especially covering multi-risk situations can not be promised for the near future. Therefore, the Delphi method is an appropriate solution to investigate factors which function as supplementary information applied with existing large and medium scale information on hazards and vulnerability parameters.

C) Choice and definition of hazards

For inquiry of the expert panel eleven natural and four technological hazards have been chosen. The choice followed the following criteria:

- Existence in the area of the European Union (EU 27+2)
- Relevance for spatial planning action
- Availability of impartial information for risk analysis and the generation of a risk map

The hazards were summarized in a table, including a brief description derived from the definitions of hazards used in the ESPON Hazards project (see chapter 2) and provided to the experts of the Delphi expert panel.

D) Choice of experts

As participants for the expert panel experts needed to be identified fulfilling several prerequisites. All needed to have sufficient scientific background in the work with hazards and especially be related to multi-hazard approaches. To avoid distortion by regional bias, experts with a clear European perspective were chosen. Also the geographical provenance of experts was considered. Finally, twelve experts from the EU-MEDIN Steering Committee, the ESPON Hazards project and the FP 6 project ARMONIA (http://www.armoniaproject.net/html/) formed the expert panel. Coincidentally six experts had southern European provenance and six represented central north European areas.

E) Carrying out the Delphi survey

Prior to the enquiry all experts were supplied information concerning the aim of investigation, characteristics of the applied method and the mode of use of results. Subsequently time was given for consideration and requests. The investigation was realised through three rounds in the period from September to mid of December 2004.

The task was to assign relative weights to the hazards from an explicitly *pan-European and long-term perspective*. This emphasis was important to support the uncoupling from an only regional, national or professional focus or the presence of recent events. Because of the reference to the total ESPON area (EU-27+2) site-specific relevance of certain hazards could not be considered. This degree of generalisation gave the weighting an experimental character, but appears sensible to the approach.

Assuming that total weight of all hazards makes up 100 % the task was to distribute these among the selected hazards thus estimating their relative importance. The weight of each hazard could be assigned from 0 to 100 (100 meaning it is the only relevant hazard in Europe, 0 meaning the hazard is totally irrelevant in Europe).

3.2.1 Results of the hazard weighting process

Results of the Delphi survey are represented by more or less calibrated average values of the responses from the expert panel. During each round experts had the possibility to alter the estimation after taking consideration of the average value from the previous round. Ideally, the final estimation represents the so far final 'opinion' on the weight of each hazard.

All proposed hazards received consideration by the experts (see table 25). The biggest emphasis was clearly on natural hazards (73,9 %) with floods (15,6 %), forest fires (11,4 %) and earthquakes (11,1 %) on the top of estimations. Technological hazards in total received 26,1 % with major accidents hazards weighted highest (8,4 %).

Table 25: Average estimations and quartile intervals of responses

Hazards		Average estimation			Round 3 / Round 1 (%)	Quartile interval		
		Round 1	Round 2	Round 3 (final result)		Round 1	Round 2	Round 3
Natural Hazards	Avalanches	3,0	2,2	**2,3**	76,0	3,1	1,9	0,6
	Droughts	7,5	8,0	**7,5**	100,4	5,0	3,4	2,0
	Earthquakes	10,5	10,0	**11,1**	105,1	3,8	4,1	2,5
	Extreme temperatures	3,7	3,7	**3,6**	96,9	3,3	1,7	0,6
	Floods	15,0	16,1	**15,6**	103,9	3,5	2,4	1,0
	Forest fires	10,0	11,2	**11,4**	114,4	5,5	1,8	2,5
	Landslides	5,7	5,6	**6,0**	106,4	2,3	1,0	0,5
	Storm surges	4,2	4,1	**4,5**	108,6	4,0	1,6	0,0
	Tsunamis	1,4	1,1	**1,4**	105,0	1,1	0,0	0,1
	Volcanic eruptions	3,6	2,7	**2,8**	77,1	1,1	1,0	0,4
	Winter storms	6,9	8,7	**7,5**	109,1	3,5	6,7	2,0
Technological hazards	Air traffic hazards	4,0	2,7	**2,1**	52,6	2,9	1,6	1,2
	Major accident hazards	8,6	8,3	**8,4**	97,9	6,0	2,0	1,6
	Nuclear power plants	8,2	8,4	**7,8**	95,2	7,3	3,6	2,5
	Oil handling, transport and storage	7,6	7,3	**7,8**	102,0	3,3	2,5	1,4
Sum		**100,0**	**100,0**	**100,0**		**100,0**	**100,0**	**100,0**

3.3 Discussion - analysis and success control

The fact that all hazards received a certain weight indicates that the careful selection of the set of hazards was also accepted by the expert panel. During the inquiry neither of the proposed hazards was called into question, nor was a remark of inconsistency made.

The realisation of several rounds in most cases did not considerably change the initial estimations (Table 25, ratio Round 3 / Round 1). In most cases, the value obtained in the third round varied from the initial estimation by only a few percent. This similarly is true for absolutely high and low scored hazards. Only the hazards ‘Volcanic eruptions’ (-23 %), ‘Snow avalanches’ (-24 %) and ‘Air traffic hazards’ (-47 %) showed considerable development. All three received absolutely low scores (below 4 %).

The conversion effect encouraged by the Delphi method was tested by calculating quartile intervals (Table 25). It measures the numerical distance between the values marked by the upper and the lower quarter of responses (cf. e.g. Scholles, 2001). In contrast to the absolute numbers, here considerable advancement in terms of conversion of responses can be seen. For six natural hazards, the interval was found to be below 1 – altogether for hazards scored 6 % and less. However, also highest scored hazards (see above) finally did not show an interval over 2,5 that already is the found maximum.

Biggest differences on provided weights (absolute) are found for the hazards 'Storm surges', 'Nuclear power plants' and 'Major accidents' – for these quartile intervals cut to one third or fully vanished. Least 'progress' is visible for those rather low scored hazards such as 'Volcanic eruptions', 'Tsunamis' and 'Air traffic hazards'. Mentionable is the relatively high consensus from the very beginning with regard to the absolutely high ranked 'Earthquake' hazard.

While the quartile difference informs about the achieved conversion effect leaving aside the lower and upper quarter of responses (extremes), it fails in unveiling the tendency of all responses. The measure capable of considering all contributions including the extremes and giving consideration to the relative development of weights for each single hazard is the 'coefficient of variation'. Looking at this, principally the similar picture is shown as indicated above: the iteration of weighting leads to a more or less significant and more or less linear conversion of responses. However, one hazard has developed considerably different from the others (Figure 5). The tsunami hazard, relatively low weighted, from the very beginning showed biggest dissonances between the experts. Already after the second round experts had largely agreed on a common weight of the hazard. In the third round dissonances where re-established at a level considerably above all others.

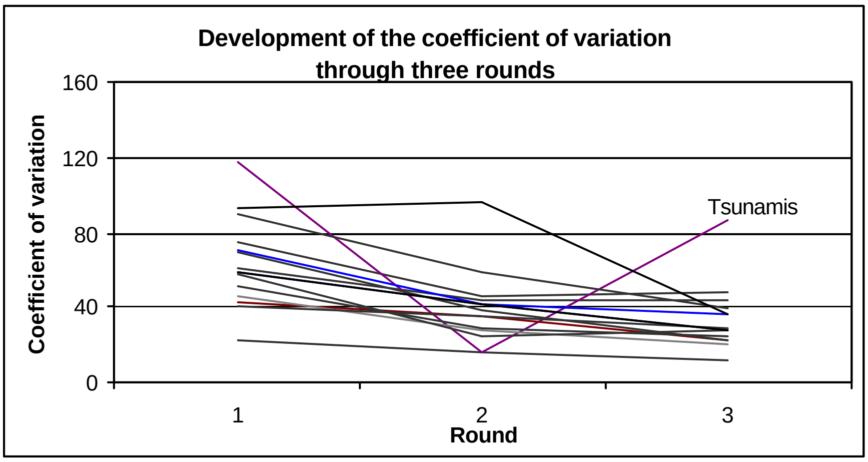


Figure 5: Weight variation in dependence of current events

The reason is evident and unveils an important weakness of the method. Most responses for the third round where sent at Christmas 2004. Two last responses were delivered in the beginning of January 2005, after the tsunami event in South-East Asia on December 26th, 2004. In particular one of those last weighting responses was obviously fundamentally recasted in the light of the event itself and the subsequent discussion of implications for Europe. The same member also doubled the estimation for 'Storm surges'. This on the one hand proves the proposition, that the issue attempted by the review is highly uncertain. But, this also indicates a certain sensitiveness of the method to current events. Although precautions were taken to avoid such influence, events occurring during the inquiry can impact the attitude of participants. Nevertheless, the occurred deviation cannot be interpreted as distortion only. Accepting that the panel is dealing with uncertainty, each event also generates knowledge and is an impulse for re-consideration in the light of the knowledge. Thus, weighting results generated by the Delphi method may be seen as snap-shots and therefore need regular update.

An experimental comparison of weights assigned by participating experts from northern/central and southern European regions was accomplished by calculating the ratio of average weights: Southern / Northern experts (Figure 6). In the result, the ratio 1 indicates that both expert groups weighted the hazard identically (in average), above 1 indicates a higher estimation by experts with southern provenance, below 1 shows higher estimation by experts with northern provenance. For most hazards no significant correlation (ratio 0,9 - 1,1) of assigned weight and provenance of experts is visible. With the exception of 'Air traffic hazards', technological hazards were weighted considerably higher (ratio 1,2 – 1,4) by experts with southern provenance. In contrast, natural hazards 'Storm surges', 'Tsunamis' and 'Winter storms' where weighted considerably higher by experts with northern and central provenance (ratios 0,8 - 0,7). Lacking a multitude of cases with different provenance of experts, these statements can hardly be further analysed. However, the light of these observations, the consideration of the geographic provenance seems to be beneficial in the selection of members of the expert panel.

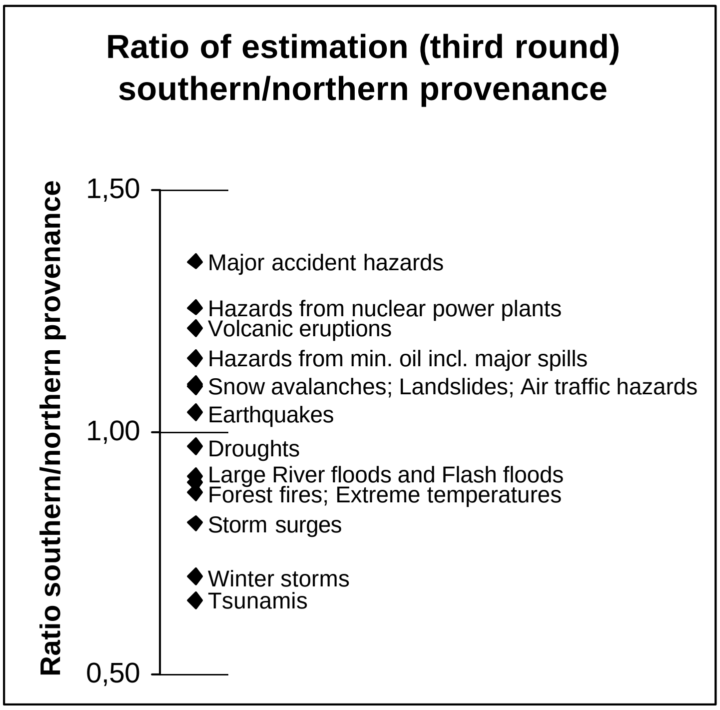


Figure 6: Expert estimations by provenance: Southern / Northern

3.4 Conclusions of the weighting process

The Delphi method is an efficient approach for weighting hazards in multi-hazard cases. The clear conversion of most weights proves the effectiveness of the method.

Nevertheless, the quality of results is closely related to the terms of implementation including issue, process, analysis and application of results. The sensitiveness of estimations proposed by members of the expert panel discussed above and other observations made in case study tests of the method (Annex 2) indicate, that a number of aspects need to be considered when applying the Delphi method. In the following, major conclusions are depicted, which shall guide future applications of the method:

- The application of the Delphi method is only sensible for investigation of widely uncertain issues.
- Due to the subjective factor of results generated by the Delphi method, it should only be used if subjective judgement appears to be the only conceivable way of generating required knowledge.
- The question(s) posed to the expert panel should be simple and must precisely describe the issue of interest to ensure that each expert has the same understanding of it. Cultural differences of participants need to be considered.
- Participants of the expert panel should be carefully selected to ensure the optimal mixture of qualities (e.g. professional knowledge, attitude to the problem, societal and/or geographical background, personal bias, etc.).
- Participating experts should be equally and properly informed about the functioning of the method, the importance of single steps and the usage of results.
- Results need statistical analysis and success control to ensure conversion of responses. Analysis must pay due attention to the sample size and thus to the used statistical measures.
- Results must not be over-interpreted - Delphi results relate to uncertain issues, and so is the result. Its use is indicative and should preferably be used as supplement to other data.
- Results can easily be influenced by meanwhile occurring events. The moderators should pay attention to factors, which can influence responses from the panel and be prepared to consider potential changes in their interpretation.
- As dealing with uncertain issues, results delivered by the Delphi method are prone to change as soon as new knowledge is generated or when conditions change. Thus results should be regularly updated.

3.5 Aggregated hazard maps

The following section shows first aggregated hazard maps of the EU 27+2 area. The first map shows the weighted natural hazards, the second one the weighted technological hazards and the last one the aggregated hazard map. The hazards were weighted according to the results of the Delphi method, and classified on the base of percentile ranking.

Table 26: Classification of aggregated natural hazards

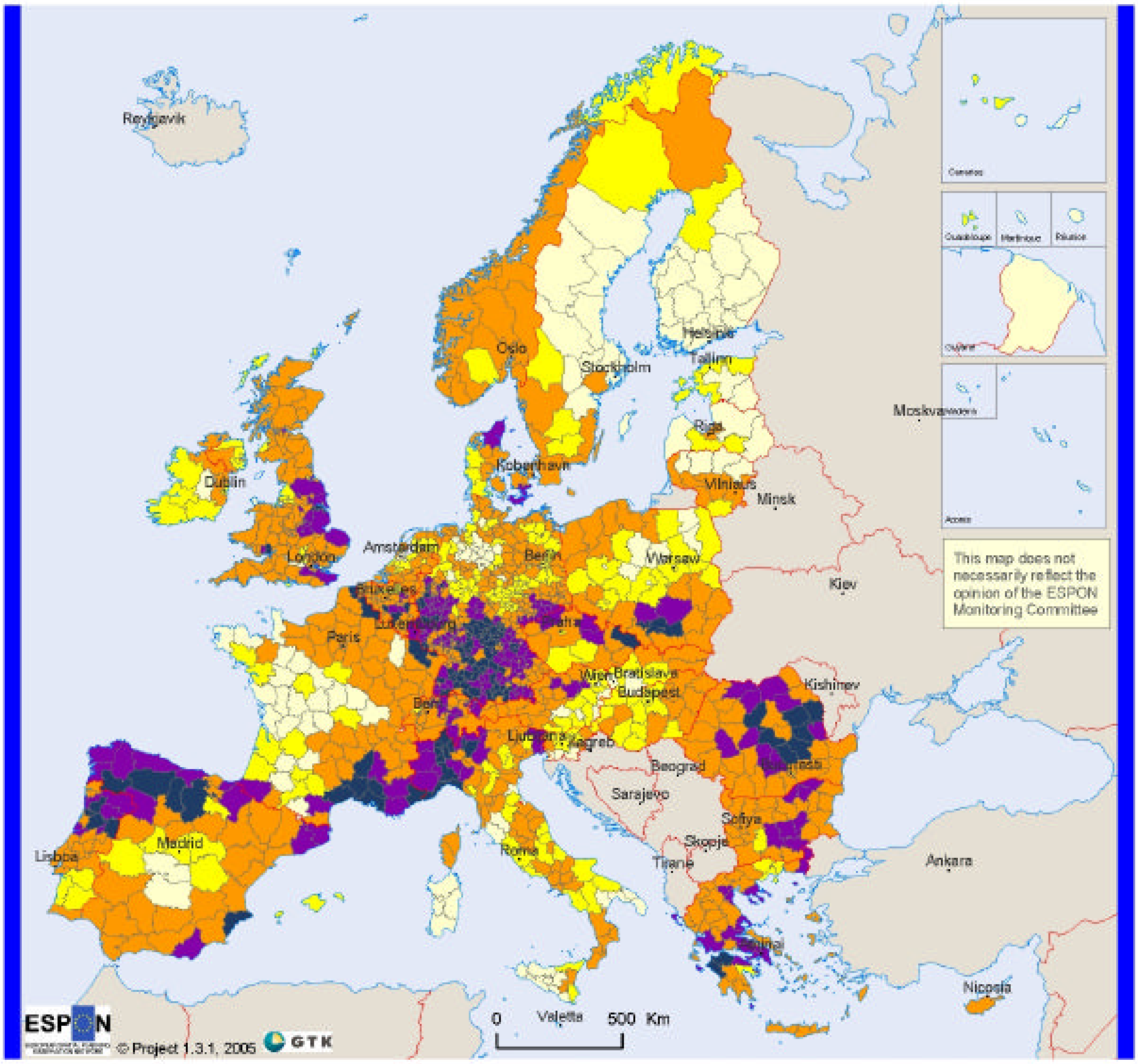
Percentiles of weighted aggregated natural hazards and distribution of scores (in brackets)	
<10 percentile (62-135)	1 Very low hazard
10-25 percentile (136-155)	2 Low hazard
25-75 percentile (156-191)	3 Medium hazard
75-90 percentile (192-207)	4 High hazard
90-100 percentile (208-264)	5 Very high hazard

Table 27: Classification of aggregated technological hazards

Percentiles of weighted aggregated technological hazards and distribution of scores (in brackets)	
<10 percentile (16-42)	1 Very low hazard
10-25 percentile (43-44)	2 Low hazard
25-75 percentile (45-68)	3 Medium hazard
75-90 percentile (69-84)	4 High hazard
90-100 percentile (85-124)	5 Very high hazard

Table 28: Classification of aggregated hazards

Percentiles of all weighted aggregated hazards and distribution of scores (in brackets)	
<10 percentile (78-189)	1 Very low hazard
10-25 percentile (190-206)	2 Low hazard
25-75 percentile (207-252)	3 Medium hazard
75-90 percentile (253-273)	4 High hazard
90-100 percentile (274-339)	5 Very high hazard



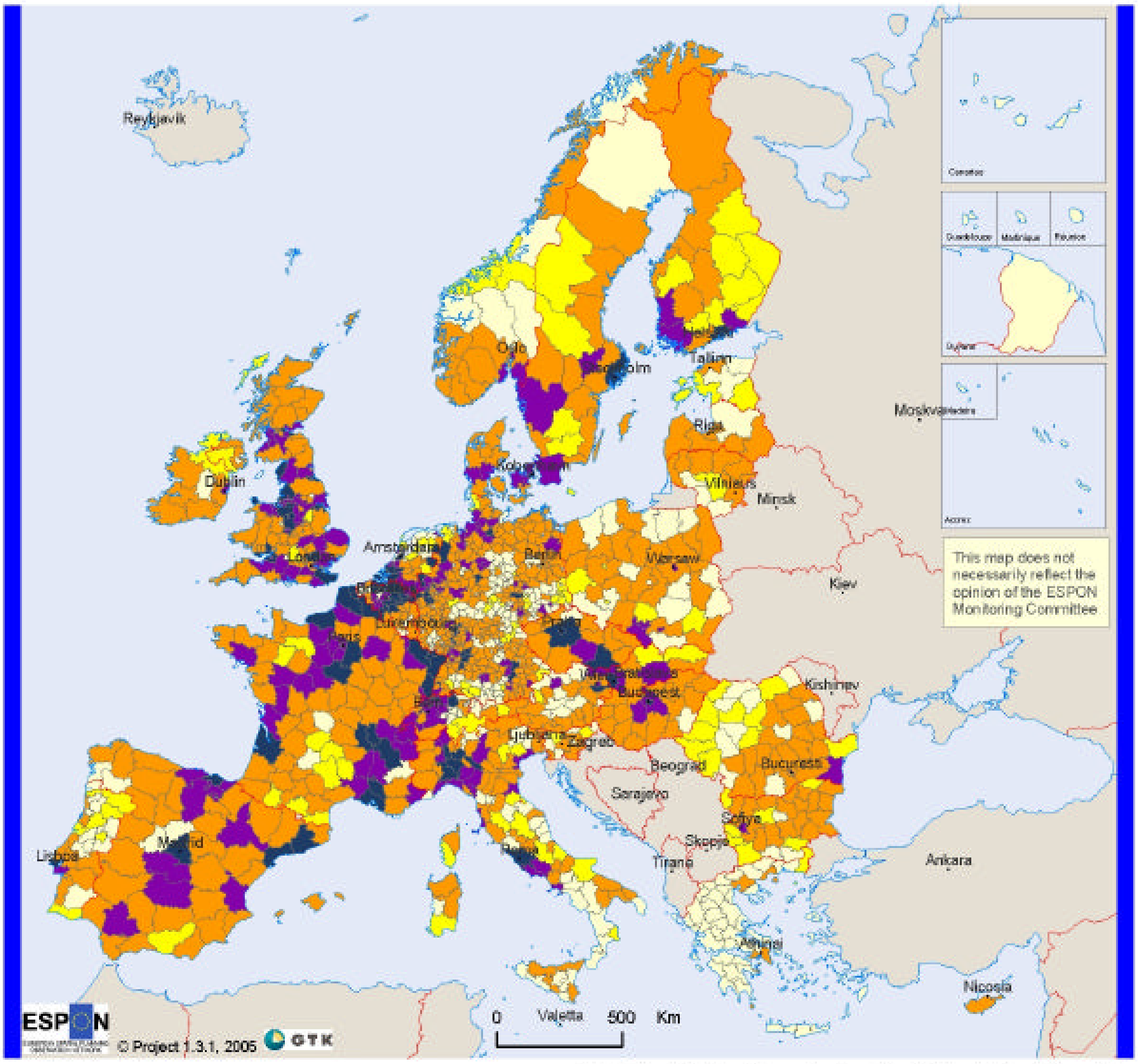
Origin of the data: © EuroGeographics Association for the administrative boundaries
Source: ESPON Data Base

Hazard classification

- 0-10 percentile
- 10-25 percentile
- 25-75 percentile
- 75-90 percentile
- 90-100 percentile
- Non ESPON space

This map shows the aggregated natural hazard typology based on 11 single hazard indicators. Every indicator gives the value from 1 to 5 depending on the magnitude of the hazard in NUTS3 area. For the class "No data" value is 0. These values are then weighted on base of expert opinion (Delphi method questionary). The sum of 11 weighted indicators are than classified on base of percentile rank. For instance, NUTS3 areas that belong in 90 -100 percentile have their score greater than or equal to 90% of the total of all the summed hazard values.

Map 16. Aggregated natural hazard map



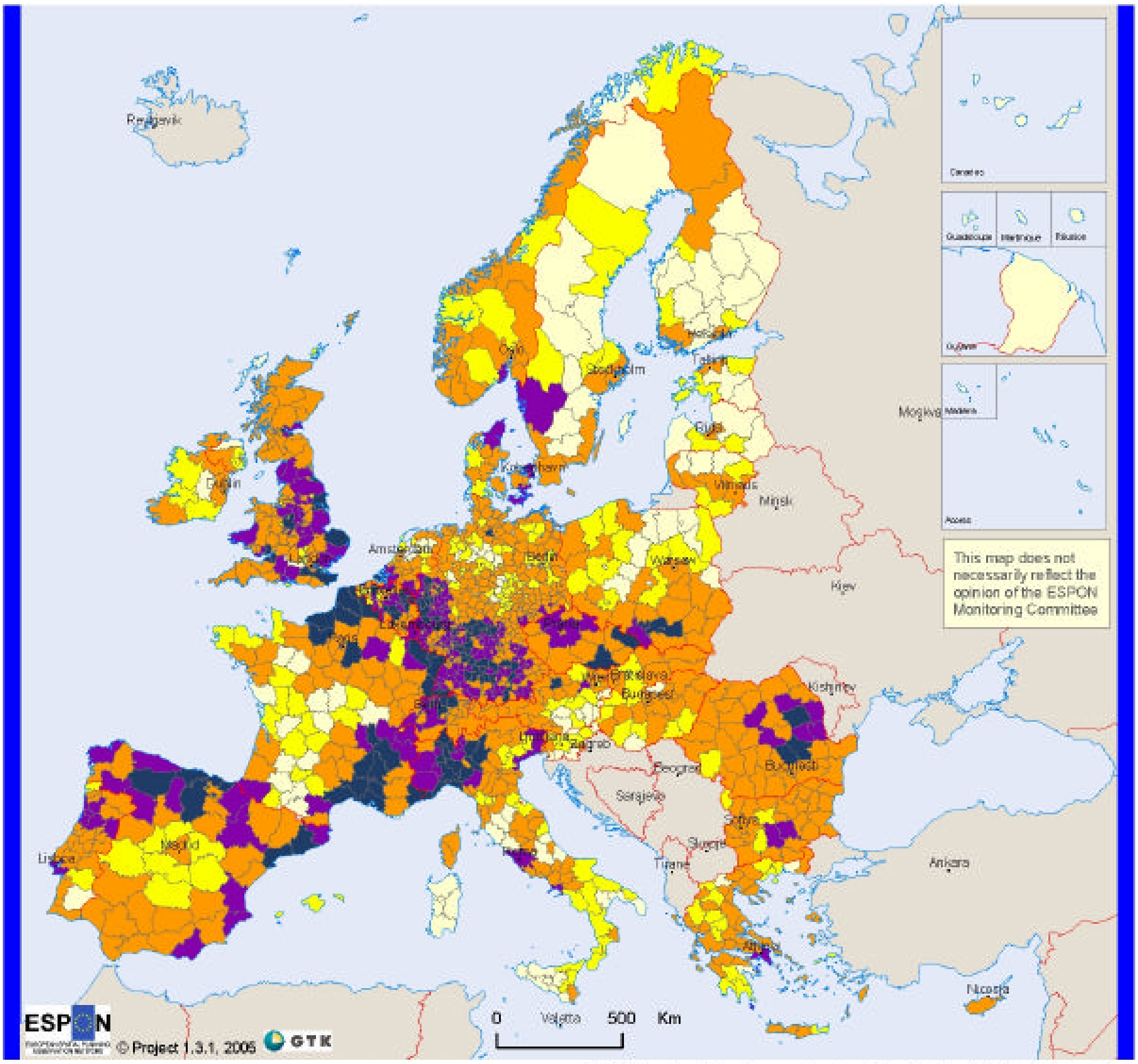
Hazard classification

- 0-10 percentile
- 10-25 percentile
- 25-75 percentile
- 75-90 percentile
- 90-100 percentile
- Non ESPON space

Origin of the data: © EuroGeographics Association for the administrative boundaries
Source: ESPON Data Base

This map shows the aggregated tecnological hazard typology based on four single hazard indicators. Every indicator gives the value from 1 to 5 depending on the magnitude of the hazard in the NUTS3 area. For the class "No data" value is 0. These values are then weighted on base of expert opinion (Delphi method questionary). At the end the sum of four weighted indicators are classified on base of percentile rank. For instance, NUTS3 areas that belong in 90-100 percentile have their score greater than or equal to 90% of the total of all the summed hazard values.

Map 17. Aggregated technological hazard map



Hazard classification

- 0-10 percentile
- 10-25 percentile
- 25-75 percentile
- 75-90 percentile
- 90-100 percentile
- Non ESPON space

Origin of the data: © EuroGeographics Association for the administrative boundaries
Source: ESPON Data Base

This map shows the aggregated hazard typology based on 15 hazard indicators. Every indicator gives the value from 1 to 5 depending on the magnitude of the hazard in the NUTS3 area. For the class "No data" value is 0. These values are then weighted on base of expert opinion (Delphi method questionary). At the end the sum of 15 weighted indicators are classified on base of percentile rank. For instance, NUTS3 areas that belong in 90-100 percentile have their score greater than or equal to 90% of the total of all the summed hazard values.

Map 18. Aggregated hazard map

Integrated map analysis

The aggregated natural hazard map reveals three main high hazard corridors in the EU 27+2 region, all of which merge in central and southern Germany. One corridor starts off in the United Kingdom and includes parts of the Benelux States, another one includes the northern Iberian peninsula and stretches over southern France, northern Italy and Switzerland. The third corridor is more scattered but starts from central Germany off to the eastern EU member states where it then turns south over the accession countries into Greece. This pattern of high and very high natural hazards nearly has the shape of a scorpion, with its head in central and southern Germany, the arms and the claws reaching into coastal areas of United Kingdom and northern Portugal, respectively, and the tail bending over eastern Europe southwards into Greece. The outliers of this "high hazard scorpion" are located in Denmark. Most of the NUTS3 regions have a medium or low natural hazard potential and only few a very low one, mainly parts of northern Europe and the Baltic States, western France, Sardinia and other scattered areas. An interconnection between hazard potential on the one hand and spatial typologies is not visible. This is easily understandable, since natural phenomena have to be seen principally independent from human activities. Human intervention may be from relevance (e. g. modifications of river bodies), but this cannot be detected on maps on NUTS3 level.

The aggregated technological hazard map shows a more fragmented picture but two main corridors of high hazards can be identified. Both of these corridors start off in Spain, one of them then encompasses Catalonia and south-central France and south western Germany, it then scatters out into northern and central Italy, parts of southern Germany and finally into Hungary, the Czech Republic, Slovakia and small parts in other countries. The other corridor turns from southern Spain towards western and northern France, the United Kingdom, the Benelux States, western Germany and finally including southern parts of Scandinavia and Finland. Most of EU 27+2 has a medium aggregated hazard, only few areas have a low aggregated technological hazard, notably most of Greece. Central and urban regions seem to be more threatened by technological hazards in comparison to rural and peripheral areas. Especially the global hubs London and Paris as well as the mega cities Madrid, Rome, Lisbon, the Randstaat, Basel, but also Eastern Europe megas like Prague or Budapest belong to the highly affected regions. The main reason for this higher hazard potential is that most of the technological facilities as well as transport infrastructure are located in the urban, central regions.

The aggregated hazard map shows a similar pattern as the natural hazard map with a scorpion shape of high hazards. The two arms and the claws of this high hazard scorpion start off on the coastal areas of the United Kingdom and the Iberian Peninsula, respectively and the head is found in central and southern Germany. The tail is then more scattered out towards eastern Europe, southwards to Greece. Some hotspots are located outside of this "high hazard scorpion", central Italy and parts of southern Scandinavia. Most of the NUTS3 areas have a medium and some a low aggregated hazard. Besides scattered spots, only few large areas have a very low aggregated hazard, mainly in northern Europe and central-south France.

In the map analysis one has to take into account that the 15 hazards used for these maps are based on current knowledge that is comparable among all EU 27+2 countries. The technological hazards are represented by only four hazard types. The maps thus serve as an overview on the entire area, but regional and local analysis always have to take the best available data into account. The map shows the tendency that the central parts of Europe are more affected by hazards than the more peripheral regions. However, a similar trend is not visible comparing urban with rural regions.

4 Vulnerability and its Dimensions

4.1 Defining regional vulnerability

Defining and measuring regional vulnerability is important in the ESPON Hazards project, since vulnerability is one of two components of risk, and the ultimate outcome of the project is an aggregated risk map of EU 27+2. The ESPON Hazards project defines risk as

Risk = Hazard potential x Vulnerability.

The field of vulnerability research embraces an array of different definitions for vulnerability (for an attempt to draw these together see Cutter, 1996). The ESPON Hazards project defines vulnerability as the degree of fragility of a (natural or socio-economic) community or a (natural or socio economic) system towards natural hazards. It is a set of conditions and processes resulting from physical, social, economical and environmental factors, which increase the susceptibility of the impact and the consequences of natural hazards. Vulnerability is determined by the potential of a natural hazard, the resulting risk and the potential to react to and/or to withstand it, i.e. its adaptability, adaptive capacity and/or coping capacity.

The UNDP Bureau for Crisis Prevention and Recovery (UNDP, 2004) offers a somewhat similar definition than that of the ESPON Hazards project. According to UNDP human vulnerability is “a condition or process resulting from physical, social, economic and environmental factors, which determine the likelihood and scale of damage from the impact of a given hazard”. This definition also encompasses response and coping, since vulnerability refers to the different variables that make people less able to absorb the impact and recover from a hazard event.

According to Cutter (1996:530), vulnerability is broadly defined as “potential for loss”. However, vulnerability is understood in different ways and Cutter (1996) has found three distinct themes in vulnerability research:

- Vulnerability as hazard exposure: Research under this theme concentrates on the distribution of some hazardous condition, human occupancy of such an area and the degree of loss associated with a hazardous event. Vulnerability is a pre-existing condition.
- Vulnerability as social response: Research under this theme concentrates on response and coping capacity, including societal resistance and resilience to hazards as well as recovery from a hazardous event. This approach highlights the social construction of vulnerability.
- Vulnerability of places: Vulnerability of places is a combination of hazard exposure and social response within a specific geographic area.

The ESPON Hazards project can be viewed as a representative of the third, integrative approach. Vulnerability in the ESPON Hazards project is place-specific and it takes into account the damage potential (including human occupation, infrastructure and natural areas) and coping capacity of regions. The areal unit for the project is a NUTS3 region, but the results are shown on maps of EU27+2.

The ESPON Hazards project acknowledges damage potential and coping capacity as the two main sides of regional vulnerability. At the same time the project recognizes three dimensions of vulnerability: economic, social and ecological.

The economic dimension of vulnerability acknowledges economic *damage potential*, which can be understood as anything concrete that affects the economy of a region and can be damaged by a hazard. The economic dimension of vulnerability represents the risk to production, distribution and consumption.

Comfort *et al.* (1999) acknowledge the fact that advanced industrial societies, especially large urban centres, are especially vulnerable, because the destruction of important and extensive systems of communications and infrastructure is costly and can have vast consequences to the economic stability even on the global scale. The economic dimension offers an interesting approach to regional vulnerability, especially from the insurance company's point-of-view of damage potential.

The social dimension of vulnerability acknowledges the vulnerability of people, and the emphasis is on *coping capacity*. Especially weak and poor population groups are considered vulnerable.

Blaikie *et al.* (1994:9-10) argue, that the most vulnerable groups are those, who find it hardest to reconstruct their livelihood after a disaster (see also UNDP, 2004). They find that, as a rule, the poor suffer more from hazards than the rich. The time dimension is relevant, since reconstruction in poor areas can take a long time, which affects the economy and livelihood of the area drastically. Further, the poorer population groups do not always have a choice of where to locate, and thus they might have to live in risky areas, e.g. on a muddy hillside or a flood plain (cf. environmental justice). Cross (2001) argues that people in small towns and rural communities are more vulnerable than people in large cities because of weaker preparedness.

Cannon *et al.* (2003) see social vulnerability as a complex set of characteristics that include a person's initial wellbeing, livelihood and resilience, self-protection, social protection and social and political networks and institutions. For Cutter *et al.* (2003) social vulnerability is "a multidimensional concept that helps identify those characteristics and experiences of communities (and individuals) that enable them to respond and recover from natural hazards".

The ecological dimension of vulnerability acknowledges ecosystem or environmental vulnerability or fragility. In the case of ecological vulnerability it is important to find out, how different kinds of natural environments cope with and recover from different hazards.

According to Williams & Kaputska (2000, cite Villa & McLeod 2002) ecosystem vulnerability can be seen as the inability of an ecosystem to tolerate stressors over time and space. Villa & McLeod (2002) state, that environmental vulnerability can be either intrinsic or extrinsic. Intrinsic vulnerability is related to factors internal to the system (ecosystem health and resilience), whereas extrinsic vulnerability contains factors external to the system (present exposure and external hazard). Ecological vulnerability thus recognizes both ecological damage potential and coping capacity.

4.2 Indicators for damage potential and coping capacity

In this project overall regional vulnerability is measured as a combination of damage potential and coping capacity. For both damage potential and coping capacity a set of indicators was chosen. The three dimensions of vulnerability are imbedded in either damage potential or coping capacity, and separate indicators measure each dimension. The basic criteria for choosing the indicators was, that they should cover the range of all three vulnerability dimensions as well as both damage potential and coping capacity. These indicators are used to measure vulnerability at the European level and they are not necessarily applicable on the regional level. In the case study areas appropriate indicators are used according to the region in question.

Damage potential indicators measure anything concrete that can be damaged by a hazard. They measure the scale of possible damage in a particular region. Coping capacity indicators measure the ability of a community or a region to prepare or respond to a hazard. They measure either human properties or the existence of infrastructure. At the same time coping capacity indicators point out social and place inequalities. Interesting indicators for measuring vulnerability to natural and technological hazards in Europe are introduced in the table 29.

This table shows for each indicator whether it stands for damage potential or coping capacity. One indicator, tourism, can be considered as both a damage potential indicator and a coping capacity indicator. Tourists affect the damage potential of a region, since they are a population group that is in danger due to their lack of knowledge of local conditions as well as due to the fact that popular tourist areas are often in risky areas. Tourists affect the coping capacity of a region since they have in most cases no knowledge of how to cope, they do not know the region and often also not the language. (See e.g. White and Hass, 1975).

Table 29 further points out which dimension each indicator represents. In the case of damage potential indicators it was simple to point out the dimension for each indicator, although population density and tourism can be connected to either the economic or the social dimension. In the case of the six last coping capacity indicators of table 29, it was not possible to pinpoint them to any of the three dimensions. All of these indicators measure mitigation and preparedness of the society, especially its infrastructure.

The vulnerability of natural areas is not easily measurable, especially since not all hazards are a risk to the environment. The ESPON project 1.3.2 on Natural Heritage states (Final report, Part 2) that "the only spatially-specific and methodologically consistent units available for environmental reporting are land areas that are distinguished either by their protection or designation status or by their land cover type." The two indicators for the ecological dimension in table 29, significant natural areas and fragmented natural areas, measure the vulnerability of the environment in two different ways. Since there is no extensive and feasible data available on the protection status or on the significance of natural areas, the ESPON Hazards project has chosen to use the “proportion of fragmented areas to all natural areas” - indicator as more vulnerable towards hazards. However, it must be noted that this is only one possible solution, since some people argue that instead of the fragmented areas the large, non-fragmented areas are the most vulnerable due to their high quality and importance for the whole ecosystem.

Table 29: Possible indicators for measuring vulnerability in Europe

Indicator	dp/ cc[1]	econ/ soc/ ecol [2]	Description	Data availability
Regional GDP/capita	dp	econ	High regional GDP/capita measures the value of endangered physical infrastructure and the extent of possible damage to the economy. Insurance company point of view.	+
Population density	dp	econ/ soc	Measures the amount of people in danger.	+
Tourism (e.g. number of tourists/number of hotel beds)	dp/ cc	econ/ soc	Tourists or people outside their well-known environment are especially vulnerable for two main reasons: First, they are generally unaware of the risks and do not necessarily understand the seriousness of hazardous situations. They do not necessarily know the local language and thus they are likely to miss important information. Secondly, tourist dwellings are often located in high-risk areas and might not meet the requirements of structural risk mitigation.	-
Culturally significant sites	dp	econ	Such sites are unique and important for the cultural and historical identity of people, e.g. sites on the UNESCO world heritage list.	-
Significant natural areas	dp	ecol	Areas with special natural values (e.g. national parks or other significant natural areas) can be considered vulnerable because they are unique and possibly home to rare species of flora or fauna.	-
Fragmented natural areas	dp	ecol	Natural areas that are small and fragmented are vulnerable, since they are likely to be totally destroyed if a hazard strikes.	+
National GDP/capita	cc	soc	Low national GDP/capita measures the capacity of people or regions to cope with a catastrophe. In the ESPON Hazards - project the national GDP/capita was used, since the presumption was that coping capacity is weak in poor countries and strong in rich countries. It was further presumed that there are no marked differences in coping capacity inside a country.	+
Education rate	cc	soc	Measures the ability to understand and gain information. The presumption is, that people with a low educational level do not find, seek or understand information concerning risks as well as others, and are therefore vulnerable.	-
Dependency ratio	cc	soc	Measures the proportion of strong and weak population groups. A region with a high dependency ratio is especially vulnerable for two reasons. First, elderly people and young children are physically frail and thus vulnerable to hazards. Secondly, elderly people and children may not be able to help themselves but need help in the face of a hazard. A region with a high dependency ratio is dependent on help from the outside.	-
Risk perception	cc	soc	Indicates how people perceive a risk and what their efforts have been to mitigate the effects of a hazard.	-
Institutional preparedness	cc		Indicates the level of mitigation of a region.	-
Medical infrastructure	cc		Indicates how a region is able to respond to a hazard (e.g. number of hospital beds per 1000 inhabitants or number of doctors per 1000 inhabitants).	-
Technical infrastructure	cc		Indicates how a region is able to respond to a hazard (e.g. number of fire brigades, fire men, helicopters etc.).	-
Alarm systems	cc		Indicates the level of mitigation of a region.	-
Share of budget spent on civil defence	cc		Indicates the level of mitigation of a region	-
Share of budget spent on research and development	cc		Indicates the level of mitigation of a region.	-

[1]dp = damage potential, cc= coping capacity

[2]econ = economic dimension, soc = social dimension, ecol = ecological dimension of vulnerability

In an ideal situation it would be possible to use all the indicators introduced in table 29 for measuring vulnerability. However, some of the indicators for coping capacity are in practice impossible to measure (e.g. institutional preparedness, risk perception) and problems in data availability make it impossible to use many other indicators (e.g. number of tourists, medical infrastructure). The data availability -column in table 29 shows the availability of data for the ESPON Hazards project for the area of EU 27+2. In many cases there would have been data on NUTS2 to NUTS0 level but on the ESPON level of NUTS3 no data was available for the whole area of EU 27+2. For these reasons, a less extensive range of indicators has been used in the ESPON Hazards project:

Damage potential:

- regional GDP/capita (high) → economic dimension
- population density → economic and social dimensions
- fragmented natural areas → ecological dimension

Coping capacity:

- national GDP/capita (low) → social dimension

4.3 Integrated vulnerability index

The Delphi method has been used by the ESPON Hazards project as a tool to weight hazards on the regional as well as on the European level. In the case of vulnerability components, the method was used only on the regional level in the case-study areas. The decision not to use the Delphi method on the European level on vulnerability was mainly made on the basis of the case study results. The experts who were able to assess the relevance of different hazards in their regions, had difficulties in deciding on the significance of different vulnerability components. It seems that not everybody was familiar with the concept of regional vulnerability, which made the task of weighing difficult. Despite the problems, regional results were attained. However, they are only valid and applicable within the regions. A European-level Delphi on vulnerability would most probably have proved too difficult for the experts who would have had to consider the joint vulnerability of all NUTS3 regions in EU27+2.

Since the Delphi method could not be used, the weighing of the four indicators was made by testing different weighing combinations for the four feasible indicators. The resulting sample maps enabled the comparison of the different combinations and showed possible changes in the overall vulnerability of different regions. This “sensitivity test” was done in the following four combinations (table 30):

Table 30: Sensitivity test for the integrated vulnerability map

Indicators and % of weighting / Comments	Regional GDP	Population density	Fragmented natural areas	National GDP
The fragmented areas show a clear trend but do not influence the other indicators too strongly (finally chosen option)	30	30	10	30
Too high focus on fragmented areas	25	25	25	25
Too high focus on GDP per capita	20	20	10	50
Too high focus on population density	20	50	10	20

Ideally all four indicators would receive the same value of 25%, which altogether adds up to 100% regional vulnerability. However, due to the fact that the indicator "fragmented natural areas" only depicts one aspect of ecological vulnerability, the indicator was given the percentage value of 10. Each of the other three indicators was given the percentage value of 30. Figure 7 shows the integrated vulnerability index with the four feasible indicators.

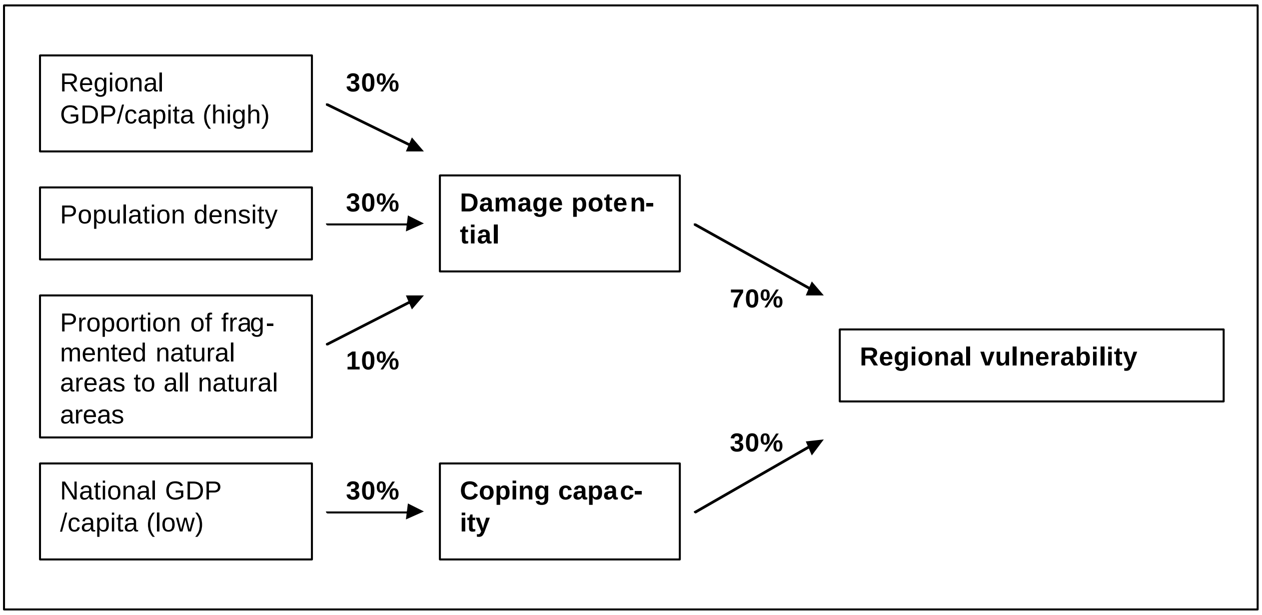


Figure 7: Integrated vulnerability index.

4.3.1 *Integrated vulnerability map for EU 27+2*

The integrated vulnerability index was used to create the integrated vulnerability map for EU 27+2. The integrated vulnerability map depicts the vulnerability of all regions individually. The map was further used to create the integrated risk map for Europe.

Table 31: Integrated vulnerability classification of European Regions

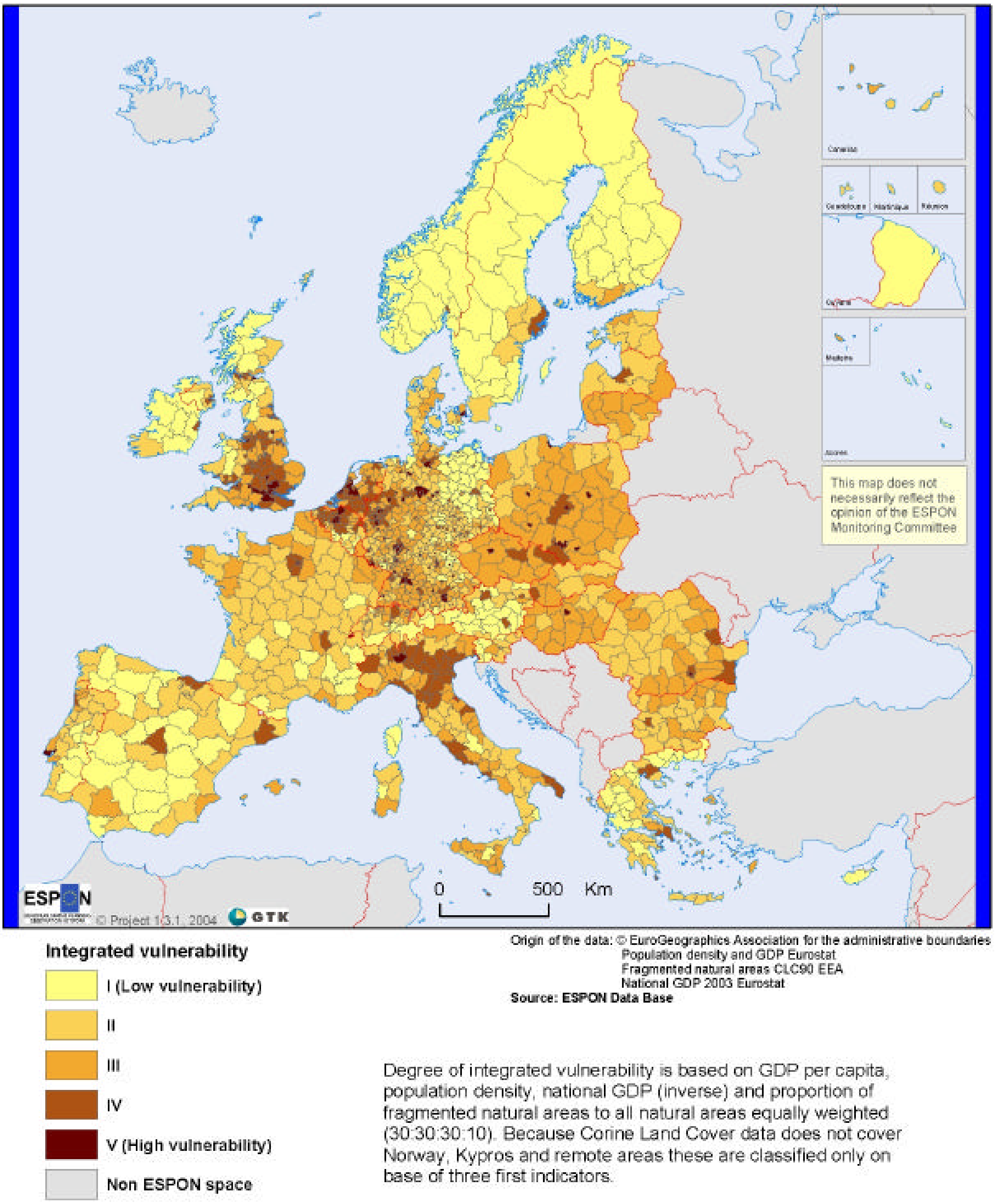
Weighting of Regional GDP/capita, population density, fragmented natural areas and national GDP/capita in the ratio 30:30:10:30	Vulnerability class
1.500000-2.200000	Very low
2.200001-2.600000	Low
2.600001-3.000000	Medium
3.000001-3.500000	High
3.500001-4.100000	Very high

Map analysis

The integrated vulnerability map (see map 19) shows several patterns over the EU 27+2 area. The vulnerability tends decrease from east to west because of a lower coping capacity, as based on the lower GDP/capita. Less fragmented areas show a lower trend towards vulnerability because the nature in larger undisturbed areas can recover faster than that in smaller areas. Densely populated areas with a high GDP per capita show the highest vulnerability, as the total amount of people and assets per km^2 poses a higher vulnerability of total damage in case of a disaster.

The varying vulnerability in western European countries in comparison to eastern European countries is based on the influence of low coping capacity levels in the latter one's. In consequence, the influence of the existing differences in population density and GDP per capita regional on the integrated vulnerability in western European countries is much greater in comparison with eastern Europe.

In a general, as well as in national perspectives the more populated central urban areas are also more vulnerable. This is due to the higher income concentration in combination with population density.



Map 19. Integrated vulnerability map

4.4 Risk maps

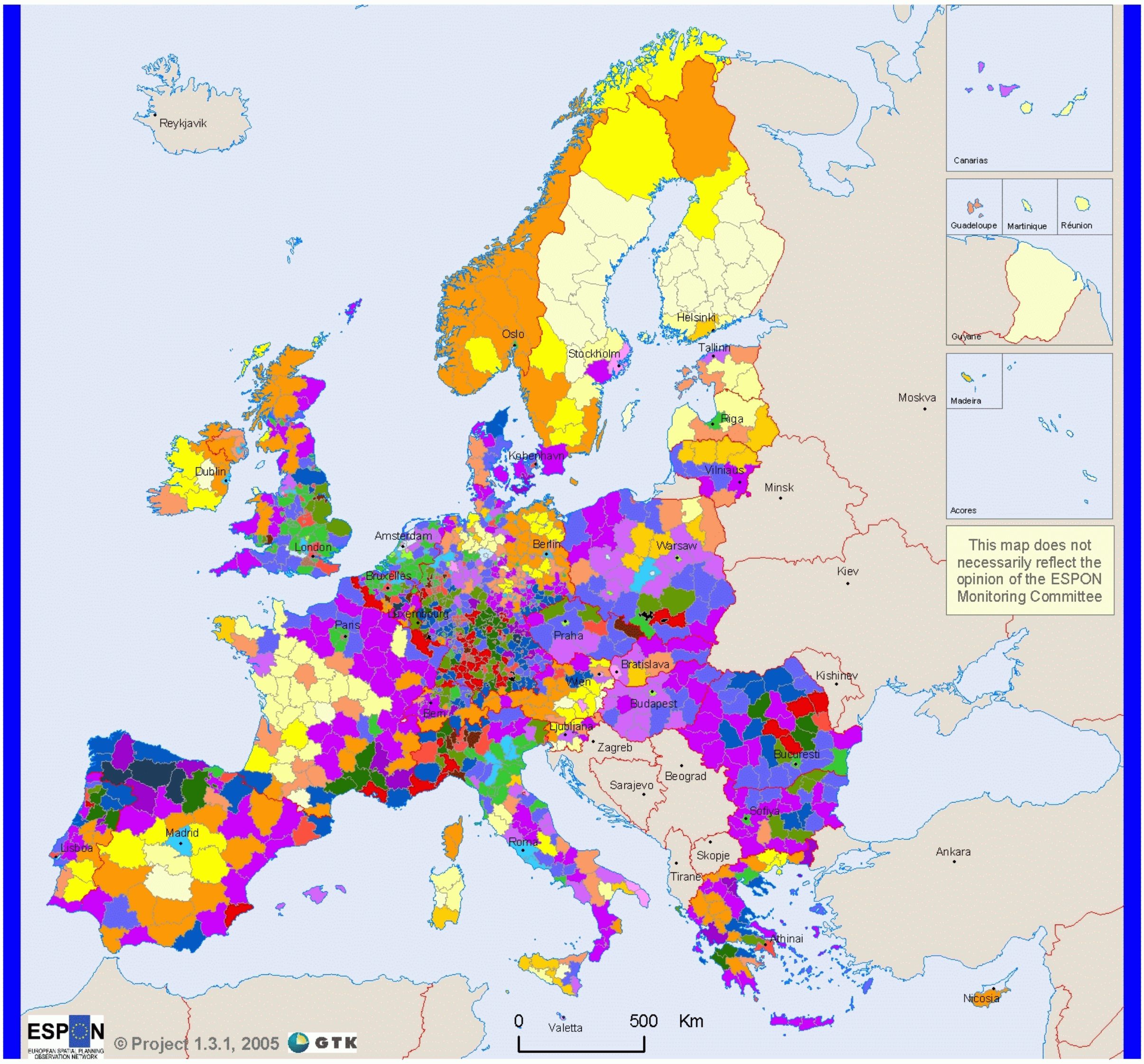
A common way to highlight the differences between risks and hazards is to stress their natural versus their anthropogenic element. Hazards are commonly understood as possible natural events with detrimental consequences whose causes are beyond human control, e.g. an earthquake. On the other hand risks would relate to dangerous situations caused by human activities, e.g. the meltdown of a nuclear reactor. Humans in general have no influence on the occurrence or magnitude of an earthquake, but to live or work in an earthquake-prone area is a more or less conscious decision. This deliberate exposure is a conscious risk that is based on a natural hazard. Furthermore natural hazards, such as river flooding, have a strong human causative element, e.g. through the straightening of rivers. Risks can therefore also be seen as "domesticated" hazards. The hazard concept stresses possible impacts of events on individuals, groups or communities and refers to a potentially damaging disaster. The risk concept emphasizes possibilities for active management (avoidance or mitigation) of harmful events and therefore renders hazards calculable and manageable. In sum, hazard refers to an event and risk to its probability (and to a range of methodological implications e.g. risk analysis and management). As explained in the chapter above, the ESPON Hazards project defines risk as:

<u>Risk = Hazard potential x Vulnerability</u>.

The following section presents aggregated risk maps. The risk maps are based on the hazard classification (chapter 2). The final map is an integrated risk map that is a combination of the vulnerability map (map 19) and the aggregated hazard map (map 18, chapter 3.5). The risk maps follow a legend that displays the hazard values on the y-axis and the integrated vulnerability described above on the x axis. The integrated vulnerability is plotted in a 50:50 relationship with the intensity of a hazard x (see chapter 2 for single hazard or chapter 3.5 for aggregated hazard classifications). Thus, all fields with the same sum (e.g. 4, i.e fields 3+1, 2+2 and 1+3) have the same risk towards a certain hazard. The different shades of the same colour allow distinguishing between a higher intensity of a hazard or a higher degree of vulnerability, respectively.

Table 32: Classification scheme of hazard and risk maps

Legend of risk maps	Degree of vulnerability				
Intensity of hazard x	1	2	3	4	5
1	2	3	4	5	6
2	3	4	5	6	7
3	4	5	6	7	8
4	5	6	7	8	9
5	6	7	8	9	10



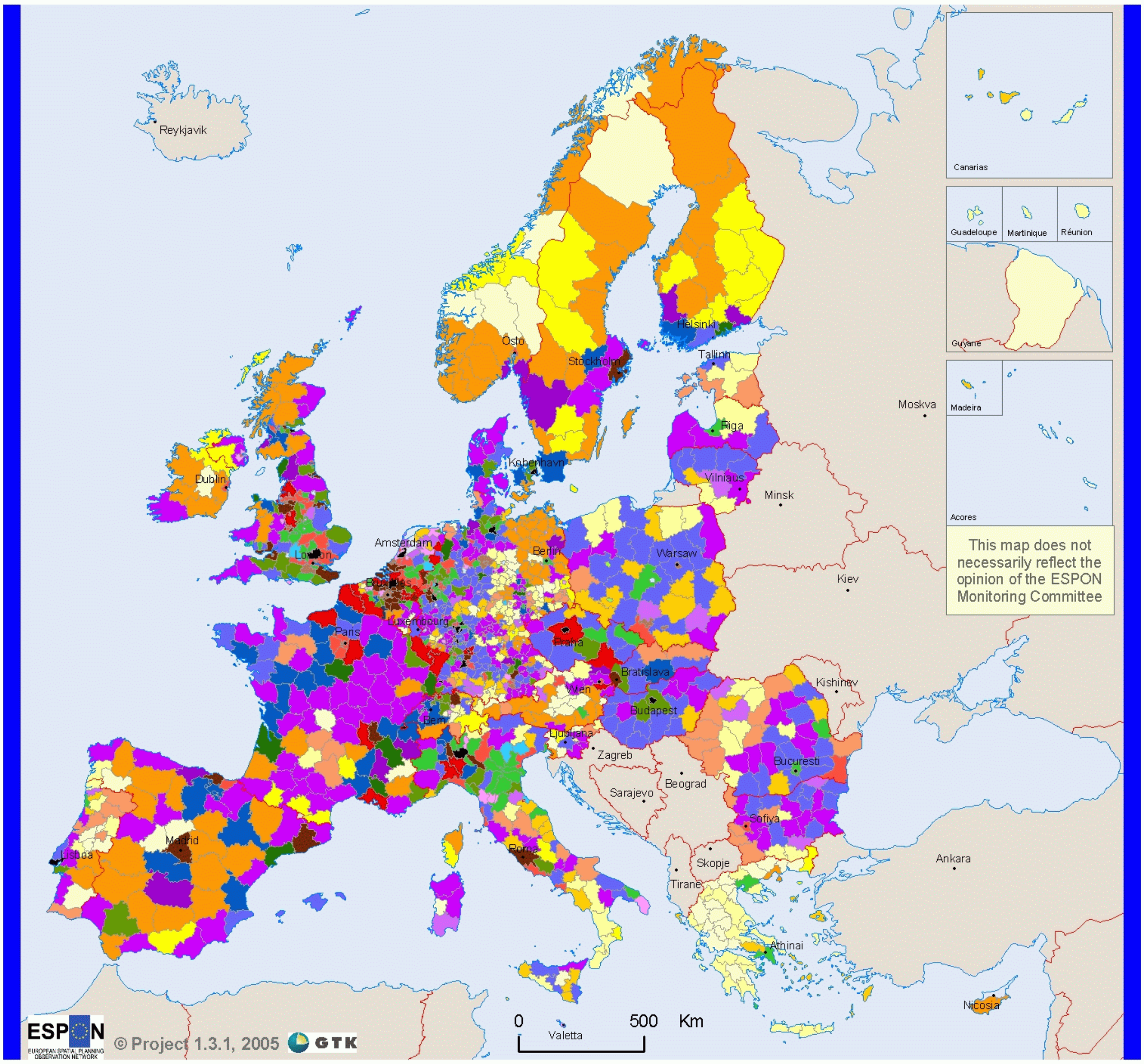
Origin of the data: © EuroGeographics Association for the administrative boundaries
GDP 2000 Eurostat Newcronos Regio
Population density 1999 Eurostat Newcronos Regio
National GDP 2003 Eurostat
CLC90 EEA

Source: ESPON Data Base

Typology of the regions

	Degree of vulnerability				
Intensity of hazard	1	2	3	4	5
1	2	3	4	5	6
2	3	4	5	6	7
3	4	5	6	7	8
4	5	6	7	8	9
5	6	7	8	9	10

Map 20. Aggregated natural risk map



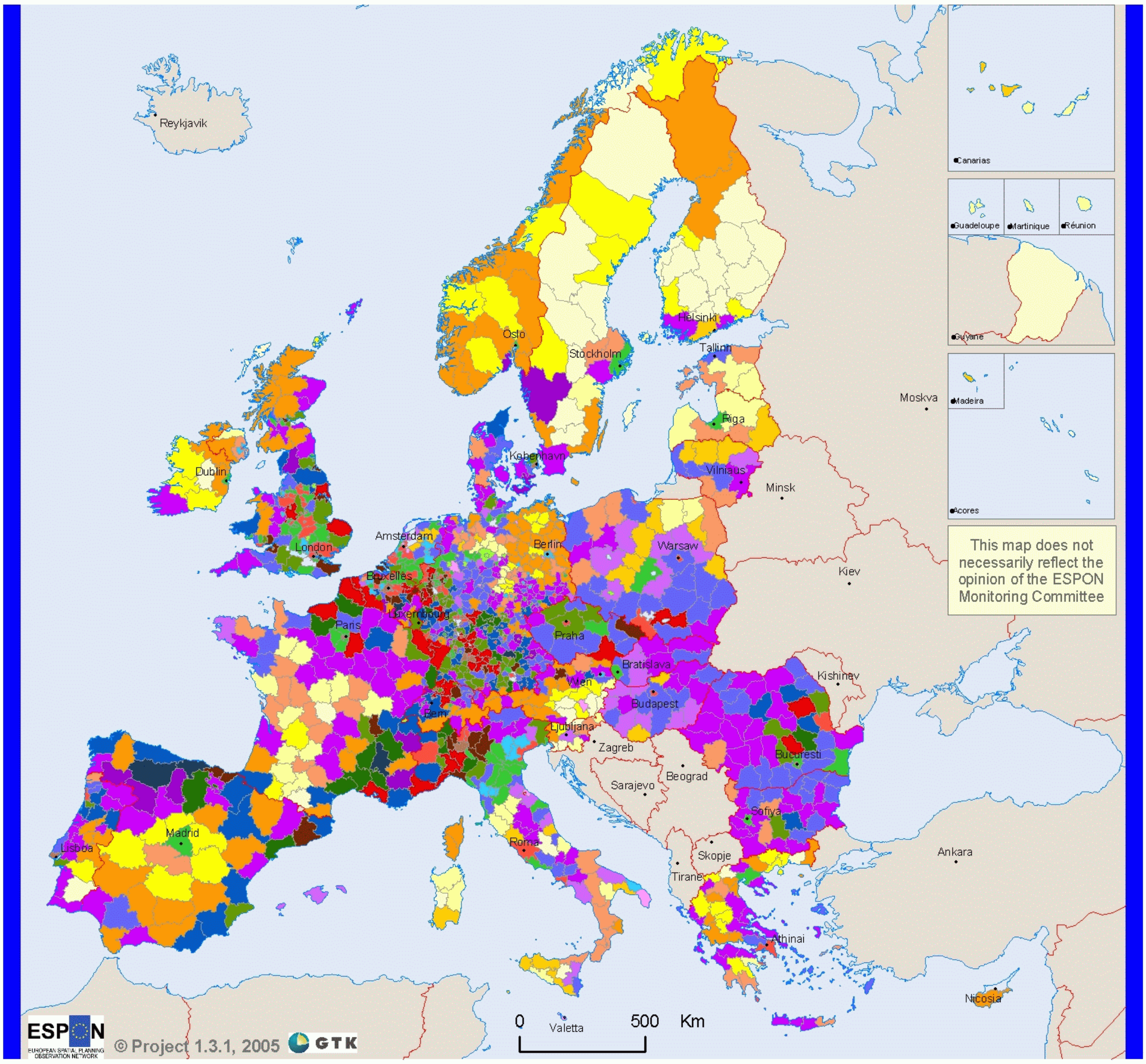
Origin of the data: © EuroGeographics Association for the administrative boundaries
GDP 2000 Eurostat Newcronos Regio
Population density 1999 Eurostat Newcronos Regio
National GDP 2003 Eurostat
CLC90 EEA

Source: ESPON Data Base

Typology of the regions

Intensity of hazard	Degree of vulnerability				
	1	2	3	4	5
1	2	3	4	5	6
2	3	4	5	6	7
3	4	5	6	7	8
4	5	6	7	8	9
5	6	7	8	9	10

Map 21. Aggregated technological risk map



Origin of the data: © EuroGeographics Association for the administrative boundaries
GDP 2000 Eurostat Newcronos Regio
Population density 1999 Eurostat Newcronos Regio
National GDP 2003 Eurostat
CLC90 EEA

Source: ESPON Data Base

Typology of the regions

	Degree of vulnerability				
Intensity of hazard	1	2	3	4	5
1	2	3	4	5	6
2	3	4	5	6	7
3	4	5	6	7	8
4	5	6	7	8	9
5	6	7	8	9	10

Map 22. Aggregated risk map

Integrated risk map analysis

The risk maps are more complicated to analyse than the hazard or the vulnerability maps, mainly because of the higher diversification due to the integration of the hazard potential and the vulnerability. Assuming that the lower risk classes are 2-4, the medium risk classes 5-7 and the high risk classes 8-10, some patterns can be distinguished.

The scorpion shape of high natural hazards (map 16 in chapter 3.5) is still visible in the aggregated natural risk map (map 20), but has shifted towards medium and risk classes (6, 7, and 8). Differently from the aggregated natural hazard map is that meanwhile most parts of central and eastern of Europe are found in the more medium risk classes (5, 6, and 7), many more parts of southern, western and northern Europe belong to the lower one's. In general urban areas seem to be more at risk as rural areas due to the influence of the vulnerability component on the overall risk. This is in particular visible by analysing each member state for itself. In so doing the influence of the national GDP/capita (which leads e. g. to a higher vulnerability in Eastern Europe) can be excluded.

The aggregated technological risk map (map 21) clearly depicts the "Pentagon Area" and other agglomeration zones as the most risky one's, and shows low risks among many parts of the Iberian peninsula, Ireland and the northern United Kingdom, as well as most of northern Europe. Eastern Europe has many areas in medium risk ranges, and Greece is the only country that has most of its NUTS3 areas in the lowest risk class. This very clear result is the result of the combination of the allocation of infrastructure in the urban areas one the one hand and the higher vulnerability of these areas on the other hand.

The aggregated risk map (map 22) again shows a similar pattern as the aggregated hazard map (map 18 in chapter 3.5), eventhough the scorpion shape of high risk has moved towards medium risk (classes 6, 7, and 8). The "Pentagon Area" displays the highest agglomeration of high risk and the largest parts with low risk are found in northern Europe's peripheral regions.

When analysing the aggregated risk maps it has to be kept mind that the data sets are based on 15 hazards, of which four are technological hazards (see chapter 3). The scale seems to be suitable for an inner-regional ranking, but a risk assessment for regional and local planning purposes has to be much more detailed (related to hazard intensity as well as vulnerability, which could relate more towards single protection goods). Possible misleading influences are of the size differences of the NUTS3 regions in the member states.

4.5 Challenges for measuring vulnerability in the future

The methodology of the ESPON Hazards project builds upon creating a European wide aggregated risk map. This approach is somewhat problematic for vulnerability, since not all hazards are relevant for the different dimensions of vulnerability. UNDP (2004) has opted to use hazard-specific vulnerability indicators in their Disaster Risk Index, since factors that make people vulnerable to one hazard are not necessarily the same for another hazard. In the future it would be fruitful to consider all hazards separately and create hazard-specific vulnerability indicators. Interesting maps that consider hazards and vulnerability on a case-specific basis include:

- *Oil spills: the threat to different sectors of economy, e.g. tourism.* The percentage amount of tourism of the GDP of a certain coastal region would allow seeing how vulnerable the economy of a certain region is in the face of oil spills. A high percentage would imply that a region is especially vulnerable. The presumption is, that the tourism industry of a coastal area suffers greatly when an oil spill pollutes the coastal environment. Oil spills are also a relevant risk to fishing industry.
- *Coastal natural areas and oil spills*: Oil spills are a severe risk to coastlines and their natural flora and fauna, since oil is difficult to remove and can leave the environment severely polluted for a long time. Natural areas with special importance, e.g. protected areas could be shown separately.
- *Droughts vs. agriculture:* This map would show the areas where agriculture is the most important sector of economy and which thus suffer from droughts the most.
- *Floods in respect to chemical plants*: Such a map would show where the natural hazard of flooding could be turned into a technological hazard if chemicals are released in the rivers.

Another aspect that needs more consideration in the future is data availability, which hindered the use of several vulnerability indicators in this project. Many interesting indicators could not be used since there was either no data at all or the data was not available on NUTS3 level, the level used for all the ESPON projects. This was especially true in the case of coping capacity indicators, which mainly measure social vulnerability. Despite these problems, the four indicators that were used offer a solid basis and lead the way to future considerations of vulnerability to natural and technological hazards in Europe.

5 Development of a Typology of Regions

An important result of ESPON Hazards project is the development of a typology of regions that clusters areas in Europe, which are threatened by similar hazards in space and time. This typology does not consider the aspect of vulnerability and therefore is a hazard based typology in contrast to a risk based typology (this should not be mixed up with the typologisation of risks which clusters risks into groups by certain characteristics; see also the Glossary in annex 1). This is due to the fact, that – according to the chosen methodology – there are (on a European-wide level) no differences in vulnerability regarding the different hazards.

5.1 Development of the hazard interactions map

The first step aims at the identification of given hazard interactions, based on real physical processes from casual correlation. This task will be managed by a plausibility test. For that purpose, the following list of given interactions (see table 34), based on a literature research, has been elaborated. It summarises the interactions of hazards in a matrix, according to the following scheme:

1 = existing influence of a hazard on the other hazard,

0 = no physical influence on the other hazard.

In the case of existing vice versa interactions (e. g. earthquakes – volcanic eruptions), these will be counted twice. This means that in areas that are threatened by, e.g. earthquakes and volcanic eruptions both interaction values are considered. Due to the regional overview character of the ESPON approach, single spot hazard combinations could not be taken into account, e.g. landslides and nuclear power plants, etc.

The most interesting result is on the one hand the dominance of geological hazards (earthquakes and volcanic eruptions) as causer of influences on other hazards. On the other hand, technological hazards are the most sensitive hazards to the influence of other hazards.

It is a clear matter of fact that the agglomeration areas within seismic or volcanic active zones thus can be identified as heavily threatened by a wide range of hazard interactions.

Table 33: Selected hazards and hazard influences

	causer (x-axe) ? / ? result (y-axe)	Avalanches	Droughts	Earthquakes	Extreme temperatures	Floods	Forest fires	Landslides	Storm surges	Tsunamis	Volcanic eruptions	Winter storms	Air traffic hazards	Chemical plants	Nuclear power plants	Oil processing, transport & storage	Sum (most sensitive hazards to other hazards)
Natural hazards	Avalanches	X	0	1	1	1	0	0	0	0	1	1	0	0	0	0	**5**
	Droughts	0	X	0	1	0	0	0	0	0	0	0	0	0	0	0	**1**
	Earthquakes	0	0	X	0	0	0	0	0	0	1	0	0	0	0	0	**1**
	Extreme temperature	0	0	0	X	0	0	0	0	0	1	0	0	0	0	0	**1**
	Floods	0	0	0	0	X	0	0	1	0	1	1	0	0	0	0	**3**
	Forest Fires	0	1	0	1	0	X	0	0	0	1	0	1	1	1	1	**7**
	Landslides	0	0	1	0	0	0	X	1	0	1	0	0	0	1	0	**4**
	Storm surges	0	0	0	0	0	0	0	X	0	0	1	0	0	0	0	**1**
	Tsunamis	0	0	1	0	0	0	1	0	X	1	0	0	0	0	0	**3**
	Volcanic eruptions	0	0	1	0	0	0	0	0	0	X	0	0	0	0	0	**1**
	Winter storms	0	0	0	0	0	0	0	0	0	0	X	0	0	0	0	**0**
Techno-logical	Air traffic hazards	0	0	0	0	0	0	0	0	0	1	1	X	0	0	0	**2**
	Chemical plants	0	0	1	0	1	1	0	1	1	1	0	1	X	1	1	**9**
	Nuclear Power Plants	0	0	1	0	1	1	0	1	1	1	0	1	1	X	1	**9**
	Oil processing, etc	1	0	1	0	1	1	1	1	1	1	1	1	1	1	X	**12**
Sum (most influencing hazards on other haz-ards)		**1**	**1**	**7**	**3**	**4**	**3**	**2**	**5**	**3**	**11**	**5**	**4**	**3**	**3**	**3**	

For the creation of the hazard typology of regions, interactions were only considered when the hazard intensities in a certain region are above average (hazard intensity classes IV and V). Otherwise it would be impossible to identify specific correlations due to the fact that almost every region is – on a moderate level – more or less threatened by certain hazards, e.g. earthquakes or major accident hazards.

The following matrix gives an example of the specific occurrence of hazards in regions. The typical and frequent occurrence of certain hazard constellations points at an existing hazard typology. Table 35 shows that Regions A and C are characterised by the hazard typology “flood-storms-oil spills”.

Table 34: Matrix for the identification of regional hazard typologies

Type of hazard/NUTS3 region	Region A	Region B	Region C	Region D	...
Flood	IV	II	IV	I	
Storms	IV	III	V	III	
Chemical plants	V	I	IV	II	
...					

The third step deals with the given cumulative effects of the identified interactions between certain hazards and their relevance for the synthetic hazard map.

There is obviously an additional hazard potential in view of a possible coincidence of different hazards in space and time (e.g. the combination of a river flood and a storm surge are a worst case scenario for Rhine or Elbe catchment areas).

However, the physical processes as well as the unforeseeable social and political implications could be very complicated in cases of an interaction between different hazards in space and time. In consequence, any changes in the weighting of hazards for the aggregated hazard map should be avoided.

As a replacement, a so called “hazard interaction map” sums up the number of identified interacting hazards per region (again in five classes) aiming at an indication of the existing additional cumulative effects of hazard interactions in space and time. This means, that a certain region in a higher class of IV or V indicates a big amount and consequently a greater probability and magnitude of consequences of hazard interactions. This analysis could be integrated in any decision about toleration or altering risks in this region.

5.2 Development of the hazard cluster map

Aside the so far described steps, which aimed at the NUTS3 level, the analysis of hazard interactions can be used for another purpose on an over-regional level, which aims at the existing geographical and normative regions in Europe and is in that way relevant for the policy recommendations at macro and meso level.

Based on the identified hazard interaction map, which shows hazard interactions for each NUTS3 level, the main hazard clusters on an over-regional level can be identified by means of a cross-checking with existing geographical and political regions in Europe.

Main clusters, which could be the basis for special policy recommendations and spatial planning response are:

- Coastal areas, threatened by storm surges/winter storms and floods (mainly in north-western Europe)
- Alpine-areas, threatened by avalanches/landslides, floods
- Mediterranean areas, threatened by forest fires and droughts
- River valleys, threatened by river floods and often technological hazards due to the given concentrations of infrastructure
- Areas that are located above tectonic active zones, threatened by volcanic eruptions and earthquakes, tsunamis and landslides
- "Pentagon Area" (cluster of technological hazards), Interreg Regions.

Some of these main clusters are shown in chapter 6.2 and are integrated in the so-called "Hazard cluster" map. Especially the cross-checking of the spatial patterns of the NUTS3 hazard interaction with existing European regions (e. g. Interreg regions) as well as spatial typologies, developed by other ESPON projects, offers a future possibility to coordinate the work of the ESPON Hazards project with the results from other ESPON projects.

6 Spatial Patterns of Hazards in Europe

Spatial patterns of hazards were studied by combining individual hazards on NUTS3 level. The hazard interaction map is based on real physical processes between hazards as described in Chapter 5. In addition to the development of the overall hazards interaction map, several hazard combinations were studied on European scale, and the distribution of selected hazard types was compared with spatial patterns, e.g. the "Pentagon Area" developed by the ESPON 1.1.1 project "Potentials of Polycentric Development in Europe" (http://www.espon.lu/) or Interreg IIIB regions.

6.1 Hazard interactions map

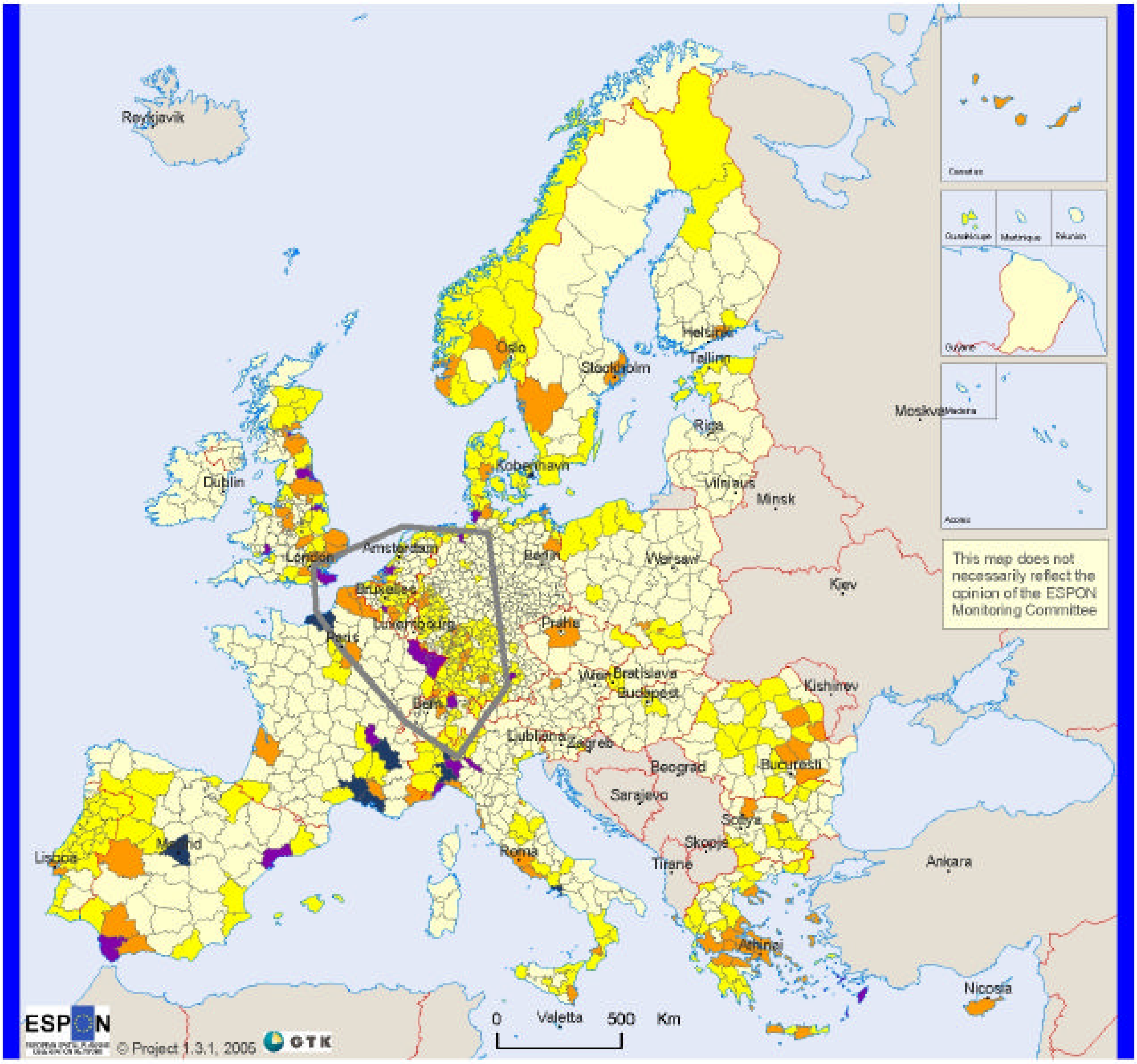
The hazard interactions map is based on the calculation method described in Chapter 5. Hazard interactions were only considered when the hazard intensities in a certain region were above average (hazard intensity classes IV and V, see chapter 2). Each individual hazard was reclassified for the interaction map as follows:

- 1 = hazard intensity higher than average (class IV or V)
- 0 = hazard intensity less or equal to average (class I to III)

Only selected combinations of hazards have physical influence to each other. For example, earthquakes can lead to landslides, but snow avalanches cannot cause forest fires. The important combinations are reported in Chapter 5, Table 34. Altogether 59 hazard combinations were studied for all NUTS3 areas. Eight of these physically possible combinations did not occur in any European NUTS3 region. For example, the combination of high volcanic eruption risk and high risk for large river floods was not identified for any region.

The most common hazard combination was major river floods – landslides: hazard intensity of these two hazards was high in 146 European NUTS3 areas (Map 24). Other common hazard combinations include: winter storms – storm surges (103 NUTS3 areas); hazards from chemical production plants – hazards from nuclear power plants (89 NUTS3 areas); droughts – forest fires (74 NUTS3 areas); storm surges – landslides (52 NUTS3 areas); storm surges – hazards from nuclear power plants (41 NUTS3 areas); earthquakes – landslides (33 NUTS3 areas); and tsunamis - landslides (33 NUTS3 areas).

Storm surges and large river floods and can potentially lead to problems of power production in nuclear power plants if the intake of clean cooling water is flooded (Mai *et al.*, 2002). This nearly occured during the winter storm in the nuclear power plant in Loviisa, Finland (STUK, 2005). A potentially elevated hazard combination of floods and nuclear power plants is found in 105 NUTS3 areas.



Number of hazard combinations

- 0
- 1 - 2
- 3 - 5
- 6 - 7
- 8 - 11
- Pentagon area
- Non ESPON space

Origin of the data: © EuroGeographics Association for the administrative boundaries
Source: ESPON Data Base

This hazard interaction map shows the total of all the 15 hazard indicators with intensity value 4 (high hazard) and 5 (very high hazard).

Map 23. Hazard interactions map

6.2 Hazard clusters

The six possible clusters discussed in Chapter 5 were compared with the hazard interactions maps. Certain patterns of hazards and European regions could be identified, for example coastal areas in north western Europe are affected by winter storms and storm surges, see map 26.

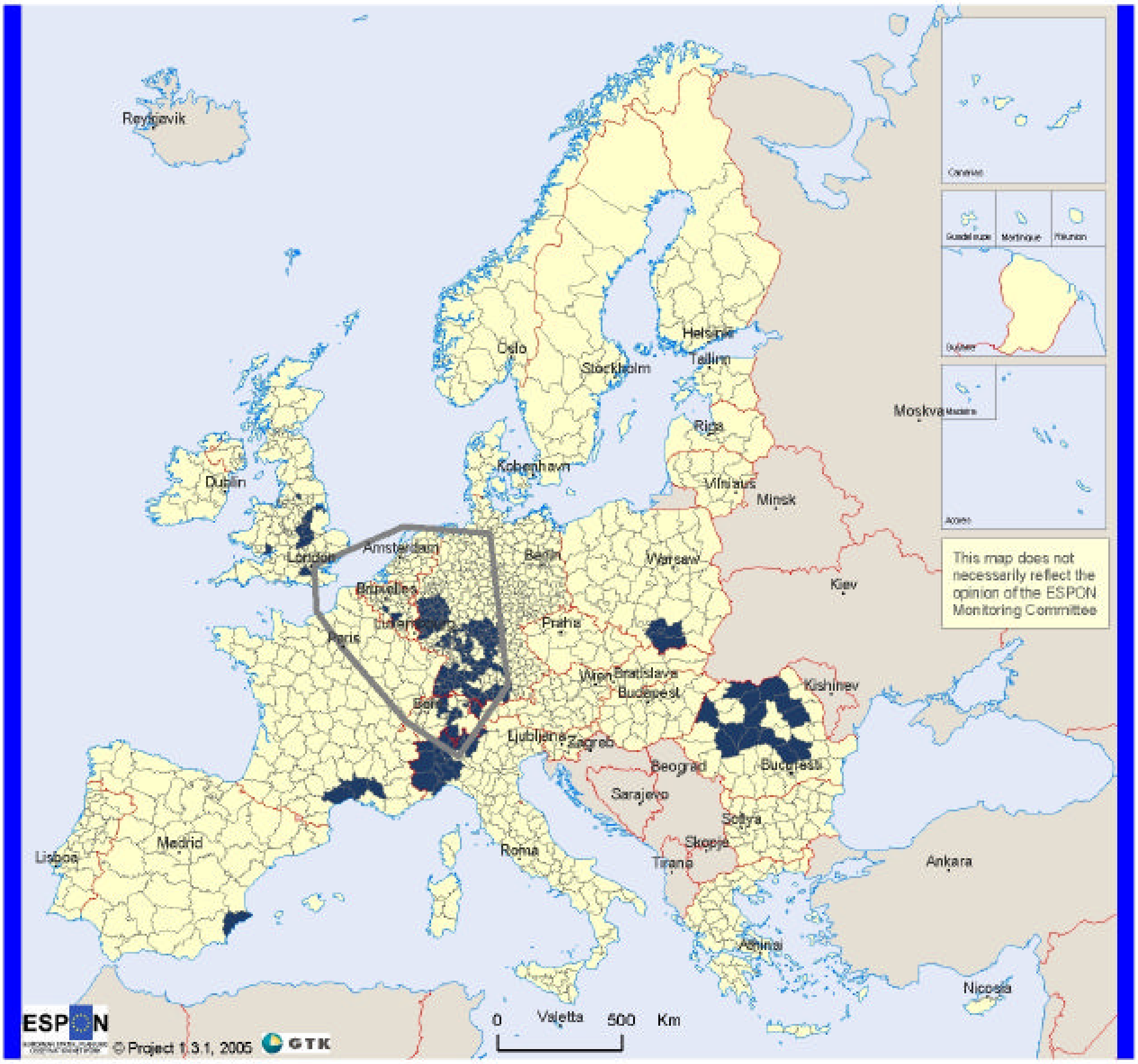
Alpine areas were expected to be threatened by landslides, avalanches and floods. Combination of floods and landslides was common in western Alpine region, but similar combinations are found also in many regions in the Schwarzwald area, in the Ardennes, in the river Rhône Valley between the Cevennes and the French Alps, as well as in the Carpathian Mountains in Romania. The majority of the flood-landslide combinations (107 out of 146) were located inside the "Pentagon Area". Avalanches are typical for the Alpine region, but they were not combined with landslides or floods, as single spot data are difficult to combine on NUTS3 level maps.

Mediterranean areas are classified as moderate to very high (III – V) in forest fire maps. The combination of drought potential and forest fire was most common in Portugal where 22 NUTS3 regions out of 30 have this kind of hazard combination. Also in Spain, Greece and Cyprus the combination of droughts and forest fires is commonly found.

It is assumed that river valleys can be threatened by floods and combined technological hazards. Many of the major European river basins have elevated flood hazard intensities (see chapter 2.1.5). The combination of a high flood hazard and hazards from chemical production plants was identified in 41 NUTS3 regions. These regions are located in the western part of the river Po Valley in Italy and in Germany around some big industrial areas near Düsseldorf, Stuttgart and München. More of these hazard combinations can be found around Northamptonshire and some other industrial areas in the United Kingdom and in Belgium (south of Brussels near the City of Namur). Elevated flood hazard intensity combined with hazards from oil production was found only in five areas in France and Italy. Elevated flood and nuclear power plant hazards were combined in 105 NUTS3 areas in France, Italy, Germany, Belgium and the United Kingdom.

Tectonically active zones could have a combination of volcanic eruption hazards. However, the combination of volcanic eruption hazards and earthquakes was identified only for two NUTS3 regions: The Dodecanese islands in Greece and Guadeloupe island (overseas territories).

The "Pentagon Area" shows a strong cluster of technological hazards, as e.g. more than 50% of the regions that have more chemical production plants than average (total 215 NUTS3 areas) are found here. The largest number of regions with a higher density of chemical plants than average outside pentagon is found in the United Kingdom. The rest of the areas of dense chemical production are scattered all over Europe.



Flood - landslide interaction

- Flood - landslide interaction
- Pentagon area
- Non ESPON space

Origin of the data: © EuroGeographics Association for the administrative boundaries
Large flood areas © Dartmouth Flood Observatory
Flood areas © ESA - Earth observation - Earth online
Rhine Atlas 2001 IKRS-CIPR-ICBR

Source: ESPON Data Base

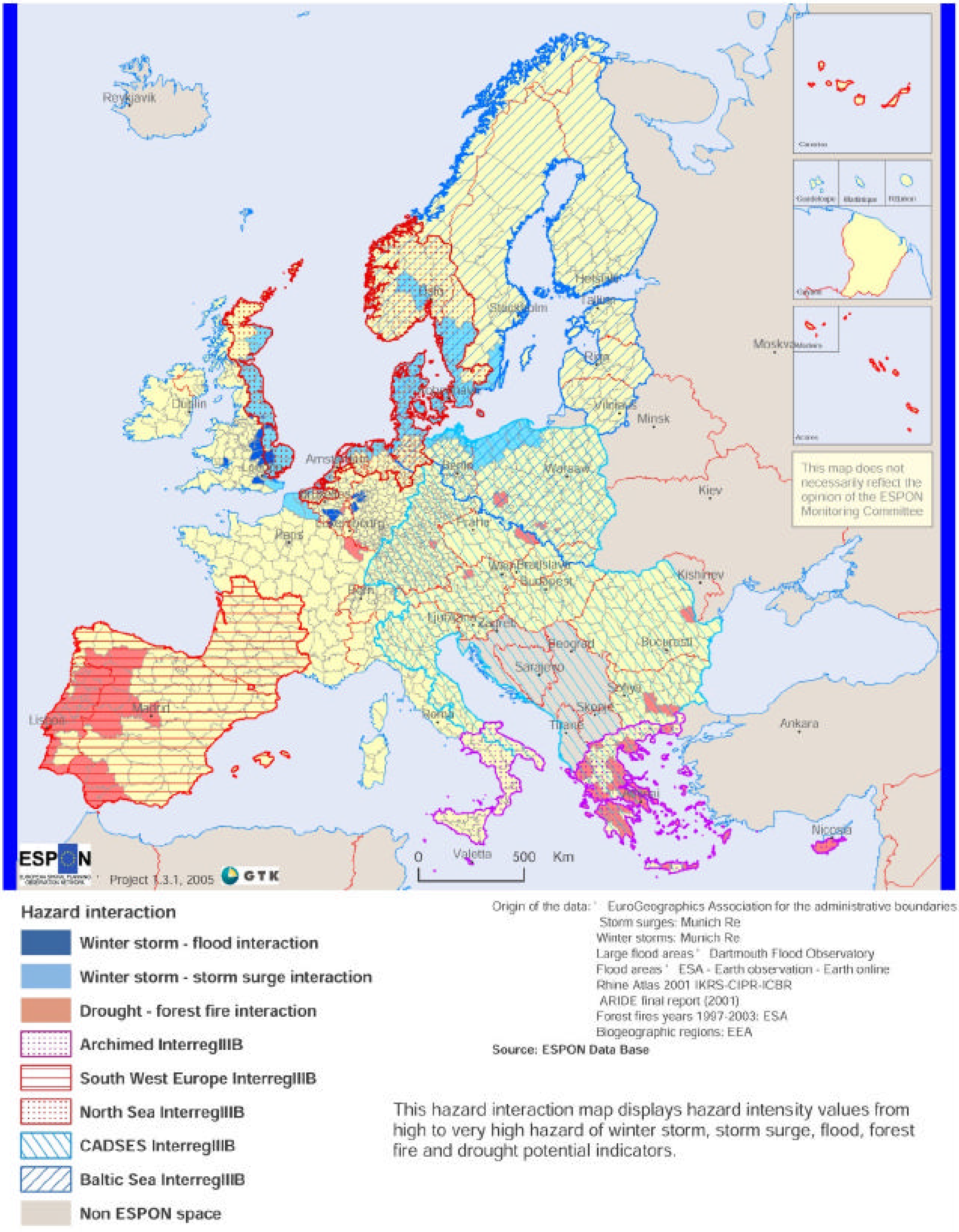
This hazard interaction map displays the hazard intensity values from high to very high hazard of both floods and landslides.

Map 24. Flood and landslide interaction map

6.3 Hazard patterns and clusters in Interreg regions

Several Interreg IIIB regions (for more information on the Interreg regions, please see http://europa.eu.int/comm/regional_policy/interreg3/abc/voletb_en.htm) show correlations with certain hazard patterns. For example, the North Western Europe Region has an elevated chemical plant hazard. The South West Europe Region has a strong accumulation of forest fires and droughts, meanwhile the Western Mediterranean Region and the Archimed Region have elevated forest fire and tsunami hazards. The entire North Sea and parts of the Baltic Sea Regions have a strong to elevated winter storm hazard.

The hazard interaction maps were also compared with the existing Interreg IIIB regions. Some of the Interreg IIIB regions show a strong correlation with certain hazard interactions. The North Sea Region is characterized by winter storm and storm surge hazards, continuing into to the southern part of the Baltic Sea Region. The combination of earthquakes and landslides is elevated in the southern part of the Interreg IIIB CADSES Region (Central, Adriatic Danubian and South-East Europe). The combination of precipitation deficit as a drought indication and forest fires are found in the Interreg IIIB Regions South West Europe, ARCHIMED and CADSES, as shown in Map 25.



Map 25. Hazard interactions in selected Interreg IIIB regions

7 Future Trends of Hazards and Vulnerability

7.1 Climate change

The Climate change concept has been given different meanings. According to the Intergovernmental Panel on Climate Change IPCC (2001a) *climate change* refers to any change in climate over time, whether due to natural variability or as a result of human activity. However, the first article of the UN Framework Convention on Climate Change states that “"*Climate change*" *means a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods*.” Many external factors force climate change and can be both natural and anthropogenic. According to IPCC, the warming over the last 100 years is very unlikely to be attributed to internal variability only, and reconstructed 1000-years climate data indicate that this warming is rapid and unlikely to be entirely natural in origin. Most of the observed warming over the last 50 years can be identified as attributed to anthropogenic greenhouse gases (Jones and Mann, 2004; Moberg *et al*., 2005).

The human dependence on fossil fuels as energy sources causes continued emissions of greenhouse gases that alter the atmospheric composition and thus the current warming is expected to continue.

7.2 Climate variability and extreme weather events

Changes in external conditions, such as the ongoing increase in carbon dioxide and other so-called greenhouse gases, may affect not only the mean state but also the variability of climate. Changes in extremes are affected by both. The response of simulated time-mean climate to increasing greenhouse gases has been studied extensively and the changes in mean temperature and precipitation tend to be addressed in all papers. Model-simulated changes in climate variability have been studied less comprehensively. There is now a trend towards an increased interest in climate variability and especially the occurrence of extremes.

The IPCC (2001a) has defined an *extreme weather event* as an event that is rare within its statistical reference distribution at a particular place. Definitions of ‘rare’ vary, but an extreme weather event would normally be as rare as or rarer than the 10th or 90th percentile. By definition, the characteristics of what is called *extreme weather* may vary from place to place. An *extreme climate event* is an average of a number of weather events over a certain period of time, an average that in itself is an extreme (e.g. rainfall over a season.)

Figure 8 provides an overview of the main links between climate change and natural hazards. The links are both direct, e.g. through an increase in extreme precipitation, and indirect as climate change may amplify the effects of other disastrous events.

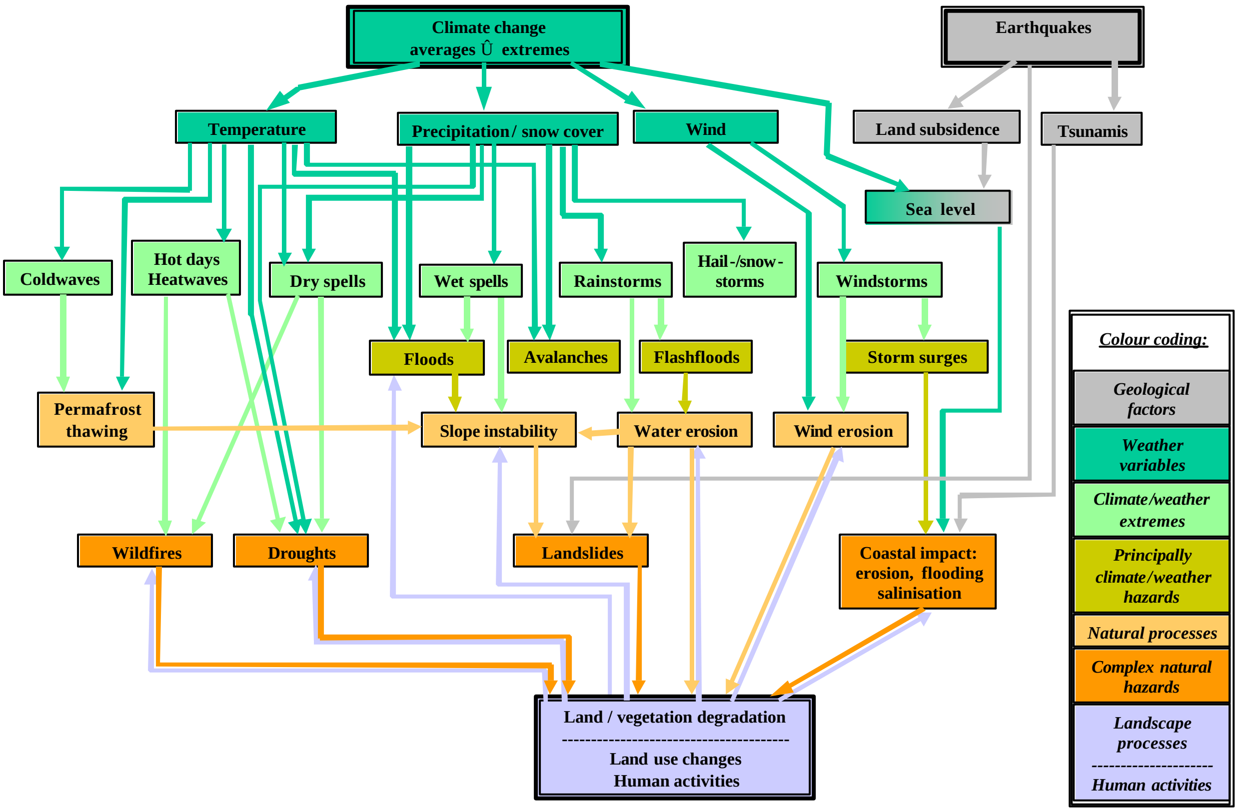


Figure 8: Multidisciplinary links between climate change and natural disasters. All natural hazards can potentially trigger technological hazards, either because of accidents or inadequate preventive measures. Modified after Dooge (1993, p 19).

7.3 Climate modelling and future climate

Complex physically-based climate models are needed to project future climate. Although the understanding of climate processes and their incorporation in climate models have improved, they cannot yet simulate all aspects of climate. Uncertainties are particularly associated with cloud and their interaction with radiation and aerosols. Confidence in the ability of these models to satisfactorily produce projections of future climate has nevertheless increased substantially in recent years (IPCC, 2001a).

Human influence will continue to alter the atmospheric composition and a number of future climate scenarios have been based upon emission scenarios from the IPCC Special Report on Emission Scenarios, SRES (Nakicenovic *et al.*, 2000). The SRES emission scenarios show a continued increase in radiative forcing through the 21st century. Global average temperature and sea level are projected to rise and with a much larger rate than observed during the 20th century. Global model simulations show a more rapid warming of land areas than the global average, which is projected from 1.4 to 5.8 degrees between 1990 and 2100. Recent results (Stainforth *et al.*, 2005) from a large ensemble of climate change simulations suggest that the *climate sensitivity to a greenhouse doubling* could be even larger, in the worst case up to about 11 °C. Global average water vapour concentration and precipitation are projected to increase and larger year-to-year variations in precipitation over areas where mean precipitation is expected to increase. Primarily due to thermal expansion and loss of mass from glaciers and ice caps the global mean sea level is projected to rise by 0.09-0.88 metres between 1990 and 2100.

The various global climate models produce consistent results with respect to the globally averaged future temperature (albeit with some variations, hence the range 1.4-5.8 °C). On the regional level, there is still a large variability between different models that are used for input (boundary conditions) to the regional climate simulations used in this study. Figure 9 illustrates this point using results from the SRES/A2-based climate change calculations using two different driving global models. Both runs driven by the HadAM3H (Hulme *et al.*, 2003) and the ECHAM4/OPYC3 (Roeckner *et al.*, 1999) global climate models are presented. Especially in the winter half of the year the GCM simulations differ over Europe. The ECHAM4/OPYC3 simulates a much stronger north-south pressure gradient over northern Europe than in the HadAM3H runs, see Figure 9. This difference leads to stronger westerlies in northern Europe in the RCAO-E experiments and thus to warmer and wetter conditions in the north.

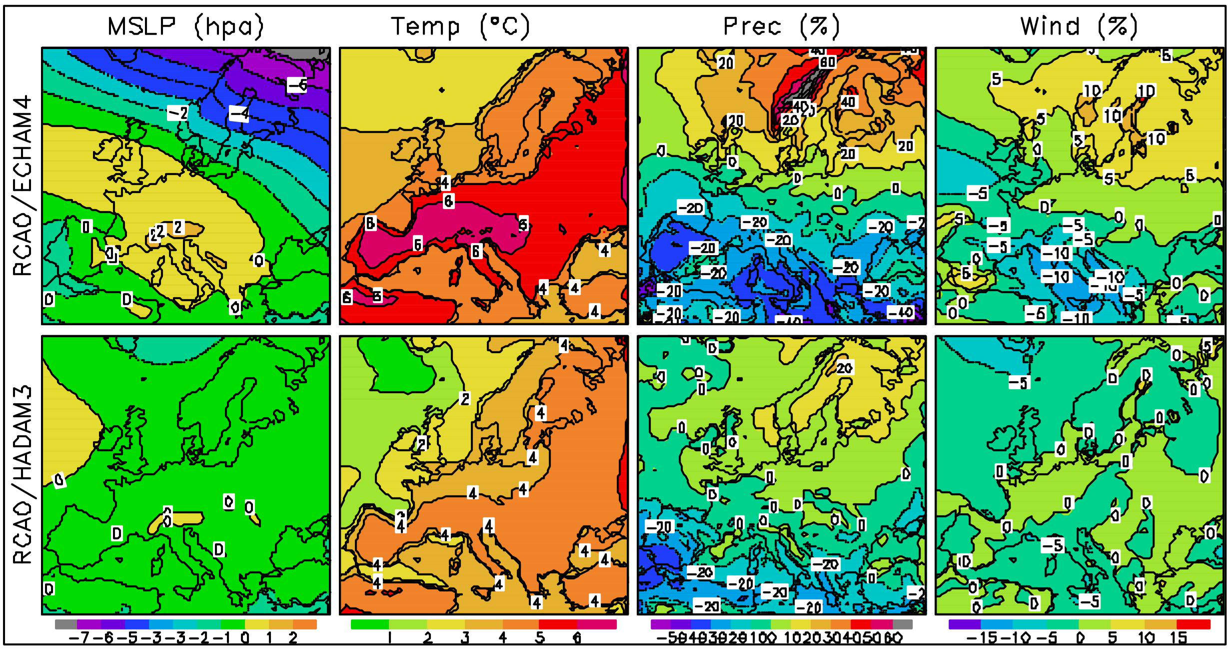


Figure 9: Changes in annual mean sea level pressure, surface air temperature, precipitation and mean wind speed (Rossby Center)

The figure above shows the modelled changes in annual mean sea level pressure, surface air temperature, precipitation and mean wind speed from 1961-1990 to 2071-2100 for the SRES A2 forcing scenario. The first row shows results for the ECHAM4-driven and the second for the HadAM3H-driven simulation using the RCAO regional climate model (Räisänen *et al.*, 2003).

Climate models project changes in daily, seasonal, inter-annual, and decadal variability. They also project changes in frequency, intensity, and duration of extreme events. More hot days, heat waves, heavy precipitation events, and fewer cold days are examples. There is currently insufficient information about small-scale extreme weather events such as thunderstorms, hail, and lightning.

7.4 Uncertainty of climate change impact

Climate change has been a major topic in scientific and political considerations for several decades. There is now scientific consensus that the main driving force behind this climatic change is the anthropogenic emission of greenhouse gases, with additional influence from anthropogenic aerosols, volcanoes, variation in solar output, as well as from internal variability within the climatic system (IPCC, 2001a). For global mean temperature it has been possible to obtain an estimate of the relative contribution of these different factors (Stott *et al.*, 2001; IPCC, 2001a; Tett *et al.*, 2002). It is however on the regional scale, the question of climatic change appears more tangible, especially when considering extreme events, compared to the more abstract and difficult to interpret world-wide development of average conditions. There is an often repeated statement that extreme events may at least become more frequent (e.g. EEA, 2004). This is straightforward when it comes to temperature extremes, where the link to the average temperature is fairly well established (IPCC, 2001a), even though the relationship between changes in the mean and changes in extremes probably is non-linear (Kjellström *et al*., 2005). For other variables, like wind or precipitation, the link between mean and extremes are more complex. Firstly, the link between an increase in mean temperature and the mean in the other variable may be non-linear. Secondly, the link between a change in the mean and in extremes of the other variable is likely even more complex. Nevertheless, McBean (2002) attempts an outlook to possible extreme weather phenomena. He further points out that the probability of extreme events raises rapidly even in the mid-latitudes and therewith in Europe. However, especially for the case of Europe McCarthy *et al.* (2001) conclude that during the 20th century only variance of the magnitude of extreme events, but no clear trend can be registered.

Another approach is taken by the EEA (2004), which draws on numerous studies of a diverse set of climate change impact indicators. In doing so it provides a review of various possible climate impacts that already seem to emerge. However, many of these climatic indicators may also be sensitive to other environmental and societal changes that are taking place in parallel. To isolate the influence on climatic change from other environmental and societal influences, meteorological observations are the best (only stringent) source of information. But due to a lack of high quality long-term data (Easterling *et al.,* 2000), major difficulties remain regarding variations and trends of climatic extremes. However, with the initiation of several European and international projects there is now a growing body of such high-quality long-term datasets with high enough time-resolution to begin analysing climatic extremes. Examples of such projects are WASA (1998), ADVICE (Jones *et al.,* 1999), IMPROVE (Camuffo and Jones, 2003), and the still ongoing EMULATE project (see http://www.cru.uea.ac.uk/projects/emulate). In addition, with particular relevance to infrequently occurring climatic extremes having catastrophic consequences (high-impact, low probability regional events) important information are being gained through historical climatology research, where Europe could be well positioned because of rich data sources in various archives (Brázdil *et al.,* 2005).

With this still limited but slowly growing body of data it is now possible to begin the assessment of recent extreme events. For example, the 2003 heat wave over southern Europe was identified as a unique event in a historic perspective and more resembling projected future conditions (Beniston, 2004; Schär *et al.,* 2004; Stott *et al.,* 2004). Windstorms and associated hazards, on the other hand, are problematic. The WASA project concludes (WASA, 1998) that long-term wind observations are fraught with various problems that make them less trustworthy, and many observational analyses (e.g. WASA, 1998; Alexandersson *et al.,* 2000; Bärring and von Storch, 2004) conclude that up to now there is no long-term change in the frequency of windstorms. However, recent results point toward that the storm frequency may increase in the future (Leckebusch and Ulbrich, 2004).

7.5 Climate change and hazards

Natural hazards are one major pathway over which climatic extremes may become manifest. Shift in mean values of certain parameters are rarely at all perceivable. Especially in industrialised countries impacts such as the change of general climatic parameters (temperature, precipitation and other) or even certain extremes are rarely experienced directly. Here technological means exist in combination with financial resources to counteract less favourable climatic conditions, e.g. through irrigation in dry areas, space heating and cooling facilities, or flood risk management, protective seawalls in coastal areas etc. to reduce losses.

Societal welfare is rarely directly impacted by regular weather patterns, as being the direct reproduction of the climate. However, the touristic implication of snow shortage on glacier retreat in the Alps (Abegg, 1996) may be seen as one counter example. The climate change impact will first manifest itself through extreme events, which if exceeding certain thresholds can be referred to as natural hazards.

With the possible exception of the July 2003 heat wave in Europe, it has not yet been possible to attribute either single climate extreme events or perceived trends in climate extremes to an ongoing climate change. Instead, concurrent changes to land use and societal sensitivity usually complicate, or even dominate the picture. For example, the increase of hurricane damages in the south-eastern United States has been shown to be an effect of increased societal vulnerability driven by changing geographical distribution of built-up areas, increasing exposure and resulting in a dramatic increase of insured losses (Pielke and Landsea, 1998). Similarly, increased forest damage due to windstorms during recent decades cannot be attributed to a change in storm frequency (Nilsson *et al.,* 2004; Stjernquist *et al.,* 2005). This entanglement of climate variability and societal change is not a new phenomenon, for example with respect to wind erosion on northern European agricultural lands (Bärring *et al.,* 2003; EU Publications Office, 2003).

Probably, the most important factor for flood damage is the development of areas exposed to the risk of flooding. And this risk is not constant over time. For example, river regulation may accelerate and concentrate flood waves. There are several examples in Europe of settlements and industrial development on flood prone areas against better knowledge. Reasons for this state of affair may be heavy pressure on land, spatial planning deficiencies, short public memory, etc.

The table below outlines the natural hazards capable of causing catastrophic societal impact, the main underlying climatic factor that affect the hazard intensity. Also other factors are listed that may contribute to a change in the overall risk of a catastrophic impact.

Table 35: Natural hazards, underlying climatic factors and other risk related factors

Natural hazard	Climatic factor	Other factors*
Storm surges (coastal flooding)	Low pressure Windstorm Sea-level rise	Geographical distribution Societal sensitivity
Flooding (inundation)	Excessive rainfall for an extended period, often in combination with snowmelt	Geographical distribution Land-use Societal sensitivity
Flash floods Heavy rainfall	Convective precipitation	Geographical distribution Land-use Societal sensitivity
Hailstorms	Convective precipitation	Societal sensitivity Land use
Landslides	Saturated soils (wet spells/heavy precipitation) Thawing of mountain permafrost	Geographical distribution
Avalanches	Snowpack structure temperature development / precipitation	Geographical distribution
Drought Water scarcity	Precipitation Temperature/evaporation	Geographical distribution Societal sensitivity Land use
Excessively hot day Heat wave	Temperature	Societal sensitivity
Excessively cold day Cold wave	Temperature	Societal sensitivity
Forest fires	Precipitation Temperature/evaporation Wind	Land use

* The terms are employed here in a tentative instrumental sense as follows:

"Societal sensitivity" is the sensitivity of the society, at any specific place, without fundamentally changing the land-use or human activities at that place (but including general societal development, for example leading to a society successively more sensitive to e.g. disruptions of power supply or transportation). Thus, it is related to the coping capacity of the society.

"Geographical distribution" denotes development of new activities at a place (e.g. constructions accepted at a flood-plain, along a low lying coast or in a steep slope), i.e. closely related to the exposure.

"Land use" is the changes to land use practices without fundamentally changing the land use (e.g. using more water-demanding crop varieties in agriculture, or introducing large clear cut forestry), thus being closely related to the coping capacity of the agricultural and forest production.

Technological hazards are considered to be only indirectly related to climate change. However, in multi-hazard cases technological hazards can be triggered by extreme natural events (e.g. Munich Reinsurance Company, 2004a). Little work has been done on the systemisation of the relationship between climate change and risk from natural and technological hazards (Bloetzer *et al.*, 1998; Meier, 1998). A few examples can serve as illustrations of possible links. During the Elbe Flood in 2002 several tons of hazardous substances such as mineral oil from private dwellings, chlorine compounds from chemical plants and dioxins were exposed to flood waters. In general considerable increase of damage can be attributed to the implication of technological issues (e.g. hazardous substances) in natural hazards. Egli (2002, p. 29) reported that alone the presence of heating oil being in flood waters made up to 70% of damage to housing structures and facilities.

7.6 Climate impact indicators - definitions

A future climate change is assumed to affect both the frequency and intensity of natural hazards and thus influence discussions on risk management of all climate-induced natural hazards. A common way to quantify the climatic control of natural hazards is to analyse indices of climate extremes. These indices are constructed as to measure the climatic factor underlying a natural hazard. There exist a large number of different but related indices of climatic extremes in previously published analyses (e.g. Frich *et al.,* 2002; Sánchez *et al.*, 2004) and used for the European Climate Assessments (Klein Tank *et al*., 2002), as well as in several current European projects (e.g. MICE (http://www.cru.uea.ac.uk/projects/mice) and STARDEX http://www.cru.uea.ac.uk/projects/stardex).

Usually, it is not possible to designate one index as better or more appropriate than another index without a detailed specification of the regional context and impact sector. Indices that measure related aspects of a natural hazard do share a large proportion of variance (see below). The detailed specification of any particular index is not critical for a general analysis of variations in the intensity of a natural hazard across an extended region, such as a large portion of Europe where similar natural hazards can be a result of slightly different climatic extreme conditions.

For this work, regional climate model data for calculating the climate extreme indices are taken from the recently published Prudence database (http://prudence.dmi.dk). 13 different regional climate models were used, cf. Christensen et al. (2006) or the web site for further details regarding the models and the experimental setup for the Prudence project). Only model runs of the SRES A2 scenario (Nakicenovic *et al.*, 2000) were used.

Each model simulation of future conditions can be regarded as a *"plausible, consistent, possible but not necessarily probable",* PCPnP (von Storch, 2004) scenario for a future climate. This concept is used to underline that the output from any model run of future climates is just one out of many (innumerable) possible outputs. Forming ensemble statistics across several model runs only reduces one type of uncertainty. Still, it is important to stress that the results presented here are scenarios for the period 2070-2100 that are based on the SRES A2 future greenhouse gas concentrations, and given one particular global coupled climate model (the UK Meteorological Office, Hadley Centre HadCM3/HadAM3H model system, Hulme *et al.,* 2003). The regional climate models all have the similar grid resolution, in this case about 50x50km or 2500km^2.

The focus lies on indices of climatic extremes related to temperature and precipitation, i.e. on the climatic factors behind several of the natural hazards listed in the table above. The indices defined in table 36 cover both one-day extremes and longer spells. Two hot indices and two cold indices are used together with two wet indices and one drought index. The one-day thermal indices *Cold day* and *Hot day* provides basic information of the severity of temperature extremes of a region and the *Coldwave* and *Heatwave,* that both are defined on the average temperature during seven days quantifies more persistent extreme conditions. Both the one-day and seven-day indices are related to the human thermal comfort and wellbeing, and to the energy consumption for space heating and space cooling. The precipitation indices are analogous. The *Heavy precipitation* index quantifies one-day precipitation in each gridbox. It is related to flashfloods, soil erosion and slope stability. It is however worth pointing out that heavy precipitation occurs as highly localised showers affecting an area much smaller than a gridbox of 50x50 km^2. The seven-day *wet spell* index is relevant for flooding (inundation) where persistent precipitation first saturates the infiltration capacity of the soil and wetlands. The drought index, *dry spell*, is constructed slightly different. It is based on the longest dry period.

Table 36: Summary of the indices of climatic extremes used in this study. The unit of each index is relevant only before the classification into five steps for the ESPON database. In the rightmost column the figure numbers refer to the figures at the end of this chapter.

Index	Explanation	Natural hazards	Figure
Hot day (°C)	99th percentile of daily temperature	Excessively hot days	A1 (left)
Heat wave (°C)	90th percentile of annual maximum 7-day average temperature	Heat wave Forest fire	A1 (right)
Cold day (°C)	1st percentile of daily temperature	Excessively cold days	A2 (left)
Cold wave (°C)	10th percentile of annual minimum 7-day mean temperature	Cold wave	A2 (right)
Heavy precipitation (mm/day)	99th percentile of daily total precipitation amount for wet days (R>0.5 mm)	Heavy precipitation Flash floods Landslides	A3 (left)
Wet spell (mm/7days)	90th percentile of annual maximum precipitation accumulated over 7 days	Flooding (inundation)	A3 (right)
Dry spell (number of days)	90th percentile of length of the annually longest dry spell (R<0.5 mm)	Drought Water scarcity Forest fire	A4

Temperature conditions are represented by four indices. Two indices concern extreme temperature conditions during single days (*Hot day* and *Cold day*) and are calculated as the 99th percentile and 1st percentile of the daily mean temperature. That is, this temperature threshold is exceeded (for the 99th percentile in positive direction for hot days, and for the 1st percentile in negative direction for cold days) about 3-4 days per year. For even more extreme conditions, the change scales in an approximate linear way. By going further out into the extreme tails of the temperature distribution the threshold becomes more and more susceptible to plain random variations and systematic biases in the models. Kjellström *et al.* (2005) validated a range of temperature percentiles of the models experiments used herein.

The other two temperature indices are designed to quantify heat waves and cold waves. They are calculated in two steps; firstly, the maximum (minimum) 7-day average temperature is calculated for each year. Secondly, the 90th percentile (10th percentile) of these annual maxima (minima) is calculated. In this way, the *Heat wave* (*Cold wave*) index characterises events that can be expected to occur once every ten years.

Three indices cover the key aspects of precipitation extremes. *Dry spell* is the 90th percentile of the annually longest period with all days having precipitation below 0.5 mm. *Wet spell* is the 90th percentile of annual maximum precipitation total over any 7-day period. *Heavy precipitation* is the 99th percentile of wet days, where a wet day is defined as a day having at least 0.5 mm of precipitation.

In line with the overall ESPON Hazards project's methodology, the calculated index values were finally transformed into only five classes for inclusion in the ESPON Hazards database. This is done in by linearly dividing the interval spanned by the index, except for the *Heavy precipitation* index that is based on daily precipitation amount measured in millimetre. For this index, and following standard practice for precipitation amounts, logarithmic intervals were used to allow for comparison across widely different precipitation regimes (as well as changes across different regimes). In effect, this means that the scale is linear in the sense of percentages.

7.7 Climate impact indicators - conclusions

Climate change is about changes in mean values and the variability around them, as well as changes regarding extreme events. Around those issues are great uncertainties, mainly divided into:

- uncertainties regarding future emissions (based on the global societal development).
- uncertainties regarding the carbon cycle (how much of future emissions will stay in the atmosphere).
- uncertainties regarding the sensitivity of the climate system (global models give different results).
- uncertainties as to how this sensitivity of the global climate system will manifest itself on the regional scale.

These uncertainties are studied and will, by time, become better characterized and eventually smaller. Despite this there will always be a certain amount of uncertainty involved when studying future processes. The results presented here are all based on the SRES A2 scenario, thus ignoring the first two types of uncertainties. Furthermore, the different regional models (RCMs) were driven by the same global model, which means that also the third type of uncertainties is ignored. However, by using several different RCMs, the fourth type of uncertainty is substantially reduced. To take all the different types of uncertainty into account and for making probability studies, ensembles of scenarios are needed and that is the stage where climate research is heading (the EU 6th Framework Programme ENSEMBLES (http://www.ensembles-eu.org).

From Figure 11 it is clear that the two warm indices provide an almost identical picture. In both the *Hot Day* (Figure 11, left) and *Heatwave* (Figure 11, right) indices there is a clear shift in the south-north direction. Large parts of Europe will see a shift towards temperature extreme conditions that now occur mainly in the Mediterranean North Africa and the south-western Iberian Peninsula. In a similar way, the present day high extreme temperature climate of France, Germany and Poland will move northwards towards the British Isles, southern Scandinavia, and southern Finland. Large parts of Europe are projected to have a warming of 5-8°C during warm extremes. Least changes are projected for northern Scandinavia and northern Finland, where the warming could be limited to 2-3°C.

According to the RCM ensemble projection, large parts of western and continental Europe will experience a few days every year when the mean temperature reaches 35-40°C or even more. And on average there will be a 7-day heat wave once every 10 years when the average temperature reaches 35-40°C. When judging these numbers it is important to keep in mind that all the indices are based on the daily mean temperature, the daytime maximum temperature will be even higher.

Also the two cold indices (Figure 12), *Cold Day* (Figure 12, left) and *Coldwave* (Figure 12, right), follow each other very closely. Both indices show a warming of 0-2°C in the maritime and south-western regions of Europe, increasing towards the northeast and continental regions where the warming of the cold events may be as strong as 10-12°C. As could be expected, these two indices show the strongest change in the continental eastern regions where the dampening effect of the ocean is less dominant. Thus, for both indices the overall picture is a shift from southwest to northeast in the climatic zonation.

In practice this means that the present wintertime cold extreme climate becomes substantially milder, with the conditions of the SW Iberian peninsula moving into France and Italy, French winter conditions appear in Germany and Poland, as well as in large parts of Central Europe and all the way up to southern Scandinavia.

Also the two precipitation indices (Figure 13), the *Heavy Precipitation* index (Figure 13 left) and the *Wetspell* index (Figure 13 right), show a close agreement in the overall geographical distribution. Both indices clearly show the close relationship between precipitation and orography. High amounts are generally occurring on the upwind slopes when moist air from the sea is lifted above a mountain range. It is also important to point out that for the Heavy precipitation index, intended to pick up high-intensity downpours, the amounts given in the maps are averages for the whole grid-cell of ~2500 km^2, which typically is an area much larger than the size of a local intensive rainstorm. Consequently, the local rainfall amount within a gridcell may be much higher at the same time as other parts of the same gridcell receives no or only little precipitation. The overall picture is that, according to the model ensemble scenario all of Europe, except the southern part of the Iberian Peninsula will see an intensification of heavy precipitation and 7-day wet spells by some 10-30%. The southern part of the Iberian Peninsula will on the other hand experience less intensive precipitation events. These results are consistent with the analyses using a single RCM (Semmler & Jacob, 2004).

There is another drought index, which indicates a general increase in the persistence of long *dry spells*, with the exception of northern Scandinavia. In southern Europe this dry spell is of course centred during the dry summer season, but in northern Scandinavia the driest season often occur during spring. The Mediterranean coastal region, in particular the Iberian Peninsula, has today a long summer dry period that is projected to become even more extended. Large parts of southern Europe may see the summer drought extended by 1-2 months. In a single RCM study Christensen and Christensen (2004) find that the overall decrease in summertime precipitation largely follows our results and they also find that the heavy precipitation events increase in southern Europe. In northern Europe the extension is less pronounced, about 10-30 days. In northern Scandinavia the dry episodes may be shortened by a few days, but this is unlikely to have any significant impact.

Summing up:

- present wintertime cold extreme climate substantially milder
- large parts of Europe projected to have a 5-8°C warming during warm extremes
- on average a 7-day mean temperature of 35-40°C every 10^{th} year
- intensification of heavy precipitation and 7-day wet spells in most parts of Europe
- general increase in dry spells, except northern Scandinavia

7.8 Societal implications of natural hazards

Independently from the discussion about whether and why climate change takes place, statistics show a significant increase of the number of catastrophic events (Swiss Re, 2003) and the extent of damages (EEA, 2004; Munich Reinsurance Company, 2004b). Considering insured losses only, the number of disastrous events with more than 1 bn US$ loss rose from one single event prior to 1987 to 34 between 1990 and 2000 with continuing tendency thereafter (cf. Berz, 2003). He further emphasises that even those catastrophic events in the developed world only represent "grazing shots" compared to what also could have happened in the scope of the same events (e.g. Hurricane Andrew and the Earthquakes of California and Kobe in 1994 and 1995).

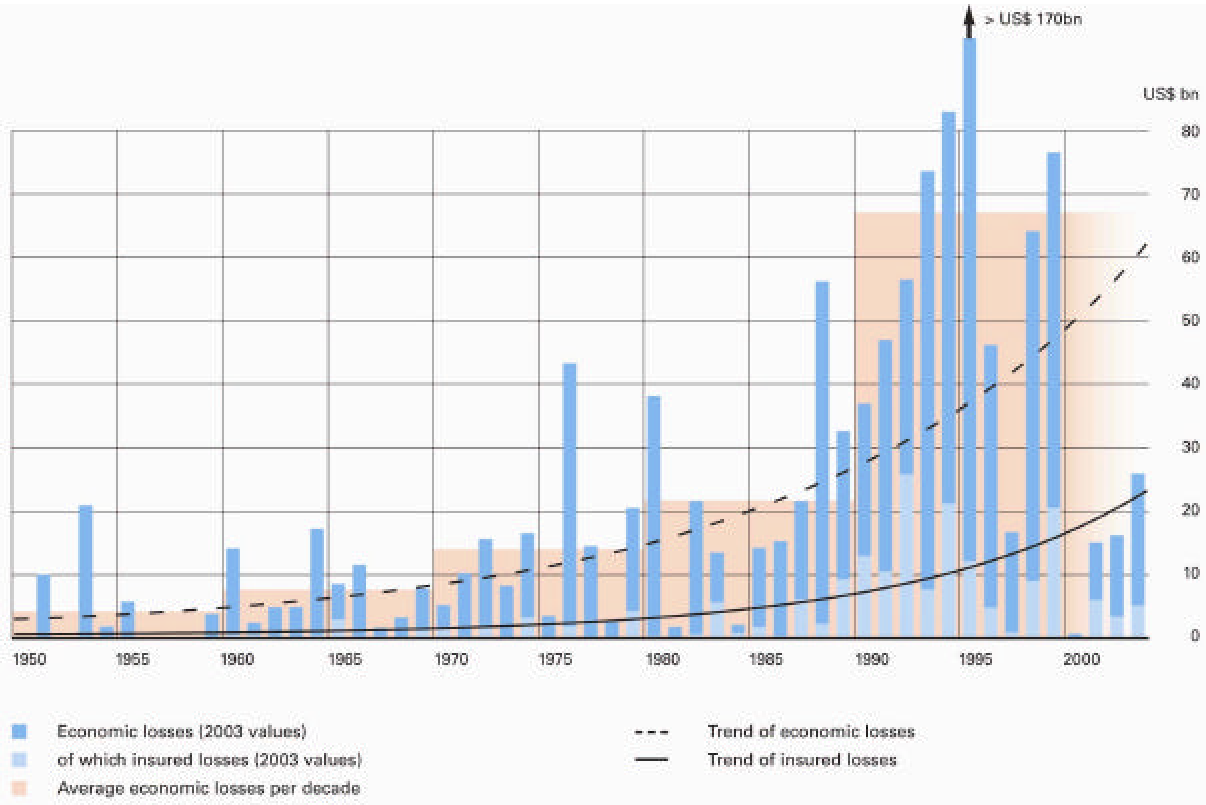


Figure 10: Global economic and insured losses with trends (Munich Re Reinsurance Company 2004b, p. 15)

Against this background the understanding of disasters as materialisation of risk is inevitable. Risk, as has been defined in the ESPON Hazards project is basically composed of two components (cf. e.g. Merz and Gocht, 2003; Molak, 1997): The natural and technological hazards, and the societal susceptibility to suffer harm (vulnerability) Damage in this sense applies to built structures, the environment and the economy in general as well as to human life. Corresponding to this understanding, the vivid discussion about risk mitigation (Plate, 2002; Weichselgartner and Obersteiner, 2002; Schanze, i.p. and other) claims for more emphasis to be laid on the reduction of vulnerability rather than to focus on the hazard side only.

There is an increasing demand for local impact assessments producing policy-relevant guidance. Research strategies on the impacts of climate change (including extreme events) have been reported for different sectors such as agriculture, water, biodiversity and coastal zones. The actual impact of climate change locally will be a product of multiple interacting systems. This calls for an *integrated assessment* (IA) – 'an interdisciplinary process that combines, interprets, and communicates knowledge from diverse scientific disciplines from the natural and social sciences to investigate and understand causal relationships within and between complicated systems' (IPCC, 2001b). A local to regional scale study was performed in East Anglia and North West England in the United Kingdom, the methodology was recently presented by Holman *et al*. (2004). Fundamental methodological issues reflect the difficulty of multi-sectoral modelling studies at local scales. There is no doubt however that the scientific community has made progress in integrated assessment methodologies.

Future highly sensitive areas, based on changes of vulnerability were not developed due to unavailability of data. This remains interesting, especially as part of hazard monitoring activities, see chapter 8.

7.9 Conclusions / Research needs

Independently from the question of whether observed variation/change of climatic extremes is within the natural variability or indeed reflecting a changing climate, natural and technological hazards caused or triggered by climatic extremes are a serious factor for societal development.

If, for the sake of the argument, it were possible to conclude that recent catastrophic natural hazard events were within the natural climatic variability, the implication would be that society is already today not fully prepared to cope with such events even without the additional strain introduced by a changing climate. If, on the other hand, it were possible to conclude the opposite, that the observed climate change (the increase in global/hemispheric temperature) has already begun to influence the frequency and intensity of climatic extremes underlying natural hazard events, then the society is facing the situation of successively becoming less prepared to natural hazards (and indirectly technological hazards) triggered by climatic extremes. The difference is that in the first case those responsible for taking preventive measures against climate extremes may act under the impression that they are adapting to a climate change, while they are in fact only responding to insufficient protection to present day 'normal climate variability'. The difference between responding to present-day climate under the perception that one is adapting to a future climate change is in fact substantial from a policy- and decision-maker point of view. If policy-makers are asking for public funding (and acceptance) for costly adaptations to a perceived climate change when the planned measures are in fact only handling deficiencies in adaptation to present day climate, it will probably be much more difficult to again to ask for support for adapting to a climate change that is at this future stage a real change. In either case, statistical summaries of annual losses due to extreme weather published by reinsurance companies unanimously confirm a trend towards increasing insured losses due to the impact of climatic extremes. The important issue lies in the awareness and perception of climate change by the decision-makers.

The uncertainty of projections are coupled with the widely agreed awareness that all action toward mitigation of climate change (e.g. Kyoto Protocol) in any case will take decades until climate can respond. Even in case of fast and concerted action uncertainty remains concerning the extent to which ongoing changes can really be attributed to human action and to which extent they are reversible. Many climate research initiatives world-wide are underway to answer the most urgent questions in this respect.

Nevertheless, climate research will not be able to answer all questions with respect to risk mitigation. Climate change has its implications first of all on the hazard side of risk. The two risk elements, hazard and vulnerability, are influenced by societal changes: the hazard by influencing physical patterns in source areas, along the hazard pathways and in receptor areas, and the vulnerability (the damage potential, exposure, coping capacity) by constantly changing distribution of values (incl. goods and people).

It is more and more accepted that a bigger part of a disaster is influenced by human activity on the vulnerability side of risk than on the hazard side (cf. Plate, 2003). Furthermore, the recognition that extreme events until now have been not significantly increasing in magnitude suggests that recent disasters in Europe and around the world is strongly related to increasing damage potential in receptor areas of hazards. Thus, activities aimed at reducing vulnerability seem to be the most promising direction to develop effective risk mitigation options. In terms of an integrated risk management, however, these must be combined with suitable (optimised) hazard related measures that take into account the range of future climate projections provided by climate models.

Preventive measures and instruments guided by sustainable long-term strategies of spatial development and legal prescriptions regulating the use of natural resources and hazardous substances can considerably contribute to robust risk mitigation options for a wide variety of uncertain futures. Examples are given by (Egli, 2002, e.g. pp. 19 and 30).

The fact that, for the time being, no clear prognosis can be given about the future development calls for robust and flexible approaches to mitigation of societal and environmental risks arising from the higher frequency of extreme events. New strategies leading to sustainable strategic options of risk management and applying robust but flexible physical measures are needed. Policy instruments embedded in an integrated risk management approach are required to meet the uncertain prognosis of climatic extremes and related natural hazards. The Decision Support Frame (DSF) developed by the Interreg IIIB project "Sea Level Changes Affecting the Spatial Development of the Baltic Sea Region" (SEAREG) fosters communication on climate change effects and its potential impacts to planners and decision makers (www.gtk.fi/slr).

In support of this multidisciplinary approaches (Schanze, 2002; i.p.) as well as planning and evaluation tools and comprehensive databases are needed. Hydrological tools describing the hazard must, for example, be complemented by tools delivering information about potential and real damage development. Damage functions for receptor areas in different contexts are far from being precise (Merz, 2004). Even less is known about environmental damage caused by natural hazards with technological implications. Also the considering of indirect and intangible societal damage underdeveloped. Furthermore, activities in the scope of risk management must undergo systematic evaluations using a comprehensive set of criteria ranging from effectiveness and efficiency considerations to societal and environmental side effects.

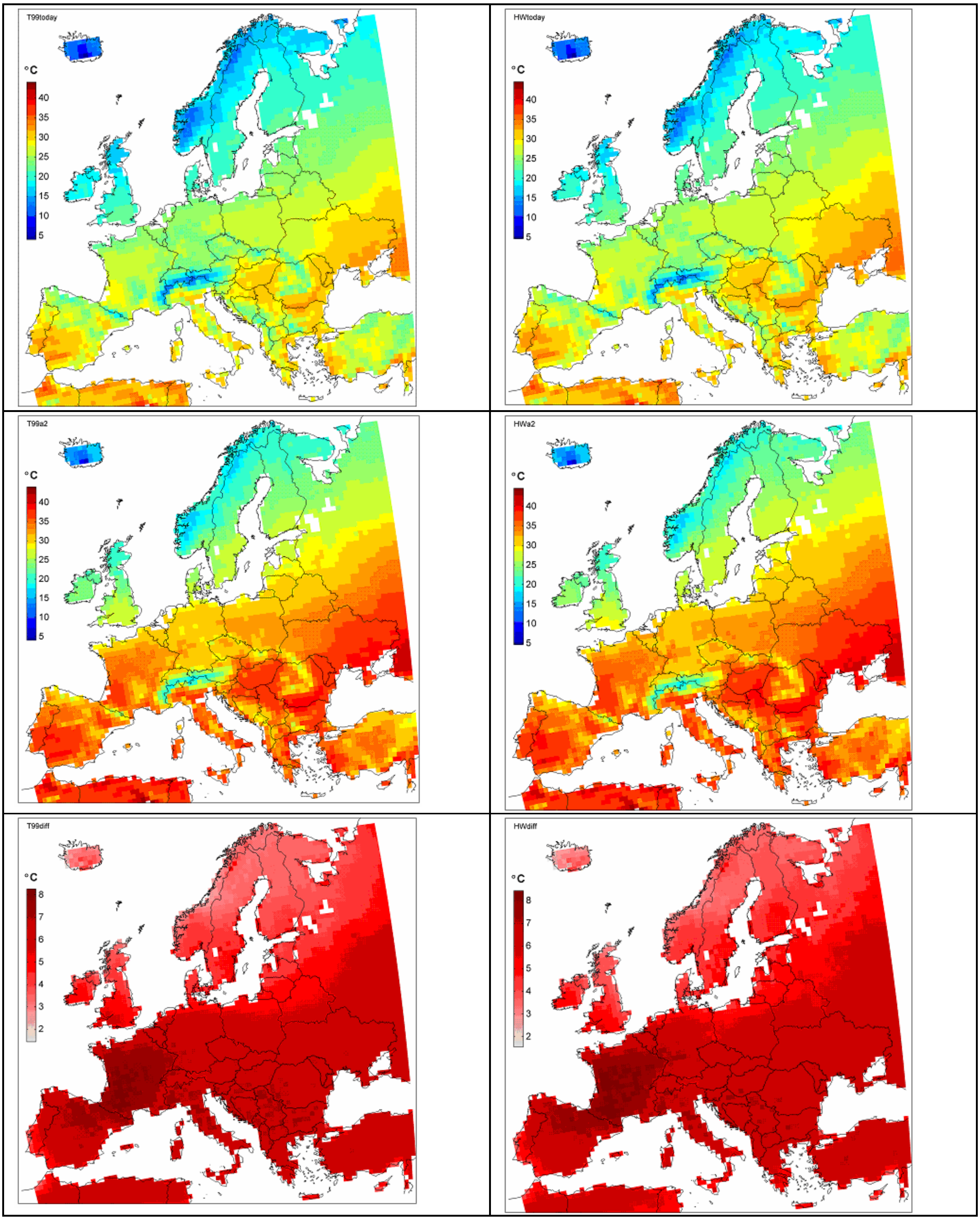


Figure 11: Summertime warm condition as estimated from an ensemble of regional climate models (Rossby Center)

The left column in Figure 11 is the 99th percentile of daily mean temperatures, and the right column is the 7-day heatwave index (cf. Table 36). Top row shows the present day (1961-1990) conditions, middle row shows the future (2070-2099) conditions for the SRES A2 greenhouse gas concentration scenario. The bottom row shows the climate change signal, that is, the difference future minus present day conditions.

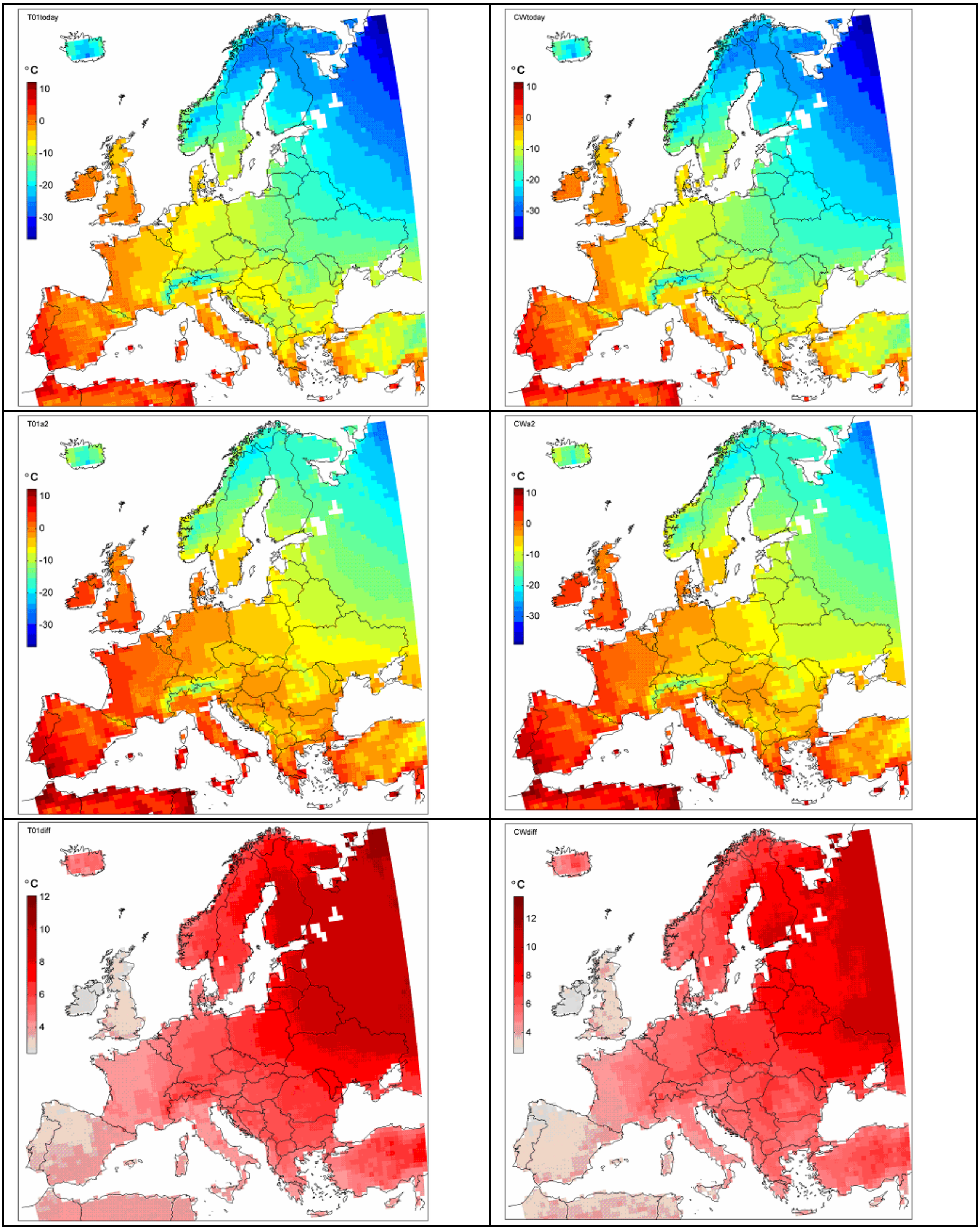


Figure 12: Wintertime cold conditions derived from an ensemble of regional climate models (Rossby Center)

The left column in figure 12 is the 1st percentile of daily mean temperatures, and the right column is the 7-day coldwave index (cf. Table 36). Top row shows the present day (1961-1990) conditions, middle row show the future (2070-2099) conditions for the SRES A2 greenhouse gas concentration scenario. The bottom row shows the climate change signal, that is, the difference future minus present day conditions.

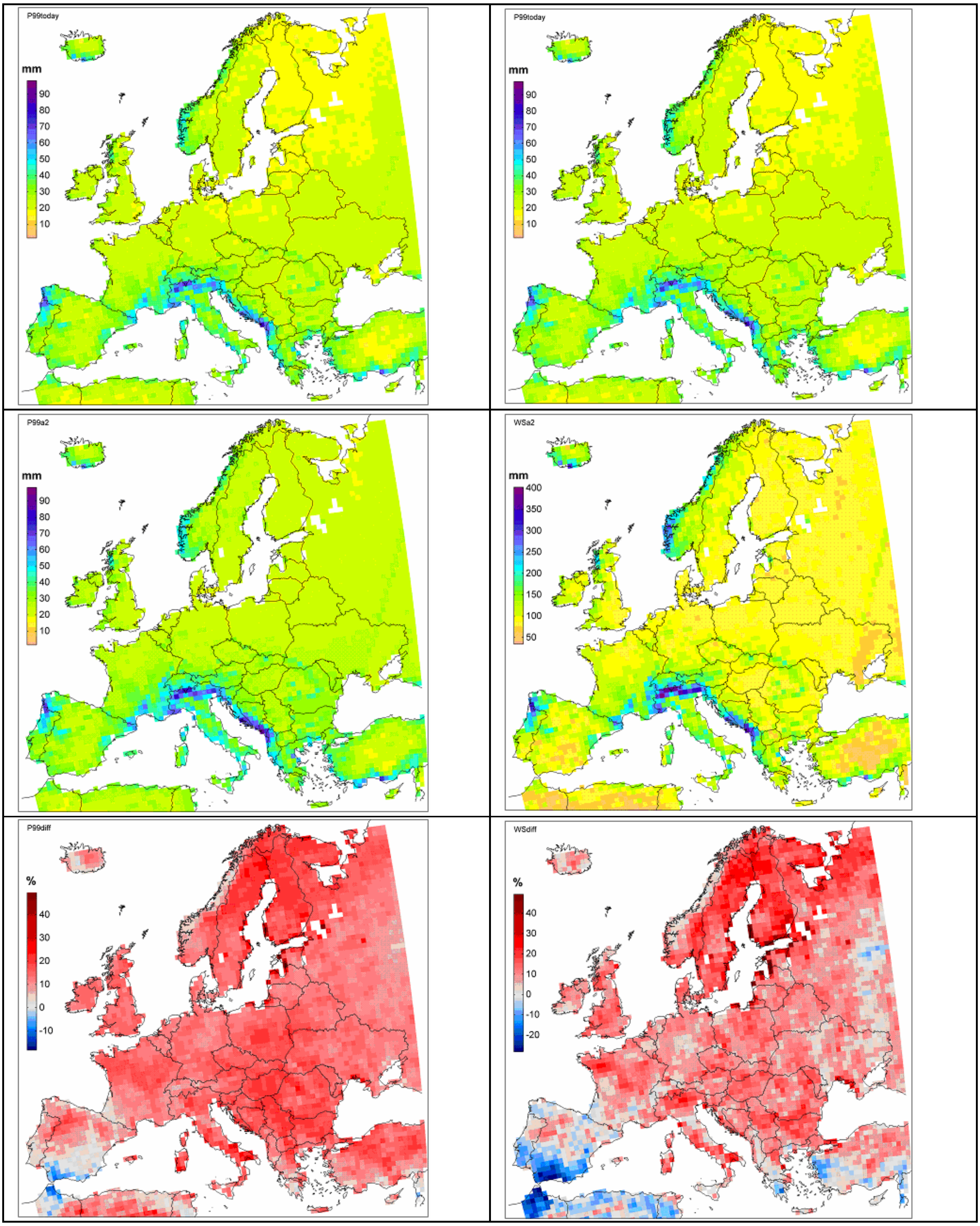


Figure 13: Precipitation condition as estimated from an ensemble of regional climate models (Rossby Center)

The left column in figure 13 is the 99th percentile of daily total rainfall for wet days, and the right column is the 7-day wetspell index (cf. Table 36). Top row shows the present day (1961-1990) conditions, middle row shows the future (2070-2099) conditions for the SRES A2 greenhouse gas concentration scenario. The bottom row shows the climate change signal, that is, the percentage change compared to present day conditions.

7.10 Typology of regions based on climate change

The following chapter outlines a first approximation towards a tyoplogy of European regions on climate change. This first typology is based on the results of climate models developed by the EU project "*Prediction of Regional scenarios and Uncertainties for Defining EuropeaN Climate change risks and Effects*" (PRUDENCE). The models used in this project are described in detail in the chapter above. Not all of the data sets that were used to present the maps in chapter 2 were feasible to develop typologies of climate change. The current results of climate models for wind patterns, e.g. still vary substantially from each other so that they are not applicable to determine changes of the winter storm hazard. Landslides and avalanches on the other hand occur in selected spots within NUTS3 regions. Therefore a climate change map that would propose, e.g. that a higher precipitation could lead to an increased landslide hazard, would be exaggerated on NUTS3 level.

A first typology of regions showing natural hazards that might be influenced by climate change focuses on the three selected hazards droughts, floods and forest fires. In the case of droughts the assumption is that a longer dry spells lead to an increase of the drought hazard, meanwhile shorter dry spells decrease it. The flood map depicts those areas with a modelled increase in precipitation and a consequent increasing flood hazard. Regions that have less modelled precipitation therefore show a decreased flood hazard. In the case of forest fires it was also assumed that a longer dry spell leads to an increase in the forest fire potential.

The reader must take into account that the presented maps are based on climate model data and thus show scenarios and not predictions or forecasts.

Table 37: Change of dry spell lenght affecting drought potential classification

Change of dry spell length - drought	Dry Spell Decrease - >Dry Spell Increase				
	1	2	3	4	5
Very low Hazard 1	**-**	**-**	**4**	**5**	**6**
Low hazard 2	**-**	**-**	**5**	**6**	**7**
Medium hazard 3	**-**	**-**	**6**	**7**	**8**
High hazard 4	**-**	**-**	**7**	**8**	**9**
Very high hazard 5	**-**	**-**	**8**	**9**	**10**

Table 38: Change of precipitation affecting the flood hazard classification

Precipitation change - flood	Precipitation decrease - > Precipitation increase				
	-2	-1	0	1	2
Precipitation_Change1	-35 to -25	-25 to -15		0 to 15	15 to 20
Precipitation_Change 2	-35 to -24	-24 to -13		-2 to 9	9 to 20
Very low Hazard 1					
Low hazard 2					
Medium hazard 3					
High hazard 4	**7**	**0**	**5**	**3**	**1**
Very high hazard 5	**8**	**0**	**6**	**4**	**2**

Table 39: Change of dry spell length affecting the forest fire hazard classification

Change of dry spell length - Forest fires	Dry spell decrease - > dry spell increase				
	0	1	2	3	4
Very low Hazard 1					
Low hazard 2					
Medium hazard 3					
High hazard 4	**7**	**0**	**5**	**3**	**1**
Very high hazard 5	**8**	**0**	**6**	**4**	**2**

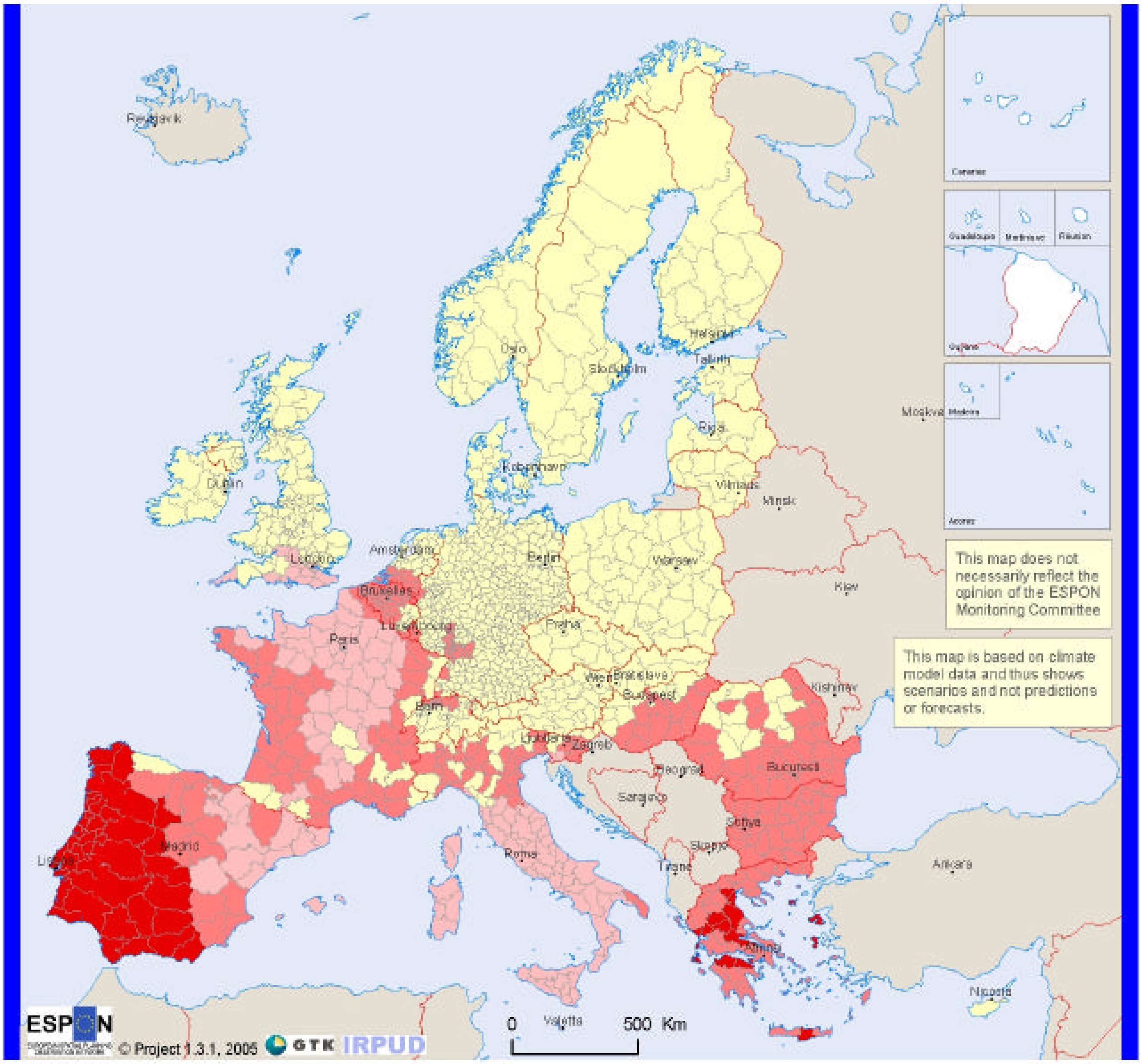
<u>Integrated climate change hazard map analysis</u>

The change of dry spell affecting the precipitation deficit as drought indication shows that those areas with a very high drought hazard in the Iberian peninsula (chapter 2) are assumed to have moderate increase of precipitation deficit, as well as some areas in Greece. Other areas with drought potential are also modelled to expect some increase (south and south eastern Europe). Meanwhile other areas in eastern and central Europe might face a low increase, some areas in central and northern Europe and the Baltic region might see no impact or even a decrease of drought potential.

Some of the areas with the highest flood hazard in central and east Europe show an increase of the flood hazard, according to modelled increase in precipitation over these areas. A decrease of the flood hazard is in one small area in the Mediterranean, based on a modelled decrease of precipitation. The highest increase in precipitation is modelled for northern Europe, but this area does currently not show a high flood hazard.

In the case of forest fires the assumption that longer dry spells lead to an increase of this hazard show a similar pattern as the precipitation deficit. The Mediterranean vegetation zone is assumed to have the highest increase of the forest fire hazard, meanwhile only some areas in central Europe might face merely a certain increase.

The selected climate hazard maps show that the southernmost areas of Europe might face the highest increase in natural hazards due to climate change. This is only partly correct, as not all natural hazards have been taken into account. A change in wind patterns or an increase in extreme events might lead to a considerably higher hazard of winter storms and storm surges. The effect of increased precipitation on landslides and avalanches has to be assessed on a local level. Therefore these maps present only a first approach on this topic and more research is needed for better scenarios.



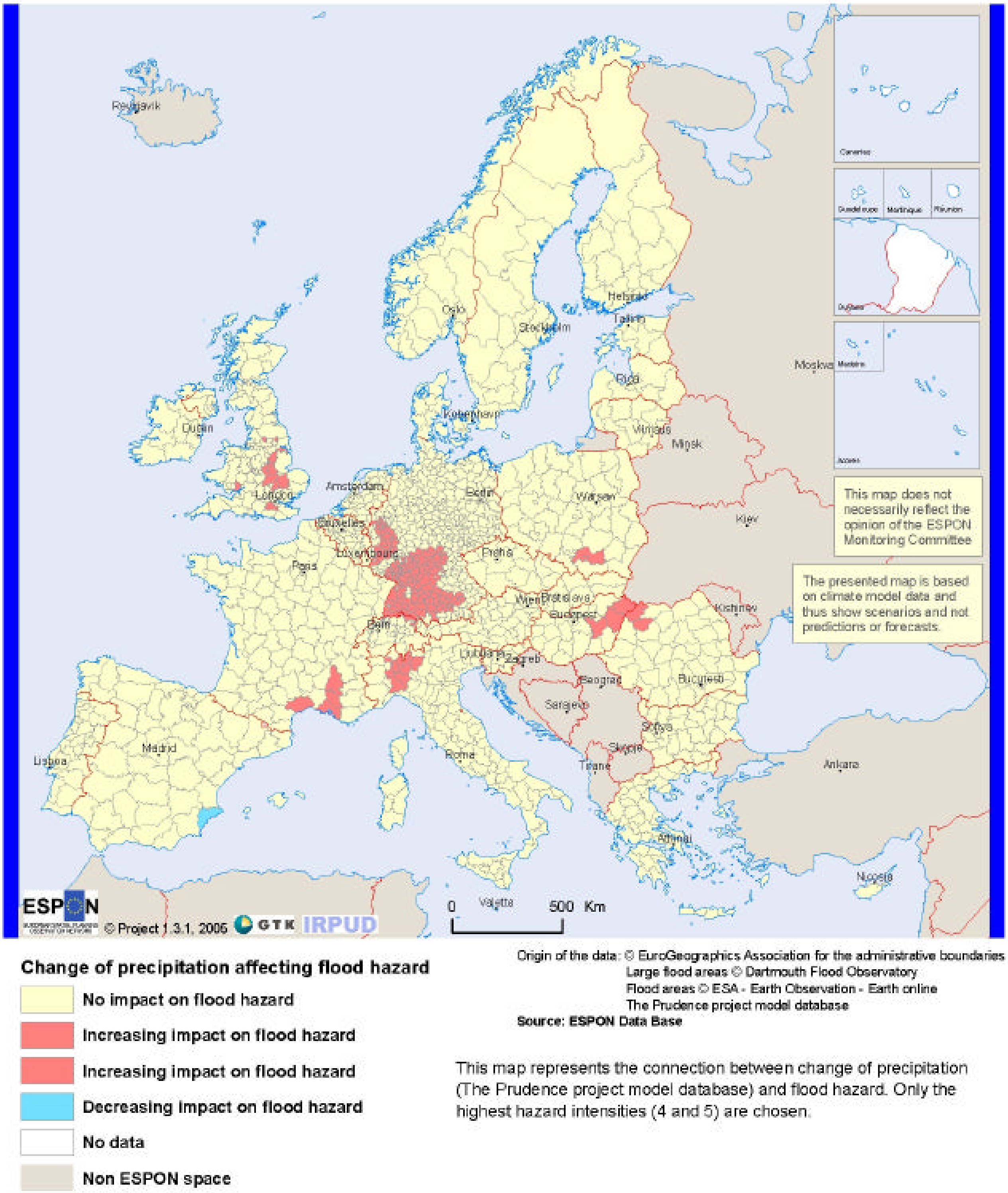
Change of dry spell length affecting drought potential

- No impact on drought potential
- Very low increasing impact on drought potential
- Low increasing impact on drought potential
- Moderate increasing impact on drought potential
- No data
- Non ESPON space

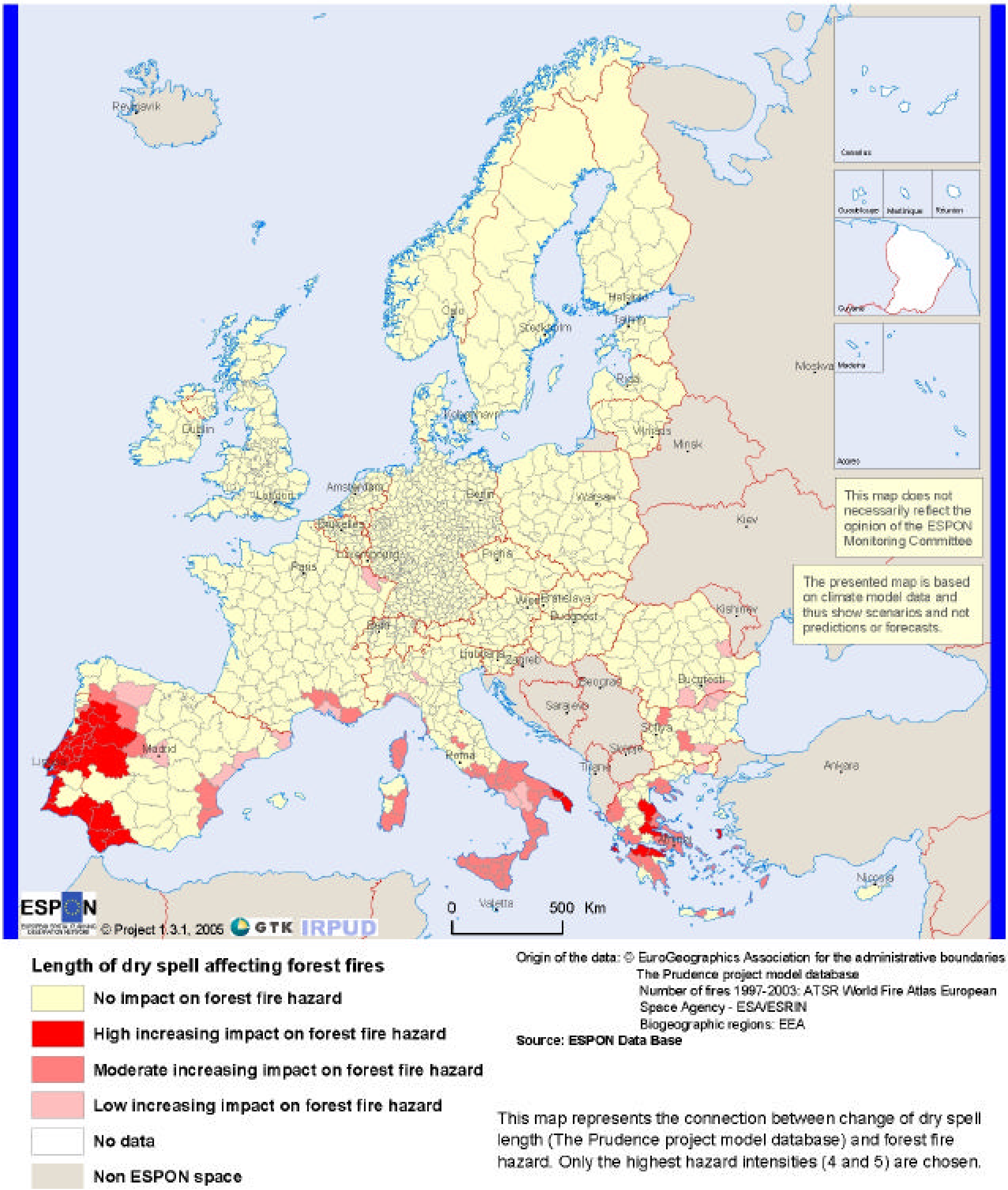
Origin of the data: © EuroGeographics Association for the administrative boundaries
ARIDE final report (2001)
The Prudence project model database
Source: ESPON Data Base

This map represents the connection between change of dry spell length (The Prudence project model database) and drought potential, based on precipitation deficit recordings 1904-1995.

Map 26. Climate change: Dry spell length affecting drought potential



Map 27. Climate change: Precipitation affecting flood



Map 28. Climate change: Length of dry spell affecting forest fires

8 Improvement of Monitoring Systems

8.1 Framework of an ideal risk monitoring system

A risk monitoring system assists in the early detection of potential negative impacts in case hazards turn into an accident or catastrophe. Thus, risk monitoring systems can help to reduce the costs of reaching and maintaining a given safety level, protection and quality. Risk monitoring systems may also be used to evaluate the outcome of environmental policies, to assist in the development of strategies for hazard prevention and management. They can also serve as research platforms for the development of analytical methods and models on hazards and hazardous processes.

By splitting up 'risk' into the elements of hazard potential, damage potential and coping capacity, a framework for monitoring not only risk as a whole but also ideally for monitoring the constitutive elements of risk can be created. Within this framework it is not only possible to monitor the hazards impact on the built up environment and humans but also the vulnerability (damage potential and coping capacity) of an area. Risk monitoring thus has a major role in defining and deciding on response actions like mitigation (structural, non-structural and prevention oriented mitigation) and reaction (preparedness, response, recovery) as shown in Figure 14.

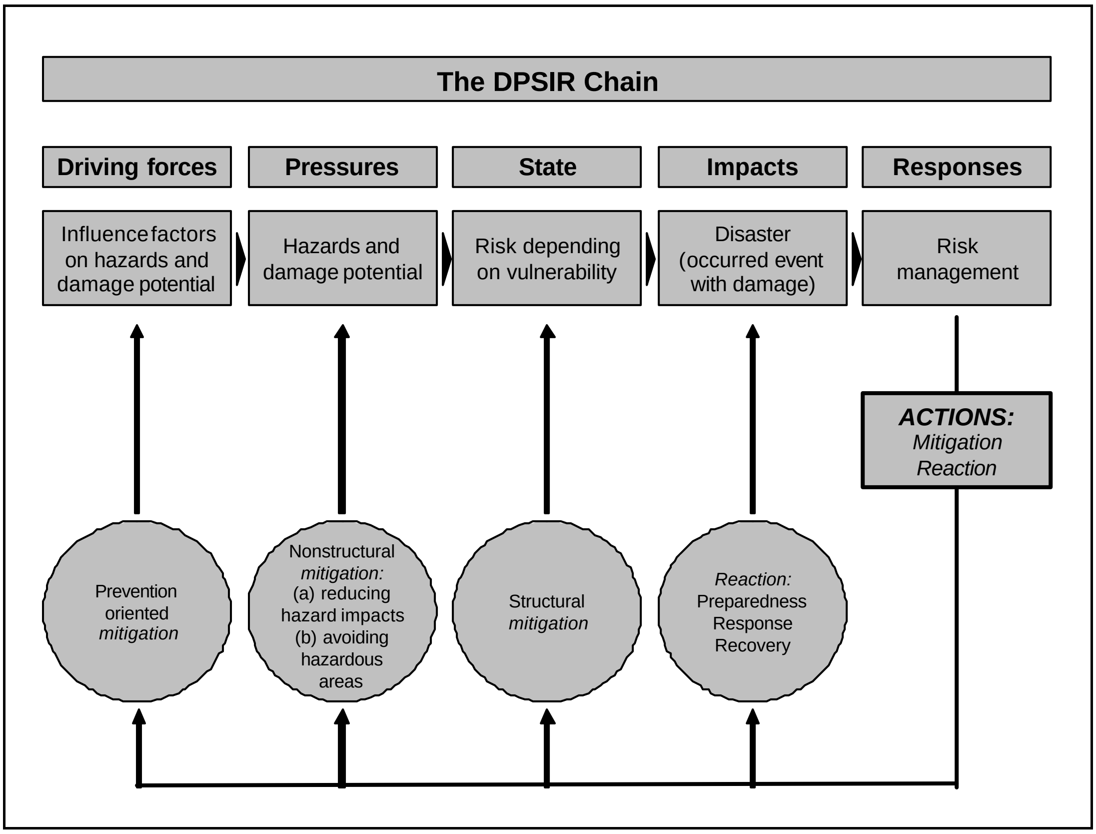


Figure 14: Framework of an ideal risk monitoring system. Source: ESPON Hazards project

The range of purposes for which risk-monitoring systems can be designed encompasses such a vast range of time scales, variables and processes that it is not possible to give specific guidance on the design of an ideal risk monitoring system to meet all the objectives that have to be respected. The design of monitoring systems should be made from a consideration of the specific objectives of the particular hazard to be monitored.

8.1.1 Proposed scale of risk monitoring systems

A general question is what kind of risk monitoring systems are useful on a European scale and which one's are rather useful on local or regional scales. Some issues like, e.g. nuclear power plants, should be assessed and controlled on a EU wide and even international level in order to reach high common standards on safety and ensure transparency. But it may be doubted if it is necessary to have a pan-European monitoring system on landslides. Landslides depend very much on the local geology and the local climate and it is therefore recommendable that this issue should be monitored on a regional or local scale. Damage potentials and coping capacities should be monitored on the European level first for analytical reasons, e.g. in the context of European cohesion. Second, monitoring is indispensable for a continuous work on the risk maps, elaborated within the ESPON Hazards project. As recommended in Chapter 9, European risk maps could be integrated as an additional indicator for the assessment of applications for EU structural funding. As a basis for risk management actions damage potentials and coping capacities should be monitored on the national or regional level (coping capacity) or respectively on the regional or local level (damage potential).

The role of the EU Commission regarding the set up and the scaling of monitoring systems on hazards, damage potentials and coping capacities could be to initiate and ensure that appropriate monitoring systems are installed. EU funding sources can be used as a tool to ensure appropriate installation of monitoring systems.

The following table shall give an input for discussion on the type of hazards and proposed scales of monitoring systems.

The coverage and the ability to function of monitoring systems also depends on political decisions. In the case of certain hazards, e.g. floods it must first be generally understood and accepted that floods are of cross-border concern, both in terms of causes and impacts. It is doubtful if a monitoring system can be successfully applied in areas where the cooperation stops at national or county borders. In the case of floods it would be necessary to install cross-border cooperation reaching from planning over protective measures to early warning systems. Also, plans on concerted help and alleviation in case of a catastrophe could be part of such a monitoring system.

Table 40: Proposed scale of risk monitoring systems. Source: ESPON Hazards project

Hazards	Scale of monitoring system
Natural hazards	
Volcanic eruptions	European and supraregional
Floods	Catchment based
Landslides / avalanches	Local/regional
Earthquakes / tsunami	European and supraregional
Droughts	European and supraregional
Forest Fires	European, supraregional, regional and local
Storms	supraregional and regional
Extreme precipitation (heavy rainfall, hail)	Regional and local
Extreme temperatures (heat waves, cold waves)	Supraregional and regional
Avalanches	Local
Technological hazards	
Dam failures	Regional and supraregional
Hazards from nuclear power plants	European
Hazards from production plants with hazardous production processes or substances	European and local
Airports	European
Hazards from the marine transport of hazardous goods (oil etc.)	European and regional
Damage potentials (selected examples)	Scale of monitoring system
Regional GDP/capita	European and regional
Population density	European and regional
Population / number of housing units in disaster risk zones	Regional and local
Number of businesses / workplaces in disaster risk zones	Regional and local
Length of infrastructure (roads, rail tracks, supply and disposal etc.) or number of infrastructure units (hospitals, schools etc.) in disaster risk zones	Regional and local
Coping capacities (selected examples)	Scale of monitoring system
National GDP/capita	European, national and regional
Dependency ratio	European, national and regional
Education rate	European, national and regional

8.1.2 *Analysis of global and supraregional monitoring systems*

One global monitoring system on a natural hazard that is currently installed is the *Global Fire Monitoring Centre (GFMC).* The GMFC is an early warning, monitoring and general information system that supports national and international agencies involved in land-use planning, disaster management or in other fire-related tasks and can utilise this information for planning and decision making. The GFMC fire documentation, information and monitoring system is accessible through its Internet website: http://www.fire.uni-freiburg.de/.

A very good example of a supraregional monitoring programme in a similar climatological environment is the *Arctic Monitoring and Assessment Programme (AMAP).* The primary objectives of AMAP are to provide reliable and sufficient information on the status of, and threats to, the Arctic environment, and to provide scientific advice on actions to be taken in order to support Arctic governments in their efforts to take remedial and preventive actions relating to contaminants. AMAP measures the level, and assesses the effects of anthropogenic pollutants in all compartments of the Arctic environment, including humans. It documents trends of pollution and sources and pathways of pollutants. It examines the impact of pollution on Arctic flora and fauna, especially those used by indigenous people. Finally, it reports on the state of the Arctic environment and gives advice to ministers on priority actions needed to improve the Arctic condition. Internet website: http://www.amap.no/.

Another supraregional monitoring system in the Artic is the *Northern territorial centre on monitoring of the environment pollution (NRPA).* NRPA's Emergency Unit maps and monitors radioactivity in the environment by analysing samples of fish, soil, vegetation, mushrooms, water and food. The main focus of monitoring is the vulnerable food chain lichen-reindeer-humans. Several studies have been conducted since the 1960's, examining radioactivity in reindeers and the Saami reindeer herders. Internet website: http://www.svanhovd.no/engelsk/engelsk.html.

For more information on the Arctic, please also see the *Nordic Council: Protection of the Artic Marine Environment (PAME).* Internet website: http://www.arctic-council.org. Among other issues, this document focuses on monitoring hazardous activities, such as artic off shore oil and gas extraction and transport.

An example for a supraregional cooperation system that covers more than one specific climatic zone and includes monitoring is *The Helsinki Commission (HELCOM).* HELCOM works to protect the marine environment of the Baltic Sea from all sources of pollution through intergovernmental co-operation between Denmark, Estonia, the European Community, Finland, Germany, Latvia, Lithuania, Poland, Russia and Sweden. HELCOM is the governing body of the "Convention on the Protection of the Marine Environment of the Baltic Sea Area" - more usually known as the Helsinki Convention. Internet website: http://www.helcom.fi/.

8.2 Analysis of international and European scale monitoring systems

This section describes international and/or EU institutions that collect data and perform research on natural and technological hazards and types of accidents, but are not explicitly designated as monitoring systems.

The *International Tanker Owners Pollution Federation Limited (ITOPF)* is a non-profit making organisation, funded by the vast majority of the world's ship-owners. They devote considerable effort to a wide range of technical services, the most important of which is responding to oil spills. The technical advisers have attended on-site at over 450 spills in more than 85 countries. However, this is mainly a response system that does not even cover all worlds' ship-owners. Internet website: http://www.itopf.com/index.html.

For the chemistry industry there is the *European Process Safety Centre (EPSC).* The EPSC is an international industry-funded organisation that provides an independent technical focus for process safety in Europe. Its goal is to provide a forum for discussion of best practices on various technical process safety-related topics amongst the members in order to improve the safety record of the European chemical industry. Internet website: http://www.epsc.org/MainFrameset.asp

Emergency Events Database – EM-DAT. The WHO Collaborating Centre for Research on the Epidemiology of Disasters (CRED) maintains the EM-DAT, which was created with the initial support of the WHO and the Belgian Government. The main objective of the database is to serve the purposes of humanitarian action at national and international levels. It is an initiative aimed to rationalise decision making for disaster preparedness, as well as providing an objective base for vulnerability assessment and priority setting. For example, it allows on to decide whether floods in a given country are more significant in terms of its human impact than earthquakes or whether a country is more vulnerable than another for computing resources is. EMDAT contains essential core data on the occurrence and effects of over 12,800 mass disasters in the world from 1900 to present. The database is compiled from various sources, including UN agencies, non-governmental organisations, insurance companies, research institutes and press agencies. Internet website: http://www.em-dat.net/.

European Commission, Joint Research Centre, Institute for the Protection and Security of the Citizen, Unit of Technological and Economic Risk Management, *Technological and Economic Risk Management (TERM).* Internet website: http://media.jrc.it/IPSC/TAERM-unit.html. TERM's mission is to contribute to the safety, security and trustworthiness of technological and societal systems by developing innovative methods, tools and strategies for the assessment and management of risk and uncertainty and for supporting decision-making processes. Methods for gathering, assessing and modelling data, information and knowledge are deployed using, in particular, web-based technologies. The main fields of activity are: management of risk for natural and technological hazards; management of emergency situations; use of advanced statistics and computer science for the fight against fraud; strategic decision-making; official statistics, econometrics and policy performance indicators.

The most important TERM sectors regarding this project are summarised below:

- *Major Accident Hazards Bureau (MAHB)*
  The sector provides scientific and technical support to the implementation and monitoring of the "Seveso II" Directive on major technological hazards; operates the Major Accident Reporting System (MARS), the Community Documentation Centre on Industrial Risks (CDCIR) and the Seveso Plant Information Retrieval System (SPIRS) fulfilling the information exchange obligations towards the Member States. After the recent extension of MARS to OECD and UN/ECE countries, MAHB has become the world centre for major industrial accident reporting and root cause analysis. The sector manages the technical working groups providing guidance to the Member States on specific items of the Directive. Sector activities are now being extended to support Candidate Countries. The principal customers are the European Commission and all those concerned with process plant safety including legislative and regulatory aspects. Internet website: http://mahbsrv.jrc.it/. A major output of MAHB is the Seveso Directive, Internet website: http://mahbsrv.jrc.it/Framework-Seveso2-Contents.html.

- Allocated below the MAHB is also the *Major Accidents Reporting System (MARS).* The MARS is a distributed information network, consisting of 15 local databases on a MS-Windows platform in each Member State of the European Union and a central UNIX-based analysis system at the European Commission's Joint Research Centre in Ispra (MAHB) that allows complex text retrieval and pattern analysis. Internet website: http://mahbsrv.jrc.it/mars/Default.html. The EC's accident database MARS is complemented by *SPIRS,* a distributed database system which was set up in order to provide access to risk related information from major hazardous industrial establishments in Europe for all interested parties. Internet website: http://mahbsrv.jrc.it/spirs/Default.html.

- *Natural Risk*: The main task of the sector is to operate the Natural and Environmental Disaster Information Exchange System (NEDIES) project, which is now being extended to support Candidate Countries. Activities include the preparation of lesson-learnt reports and guidance documents on countermeasures for different disaster types, including some large technological accidents not falling under the Seveso Directive (e.g., train accidents and tunnel accidents). Internet website: http://nedies.jrc.it.

- *Human Factors:* The sector is involved in the analysis and optimisation of the relationship between people and their activities, and the integration of human sciences and systems engineering in systemic applications and working environment frameworks. Activities include accident investigation, design of interfaces and procedures, safety assessment, and training. The application areas are transport, nuclear safety, process industries, manufacturing and humanitarian de-mining. Internet website: http://humanfactors.jrc.it.

- *Integration of Information for Risk and Emergency Management*
  The sector develops integrated systems for the management of industrial and transport accidents, environmental monitoring, analysis of risk, civil protection planning and strategic decision-making, development of models and information fusion methodologies and software tools to support EU policies aiming at technological risk abatement. The activities support regional and national authorities. The sector also supports the Transport and Energy DG for the operation of the European Co-ordination Centre for Aviation Incident Reporting Systems (ECCAIRS) as an EU information collection point and as a reporting system for air traffic incidents in Member States; designs and implements ECCAIRS network nodes in the Member States; and collects and analyses data. Internet website: http://eccairs-www.jrc.it.

- *Decision Support for Risk and Emergencies* The sector focuses on research and development to improve the quality of decision-making for the management of risk and emergencies, evaluation of the impact of EU policies on sustainability criteria, transport planning. The sector further develops tools to navigate complex, multi-criteria problem streams, characterised by high uncertainty, a mix of quantitative, qualitative and fuzzy data and contrasting agendas of multiple stakeholders. The tools incorporate multi-criteria evaluation methods, Decision Support Systems, spatial analysis (GIS), systems inter-operability and participatory research.

- The *Euro-Mediterranean Disaster Information Network (EU-MEDIN)* project aims to improve the interaction and synergy between the actors of the European research in the field of Natural Risks and Disasters. It addresses all organisations, institutions or individuals interested in disasters management research and development issues. Internet website: http://www.eu-medin.org/.

- The *International Atomic Energy Agency (IAEA)* serves as the world's central intergovernmental forum for scientific and technical co-operation in the nuclear field, and as the international inspectorate for the application of nuclear safeguards and verification measures covering civilian nuclear programmes. Internet website: http://www.iaea.or.at/.
- *International Decade for Natural Disaster Reduction (IDNDR)*: *Report on Early Warning for Technological Hazards.* Internet website: http://www.unisdr.org/
- The *Forum of European Geological Surveys (FOREGS)* has established a working group on natural hazards, to target policies on natural hazards in order to reduce the impacts of natural hazards and contribute to sustainable development in Europe. In this context, FOREGS intends to closely cooperate with *EuroGeoSurveys (EGS).* Internet website:

  http://www.eurogeosurveys.org/foregs/meetings/meeting_2001/wgr_natural_hazards.pdf.
- The Institute for *Environment and Sustainability (IES)* is one of the institutes that constitute the *Joint Research Centre (JRC)* of the European Commission. One of the important contributions in the field of hazards research is the FP5 "Natural Hazards Project" (Internet website: http://natural-hazards.jrc.it/). This project is targeted to provide scientific and technical support (risk indicators and damage maps) for the conception of implementation and monitoring of EU policies linked to the protection of the environment and of the citizens against floods and forest fires. Please also see the First Interim report of the ESPON Hazards project, page 41 ff. for further information.
- The *UNDP Emergency Response Division (ERD)* is preparing a *World Vulnerability Report (WVR)* that will focus on government strategies that can help avoid or minimise damage from floods, drought, earthquakes and other natural disasters. A central feature of the report, originally scheduled for release in 2001, will be a *Global Risk Vulnerability Index (GRVI)* that will compare countries according to their level of risk over time and demonstrate how patterns of risk and vulnerability have evolved. The index will identify countries' social and economic vulnerabilities, along with hazards caused by natural conditions and human activities that contribute to risk. A pilot of the vulnerability index, combining several indicators to represent a country's level of disaster risk, is to be tested by collaborating centres in Africa, Asia and Latin America. The index will then be refined and improved for global application. Parallel with this process, UNDP will facilitate information sharing and communication between organisations involved in vulnerability and risk indexing through a specialised web page, publications and meetings. Internet website: http://www.undp.org.
- *Munich Re* provides the *NatCatSERVICE* database. This database collates and processes data on market losses on the basis of regions and results (this database can be accessed via the Financial Information Service of Reuters). The NatCat*SERVICE* can be used as a market loss index for an insurance derivative transaction. The MRNatCat*SERVICE* provides data (date, region, damage [monetary and loss of lives], description of event) about the following natural disasters: Earthquakes, volcanic eruptions, storms (winter storms, snow storms, thunder storms, hail storms, tornados), floods (river floods, coastal floods, torrent floods), others (heat waves / droughts, cold waves, forest fires, lightning strikes, land- and rock slides, avalanches). The MRNatCat*SERVICE* covers data worldwide for the last 25-30 years. The database is not public, access to certain data is given to Munich Re Underwriter, clients, governments, NGO's, scientific bodies, Universities, media etc. Internet website: http://www.munichre.com.

- The *Swiss Re* holds the *Sigma database* about natural hazards. The categories include: Earthquake, Flood, Storms, Drought, Frost and Other. Sigma includes 7,000 events with 300 new events added each year. Losses are recorded if any one of the following criteria are sufficient for an event's inclusion in the database: (i) More than 20 fatalities, (ii) more than 2000 homeless, (iii) insured losses exceed more than $14m in respect of Marine and $28m in respect of Aviation or $35m in respect of all other losses, (iv) total losses in excess of $70m. An event in Sigma that affects a number of nations, e.g. Hurricane Mitch, is recorded only once. The Sigma database not public. The annual sigma catastrophe publication available to whoever is involved in natural hazards issues, insurance companies, brokers, global companies, banks, media, scientific institutions. Information can be found at the Swiss Re internet website http://www.swissre.com.

8.2.1 Selected links to natural hazards monitoring systems and projects

- United Nations Economic and Social Commission for Asia and the Pacific, http://www.markmyweb.com/icstd/SPACE/resap/metsat/metsat.asp.
- The British National Space Centre, http://www.bnsc.gov.uk/index.cfm?pid=372.
- Dartmouth Flood Observatory, http://www.dartmouth.edu/artsci/geog/floods/.
- Canada, remote sensing for natural hazards monitoring, Canada Centre for Remote Sensing, http://www.ccrs.nrcan.gc.ca/ccrs/misc/issues/hazards_e.html.
- Glacier Lake Outburst Flood monitoring in the Himalayas, http://rolwaling.tripod.com/glof/.
- The Natural Hazards Research Centre, University of Canterbury, Christchurch, New Zealand, http://www.nhrc.canterbury.ac.nz/.
- National Institute of Water & Atmospheric Research, New Zealand, http://www.niwa.cri.nz/rc/hazards/.
- Natural hazards research at academic institutions in the United States, http://www.naturalhazards.org/discover/research.html.
- United States Geological Survey research on natural hazards, http://www.usgs.gov/themes/factsheet/093-99/.
- USA, remote sensing and natural hazards monitoring, National Geophysical Data Centre, http://www.ngdc.noaa.gov/.
- International coordination group for the tsunami warning system in the Pacific http://ioc.unesco.org/itsu/
- Global Change Master Directory, NASA's directory of earth science data. http://gcmd.gsfc.nasa.gov/Resources/pointers/hazards_general.html.

9 Policy recommendations

9.1 Principles

9.1.1 Risk management is about cohesion and solidarity

Natural and technological hazards pose challenges for balanced and sustainable development in Europe. Regions are exposed to hazards in varying degrees, placing them in different "risk positions". The EU Policy instruments should contribute to even out these differences as a matter of European solidarity. Consequently, the role of risk management should be understood as an important task for the cohesion policy. Overall, better inclusion of risks related to natural and technological hazards in EU policies is needed for the implementation and monitoring of risk management practices.

Natural and technological hazards do not simply fall in the category of "environmental protection". Rather, they are hybrid phenomena involving complex socio-ecological processes, which bring together multiple institutions and stakeholders and many fields of action such as nature protection, civil protection and security policy. The growing recognition for the need of a risk management perspective is comparable to the historical evolution whereby the "environment" was included on the EU policy agenda. The introduction of the notion of territorial cohesion is important in this respect. It covers the territorial dimension of social and economic cohesion and is closely linked to the fundamental EU objective of "balanced and sustainable development" (Art. 2 EU-treaty). It demands a more integrated approach, from a territorial perspective, to both EU investments directly relevant to the cohesion of the European territory (structural funds/cohesion fund) and other relevant EU policies.

Although disaster resilient communities are not identified as specific objective of Article III-129 ("Environment"), it is a matter of fact, that disaster resiliency will be an important prerequisite for reaching the named objectives "preserving, protecting and improving the quality of the environment" and "protecting human health". Moreover, Section 5 ("Civil Protection"), Article III-184 determines that *"the Union shall encourage cooperation between Member States in order to improve the effectiveness of systems for preventing and protecting against natural or man-made disasters within the Union. Union action shall aim to: (a) support and complement Member States' action at national, regional and local level in risk prevention, in preparing their civil-protection personnel and in responding to natural or man-made disasters".*

In sum, *risk management should be seen more explicitly as an important tool for achieving goals of human development inside the EU.* The inclusion of risk management perspective in EU policy requires three dimensions of integration: Horizontal integration of policies and financial instruments, vertical integration of spatial planning scales from the local to the EU level and horizontal integration of different aspects of resilience towards hazards at the local and regional planning level. A necessary task at the local and regional levels is to integrate different hazards into one management scheme, taking into account their interrelated nature. Here the recently adopted Strategic Environmental Assessment (SEA) directive is of key importance.

With a multitude of hazard-relevant actors and institutions, the issues of integration of policies and interplay between actors become crucial. A key principle should be the integration of spatial planning measures and environmental concerns. This integration has seen progress at the EU policy level, but implementation practices in member states still vary (Clement, 2001; Roberts, 2001). Such integration is a challenge since spatial development goals have predominantly been based on economic development concerns. This emphasis is still visible in the 3rd Cohesion Report and the ESDP. However, the revision of cohesion policy for the period 2007-2013 includes new promising priorities for environmental protection and risk prevention. The increasing recognition of the need to address risks in EU should be accompanied by increasing funding and determination on implementation and monitoring of risk prevention measures through EU instruments.

9.1.2 Focus on vulnerability and preventive action

An important aspect in tackling the challenge posed by hazards is to shift from a reactive (post-event) disaster-orientation to a *preventive orientation* concentrating on risk management and mitigation. Civil protection and disaster (ex-post) response, for instance, are important factors in the way individuals, families, localities and regions cope with natural and technological hazards and disaster events. Civil Protection, however, is only part of coping with hazards. Cooperation should be strengthened especially in the field of risk mitigation through planning.[1] So far, no holistic approach exists to face natural and man-made risks.

In accordance with the preventive orientation, stress should be put on a broader strategy of *vulnerability reduction, i.e.* not putting people and/or other valuable assets in harm's way. Such efforts should balance the efforts taken towards post-event disaster response, rescue and recovery. From this perspective, spatial and urban planning should be seen as key instruments (cf. UNISDR, 2002: 224).

This orientation is based on the evidence that disasters are constituted more by human and societal activities shaping spatial patterns of damage potentials and coping capacities rather than the changes in the frequencies and magnitudes of the extreme hazard events themselves. 'Man-made' societal and spatial developments alter the patterns of vulnerability far more forcefully than 'natural' driving forces such as climate change. (Sarewitz *et al.*, 2003) Stressing the importance of changes in 'man-made' vulnerability patterns related to European river floods, Mitchell (2003, 573) notes that "there is ample reason to be concerned about the growth of flood disaster potential [...] even without taking climate change into account." In addition, the uncertainties involved in understanding the complex dynamics of climate change favour the strategy of vulnerability reduction (see chapter 7 above). In fact, climate change seems to have acquired attention from the policy and research communities, which is probably larger than its significance as a driving force affecting risk patterns across Europe.

For example, the disproportionate frequencies and magnitude of forest fires in Northern Portugal are not due to unique natural conditions (e.g. climatic conditions), but a socio-ecological combination of climatic conditions and local human activities such as traditional cultivation methods, which act as fire-starters. Hence, more attention should be paid to the human side and the context of extreme events, instead of the natural events themselves. This means shifting attention and resources from predictive measures to robust preventive measures. This should also inform European research in the field: the natural scientific study of natural hazards should be accompanied by a better understanding of the socio-economic processes which put people and valuable assets in harm's way.

1 The new EU constitution seeks to encourage cooperation between Member States in the field of civil protection in order to improve the effectiveness of systems for preventing and protecting against natural or man-made disasters within the Union. In response to the events of September 11th, the EU civil protection activities have focused on the repid implementation of the Community Mechanism for Civil Protection. The scope of the EU intervention in this field encompasses actions to reduce the consequences of Chemical, Biological, Radiological and Nuclear (CBRN) threats to society. It serves to note that the ESPON 1.3.1 project has focused, instead of civil protection, on prevention through spatial planning instruments, in the spirit of the ESPON programme.

It is important to note that public policies mitigating the impacts of extreme events differ depending on whether they focus on reducing risk or reducing vulnerability. While risk-based approaches to preparing for extreme events are focused on acquiring accurate probabilistic information about the events themselves, reducing vulnerability does not demand accurate predictions of the incidence of extreme events. Defending the vulnerability reduction strategy, Sarewitz *et al.* (2003) point out that extreme events are *created by context* and that vulnerability reduction is a human rights issue while risk reduction is not. It should therefore be recognized that vulnerability is also a political issue with normative underpinnings. As described above (see chapter 4 on vulnerability), the different dimensions of vulnerability (economic, social, ecological) may be weighted in many ways. The recent Asian tsunami disaster in December 2004 serves as an illuminating example: even if the death toll of the disaster was the highest ever recorded, the economic losses of the event were small compared to those in disasters that have affected more affluent countries. Purely economical indicators neglect human suffering, especially if the people affected are poor. Likewise, the environmental dimension of vulnerability does not translate easily into monetary terms. Therefore, reducing vulnerability to natural and technological hazards should address all the dimensions of vulnerability concerning losses in lives and in social, economic and environmental assets.

Economic development increases economic vulnerability, but it also reduces social vulnerability. This, however depends not only on accumulation, but distribution of wealth. Socially balanced economic development reduces social vulnerability. This also applies in spatial terms: spatially balanced development is generally less vulnerable to hazards than the concentration of population and productivity around single growth poles. *In sum, a polycentric, spatially and socially balanced economic development which takes necessary environmental precautions, is beneficial for the reduction of vulnerability in Europe*.

On one hand, great damage potentials in both human and monetary terms are concentrated in the European cities and urban agglomerations, especially in the “pentagon” area. On the other hand, the rapidly growing economies of the new member states require increasing attention. The rapid growth of GDP figures implies that risks might be increasingly taken in relation to environmental precautions. In other words, for the sake of economical development risks are taken despite of environmental problems that might arise (up to destruction of the environment) or increase of hazards and risks, e.g. developing settlements or making other investments in flood prone areas. In the new member states it will be especially important that the EU financing instruments do not contribute to economic development at the expense of environmental protection or social welfare. Unrestricted development in hazardous regions should be controlled, i.e. the financing of further development in hazardous areas should be monitored in order to ensure safety standards. There are examples of settlement constructions in flood prone areas of the Elbe in the 1990'2. This kind of unrestricted development has also lead to the catastrophic outcome of the 2002 flood.

The patterns of vulnerability should be also considered at a smaller scale. Major cities have traditionally been rather well protected against different hazards, i.e. some cities have invested more on hazard protection (by e.g. dams, forest management, etc) against hazards than surrounding, often also poorer areas. Also, many major cities have a better disaster recoverage infrastructure than surrounding areas, simply because of a greater density of specialised doctors, fire brigades, etc. Today, most trends in vulnerability are influenced by a complex mixture of natural and social developments. Vulnerabilities are altered by local and regional phenomena such as development at urban fringe areas, including the phenomenon of urban sprawl. Local vulnerability patterns may also be linked to macro-trends such as globalisation, resulting in increasing mobility and accumulation of goods, services and investments, demand for flexibility in production patterns (Mitchell, 2003). The effects of globalisation should clearly be a topic of future research. Interventions are especially crucial where growth and development are very rapid and poorly distributed.

The rest of this chapter shall, first, focus on policy recommendations at the EU-level (chapter 9.2) with respect to cohesion policy and other EU instruments. Second, recommendations concerning resilient regional planning will be presented (chapter 9.3). A more detailed discussion on risk prevention in regional planning is included in chapter 11.

9.2 Recommendations in relation to EU policies and programs

Thus far, there is no uniform and holistic approach within the EU to deal with natural and technological hazards. Hazards are addressed in heterogeneous and partial ways, and at different levels by existing Community instruments. Furthermore, policy responses to technological hazards are much better developed, mainly through the SEVESO II directive, than those addressing natural hazards. (e.g. EEA 2003, 62-63.)

There are several elements in EU legislation, policies and programmes, however, seeking to include hazards and risk management into planning and decision-making as mainstream concerns. They have become increasingly visible in EU policies and legislation, similarly to the recent integration of environmental concerns and sustainable development. The need to include risk prevention in regional policy has been recognized in the ESDP[2], but the lack of EU-level authority in spatial planning makes it all the more important to ensure that the financial instruments and sectoral policies of the union support risk reduction in a complementary fashion at different spatial scales.

9.2.1 Cohesion Policy in relation to risks and hazards

The primary aim of the EU Structural Funds is to reduce the socio-economic disparities that exist between different regions. Such disparities hinder the cohesion of the EU, which is one of EU's primary objectives. *It should be acknowledged that natural and technological hazards influence European cohesion in a negative way by impeding the development of regions burdened by disaster events and resulting losses*.

Thus it is important that hazards be taken into account when financing operations through Structural Funds. At present, the general provisions on the Structural Funds do not mention natural or technological hazards, nor have they been mentioned in the official regulations on the four Structural Funds for the period 2000-2006.

In July 2004, however, the European Commission adopted its legislative proposals for cohesion policy reform covering the period 2007-2013 (COM 2004, 492-496). Environmental protection and risk prevention have been given much more emphasis than before. The Commission proposes a set of key themes for the regional programmes that are especially important for the cohesion of the EU. Risk prevention is mentioned

2 The ESDP and the SUD call for the inclusion of hazards into regional policy. They stress the importance of natural hazards, while man-made and technological hazards receive less attention. The ESDP (EC 1999), Goal 142 underlines, that "[...] spatial planning at suitable government and administrative levels can play a decisive role[...] in the protection of humans and resources against natural disasters. In decisions concerning territorial development, potential risks - such as floods; fires; earthquakes; landslides; erosion; mudflows; and avalanches and the expansion of arid zones should be considered. In dealing with risks, it is important, in particular, to take the regional and transnational dimensions into account." With reference to goal 142 the following policy option 46 was introduced: "Development of strategies at regional and transnational levels for risk management in disaster prone areas." Also the EU Working Group on Spatial and Urban Development clearly proclaimed as part of their key messages, that "areas at risk from large-scale natural disasters (e.g. flooding) need risk assessment and management incorporating a European perspective." (SUD 2003, 2). Furthermore, the expert group recommended "a strand in future regional policy reflecting the need for a territorial approach to development, where all regions of the EU are in principle eligible, depending on the chosen priority themes (e.g. accessibility, vulnerability to natural disasters, etc). This would give more emphasis to strategic territorial development frameworks" (SUD 2003, 3).

as a priority under all the three objectives of convergence, regional competitiveness and employment and European territorial cooperation.

The first priority, convergence, acknowledges the need to help the least developed Member States and regions e.g. by supporting plans aimed at preventing natural and technological risks. The second priority of regional competitiveness acknowledges natural hazards under "Infrastructure for a high-quality environment". Here preventive measures in natural areas exposed to disasters are considered important for attaining high-quality environment. The third priority, territorial co-operation, acknowledges risk prevention at cross-border, transnational and interregional level. Territorial cooperation objectives include the following themes: maritime security, protection against flooding, protection against erosion, earthquakes and avalanches. These themes are to be addressed through actions such as supply of equipment, development of infrastructures, transnational assistance plans and risk mapping systems.

In the field of rural development, the Commission adopted a proposal (COM 2004, 490) on support for rural development by the European Agricultural Fund for Rural Development (EAFRD), which will replace the current Regulation for the next programming period 2007-2013. Within the EAFRD, risks are addressed in relation to natural resource management, e.g. through development of forest resources and their quality and the prevention of forest fires affecting agricultural and forestry production. Also the fisheries policy for 2007-2013 allows for the reconstitution of the production potential of the fisheries sector damaged by natural or industrial disasters.

In the summary of the guidelines it is stressed, that in areas prone to danger from natural disasters preventive civil protection measures should be encouraged. Further, Structural Fund assistance must give priority to investments, which follow a preventive approach to environmental hazards.

The Commission indicative guidelines under these objectives should help member states draft their programming documents in ways that address vulnerability reduction and risk mitigation. The fact that these guidelines exist and they acknowledge hazards, doesn't automatically mean that operations concerning them exist. However, the guidelines have to be taken into account when Member States prepare regional development plans and programming documents for the three priority objectives, in order to get assistance under the Structural Funds and the Cohesion Fund.

The principle of environmentally sensitive development has been linked to the Structural Funds and especially to the Cohesion Fund, which concentrates on environmental issues in aiming to strengthen the economic and social cohesion of the Community. Hence it is acknowledged that environmental issues are necessarily linked to hazards:

- Natural resources have both environmental and socio-economic importance and the quality of the environment determines regional attractiveness. E.g. water resources are a basis for economic activity and therefore water resources management is a major-issue. E.g. flooding is a severe economic threat.
- The environment is an important area of new employment, e.g. telematics applications for better integrated approaches to local and regional environmental management for prevention of natural and man-made risks and for natural resource management.

In the Structural Funds regulations, environmental issues and sustainable development are taken into account in ERDF, EAGGF and FIFG. Environmental concerns and sustainable development can be linked to hazards in many cases, for example in the protection of marine resources in coastal waters (FIFG), oil spills need to be considered as one threat marine resources face. In addition, the Indicative guidelines for receiving funding from the Structural Funds state that the Structural Funds and the Cohesion Fund should assist compliance with the environmental standards established in the relevant Community Directives.

It is of great importance that natural and technological hazards are taken into account in the first priority, which comprises most of the new member states. As indicated in the integrated vulnerability map (chapter 4; map 19), the new member states are generally more vulnerable to hazards due to their economic status. Economic growth in these countries is bound to be fast in the years following the accession, and in such a situation the existence of hazards must be considered carefully. With regional planning it will be possible to affect the development of risky regions.

In sum, looking at the remodelling of the cohesion policy for the 2007-2013 period, it seems that taking natural and technological hazards into account in regional development is becoming an increasingly important criteria for receiving financing through the Structural Funds. This is a welcome development. It should be ensured that structural financial instruments make a contribution to taking the prevention of natural, technological and environmental hazards into account in regional development. It is crucial that the emphasis of actions lies on the prevention of risks, not only on helping in the aftermath of disasters. These principles should also become mainstream practice in member states and regions. It still needs to be made clear exactly how their inclusion in the national programming documents can be guaranteed. There are three preliminary suggestions:

- The criteria used to identify a region as an objective 1, 2 or 3 region could be extended to hazard or risk relevant criteria (highly sensitive areas, e.g.).
- The categories where projects are allowed to be funded within the operational programmes of the objective 1, 2 or 3 regions could be extended to risk relevant projects (projects that decrease the hazard potential and the damage potential or that increase the coping capacity).
- Monitoring in the field of structural assistance should focus on environmental effects of the concerned programmes. This attitude has recently changed significantly, but practices in member states are heterogeneous. Exemplary practices have been adopted to this effect in some member states such as France and Austria (Barth and Fuder 2002, 67)

In the scope of post-disaster recovery and relief, instigated by the large number of recent disastrous natural hazards such as the dramatic floods, the Commission set up the Community solidarity fund (EUSF) in 2002 to help regions recover.[3] The EUSF will "intervene mainly in cases of major natural disasters with serious repercussions on living conditions, the natural environment or the economy in one or more regions of a Member State or a country applying for accession." (http://europa.eu.int/scadplus/leg/en/lvb/g24217.htm) Ecological disasters from oil spills are fought with the help of the European agency for maritime safety, as well as with a possible compensation fund for damage from oil spills. Despite these efforts, it is noted that the impact of recent disasters on the economy of the affected regions exceeds the capacity of existing compensation mechanisms. This underlines the importance of prevention.

3 According to the EUSF provisions, a natural disaster is considered as 'major' if, within a single country, the damage caused exceeds over EUR 3 billion (2002 prices), or more than 0,6% of gross national income. Or, in case of extraordinary regional disaster, if damage is less serious but causes serious and lasting repercussions on living conditions and the economic stability of the region -particular attention is paid to remote and isolated regions. Eligible costs include: 1) Immediate restoration of infrastructure; 2) Providing temporary accommodation and funding rescue services to meet the immediate needs of the population concerned; 3) Immediate securing of preventive infrastructures and measures of immediate protection of the cultural heritage, and 4) Immediate cleaning up of disaster-stricken areas. (http://europa.eu.int/scadplus/leg/en/lvb/g24217.htm)

9.2.2 Recent EU initiatives

Several Directives in the field of European environmental policy have an influence on land use and vulnerability, notably the Directives on environmental impact assessment (EIA) and strategic environmental assessment (SEA), as well as the Water Framework Directive (WFD). Article 12 of the Directive on the control of major accident hazards ("Seveso II") requires that Member State's land-use planning and/or other relevant policies take into account the objectives of preventing major accidents and limiting the consequences of such accidents. The inclusion of natural hazards is less developed in the field of environmental policy, evidently because nature has not been seen as a potential threat to the 'environment'. Furthermore, public participation in environmental decision making is an important element in these procedures, in line with the Aarhus Convention.

The Sixth Environment Action Programme (EAP)[4] indicates that the EU needs a coherent and consolidated policy to deal with natural disasters and accidental risk. As key concerns, the 6th EAP seeks to 1) promote Community coordination to actions by Member States in relation to accidents and natural disasters by, for example, setting up a network for exchange of prevention practices and tools; 2) develop further measures to help prevent the major accident hazards with special regards to those arising from pipelines, mining, marine transport of hazardous substances and developing measures on mining waste.

As to technological hazards, the 6EAP suggests measures to help prevent industrial accidents. The Seveso II Directive is seen as a good basis for managing industrial risks but it proposes that the scope of the Directive should be extended to cover new activities such as mining accidents and pipelines. (p. 32) In addition to the human and health impacts of disasters, the 6EAP also points out that disasters are also a threat to natural areas and wildlife.[5] This points to the *need of further development of indicators for ecological vulnerability in relation to both natural and technological hazards.* Regarding natural hazards, Climate change is seen as an important driving force, which is specifically mentioned in 6EAP.[6] As it seems that climate change adaptation is becoming a pervasive trend in environmental policy, *it should be guaranteed that focussing on this driving force does not exclude measures related to other driving forces influencing socio-economic vulnerability patterns in Europe*.

The 6EAP stresses the importance of community coordination to Member States' action on accidents and natural disasters. Such coordination efforts have been furthered through the Commission Work Programme for 2002, which foresees the development of an integrated EU strategy on prevention, preparedness and response to natural, man-made and other risks.[7] The intention to adopt such a strategy was confirmed in the recent Communication on "The EC response to the flooding in Austria, Germany and several applicant countries" (COM 2002, 481).

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4 Environment 2010: Our future, Our Choice – The Sixth Environment Action Programme – COM (2001) 31 final. http://europa.eu.int/eur-lex/pri/en/oj/dat/2002/l_242/l_24220020910en00010015.pdf

5 In this context the Baia Mare cyanide & heavy metals leakage from a gold mine in Romania into the river are mentioned. (p. 30)

6 Article 5 of the 6EAP states that "In addition to the mitigation of climate change, the Community should prepare for measures aimed at adaptation to the consequences of climate change, by 1) reviewing Community policies, in particular those relevant to climate change, so that adaptation is addressed adequately in investment decisions; 2) encouraging regional climate modelling and assessments both to prepare regional adaptation measures such as water resources management, conservation of biodiversity, desertification and flooding prevention and to support awareness rising among citizens and business".

7 The strategy includes the following points: i) Initiative for developing action plans to reduce the level of risks in the most vulnerable areas. Ensure that these areas are covered by emergency management plans that can be implemented; ii) Integration of the risk component in all Community policies, in the same way as the "environmental component" is taken into account. (E.g., no support to projects that would increase the risk to people, request to carry out a Risk or Vulnerability Assessment of a project similarly to an EIA);
iii) Access to best practices based on the experience gained during recent emergencies; iv) Promote further preventive measures within the Structural Fund. (See http://europa.eu.int/comm/environment/civil/pdfdocs/integrated_strategy_meeting021112.pdf)
Commission workplan 2002: COM (2001) 620 final. See http://europa.eu.int/eur-lex/en/com/cnc/2001/com2001_0620en01.pdf

Another ongoing development is related to monitoring. The Commission is preparing a proposal for a framework Directive to create a policy and legal framework for the establishment and operation of an Infrastructure for Spatial Information in Europe (INSPIRE). It will make harmonised and high-quality spatial (geographic) information readily available for formulating, implementing, monitoring and evaluating Community policies and for providing information to the citizen in a wide range of sectors at local, regional, national or international level. This will have a major effect in improving the range and quality of spatial data available to those involved in urban design and land-use planning. It also facilitates environmental impact assessment efforts (Vanderhaegen and Muro, 2005). The co-ordination efforts also extend to the field of civil protection.

Descending from the EU-level to the regional and local actors, the recent thematic strategy on the urban environment is of high interest for the ESPON Hazards project, since urban areas are characterised by high damage potentials in the face of disasters. The thematic strategy carries many important initiatives which can be linked to risk reduction efforts. These include proposed actions such as comprehensive urban environmental management plans (p. 12) and encouraging member states to "evaluate the consequences of climate change for their cities so that inappropriate developments are not begun and adaptations to the new climatic conditions can be incorporated into the land use planning process" (p. 31) *However, a comprehensive risk management perspective is still lacking in the strategy.*

Another interesting development from the regional perspective is the recent Water Framework Directive (2000/60/EC)[8] is to establish a framework for the protection of inland surface waters, transitional waters, coastal waters and groundwater which seeks to protect ecosystems, reduce pollution and promote sustainable water use. The relevance for Hazards arises from two reasons; first, the purpose of the directive to *contribute to mitigating the effects of floods and droughts*. (Article 1, L 327/5) and, second, from the fact that the directive introduces an interesting management tool in assigning *river basin districts* as prime unit for the management of river basins (Article 3/1)[9]. *From the hazard perspective, the water framework directive should be seen as a tool which facilitates risk management at the scale of water basins. This dimension should be highlighted in its implementation. At present, there is not enough recognition of the implications of WFD in relation to spatial planning and risk prevention.*

9.2.3 Territorial co-operation and Interreg

The Interreg initative can be seen as an important channel to develop, apply and test ideas furthering ESDP objectives in practice. In the context of risk management they provide a potential platform for working with European 'meso-level' governance issues.[10] Interreg programmes can address spatially relevant hazards with transboundary dimensions, helping to overcome the discrepancy between ecological regions and administrative jurisdictions (i.e. the *problem of fit*, see Young 2002). Furthermore, the Interreg initatives provide potential for horizontal networking and information ex-

8 See http://europa.eu.int/eur-lex/pri/en/oj/dat/2000/l_327/l_32720001222en00010072.pdf
On the Implementation of the Water Framework Directive, see
http://europa.eu.int/comm/environment/water/water-framework/implementation.html
9 The river basin district is defined as "the area of land and sea, made up of one or more neighbouring river basins together with their associated groundwaters and coastal waters" (Article 2, paragraph 15). Thus, the river basin management plans are destined to be important tools for implementing the directive. It is required, among other things, that every plan has to include a summary of significant pressures and impact of human activity on the status of surface water and groundwater. It also requires to plan for measures to be taken under exceptional circumstances.
10 Under Interreg there are cross-border initiatives, transnational programmes and interregional programs. The transnational Interreg areas are kind of "meso-regions" in Europe – there ten of them in the "continental" Europe.
http://europa.eu.int/comm/regional_policy/interreg3/abc/progweb_en.htm

change for a wide variety of actors such as regional governments, towns and cities (Thematic strategy on urban environment, 39).

At the moment, however, the potential of the Interreg initiatives is not being exploited for risk prevention. Judging by the declared priorities of the different programmes, it seems that the status of risk management is generally low or negligible[11]. In Interreg III A, only six (6) out of 53 programmes include a clear indication of risk management in their priority wordings. Often risks are mentioned in vague terms, in relation to environmental protection. The more deliberate cases focus on forest fires and civil protection (Sardinia-Corsica-Tuscany) and flood-related risks (Mecklenburg-Poland and Euregio Maas-Rhein). In the case of Interreg IIIB, three (3) out of 13 programmes had clear indications of risk management in their priorities. The focus was either on general prevention of disasters (Alpine Space) or floods (North West Europe, CADSES). In the frame of INTERREG IIIC, no mention of risk management was found. Risks are considered where hazards are considered, the focus is often on water resources and floods. (see table 41)

11 Based on a review of Interreg programme priorities at the EU INFOREGIO website, 22 October, 2004. http://europa.eu.int/comm/regional_policy/country/prordn/index_en.cfm?gv_pay=ALL&gv_reg=ALL&gv_obj=13&gv_the=5

Table 41: Risk-related Interreg III programmes

Programme	risk focus	Priority wording
Interreg IIIA		
D/PL – Saxony/Poland	recuding pollution and risk	Priority 3: The environment. Plans for the quality of water, reduction of environmental pollution and risks, and protection of nature, the countryside and the climate will guarantee sustainable, overall development in the border area.
D/CZ – Saxony/Czech Rep.	recuding pollution and risk	Priority 3: Environmental development of the area. Plans for the quality of water, reduction of environmental pollution and risks, and protection of nature, the countryside and the climate will guarantee sustainable, overall development in the border area. Cross-border network systems will help make agriculture and forestry more competitive and take advantage of the effects of the common agricultural policy established on the agenda for 2000.
D/PL – Brandenburg-Lubuskie	recuding pollution and risk	Priority 3: The environment. The essential aims of this priority are the reduction of environmental pollution and risks, in view of sustainable, environmentally friendly development in the border area, the protection of residential areas that are close to nature and to natural resources, elimination of abandoned industrial waste and cleansing of watercourses polluted through mining, and the construction of purification plants and waste water treatment systems.
I/FR – Sardinia-Corsica-Tuscany	combating fires, civil protection	Priority 2: Environment, tourism and sustainable development: This priority involves three types of specific objectives: protection and upgrading of the environment, development and promotion of tourism in the border area and sustainable economic development. Among the most important measures covered are cooperation in combating and preventing fires and civil protection, waste treatment and recycling, joint promotion and marketing in the tourism sector and services to SMEs in the field of innovation and technology transfer.
D/PL – Mecklenburg-Poland	catastrophe, disaster & high water protection	Priority 3: The environment This priority contains measures for the protection of nature and the countryside. Care for the countryside will preserve the attraction of the region's cultural landscapes, secure resources and provide the basis for creating a cross-border catastrophe, disaster and high-water protection facility. Further objectives are the improvement of environmental consciousness and enhancement of the quality of the water in the interior and along the coast.
D/NL/B Euregio Maas-Rhein	floods	Priority 3: Promoting environmental improvement (including agriculture). Key actions concern the improvement of quality of life and the importance of agriculture. Special attention is being paid to overcoming the risks of flooding and the treatment of waste.
Interreg IIIB		
Alpine Space (F, D, I, AUT)	prevention of natural disasters	Priority 3: Smart management of nature, landscapes and cultural heritage, promotion of the environment and the prevention of natural disasters. Key actions focus on good management and promotion of landscapes and cultural heritage, including water resources, and the prevention of natural disasters.
North West Europe (UK, IRL, F, B, NL, LUX, D)	water resources, floods	Priority 3: Sustainable management of water resources and prevention of flood damage. Key actions concern the management of transnational water systems in an integrated and sustainable way and minimising damage from river and coastal flooding.
CADSES (D, AUT, I, GR)	water resources, floods	Priority 4: Environment protection, resource management and risk prevention. Prevention of natural and man made disasters and risk management as well as projects focusing on integrated water management and the prevention of floods make up the key actions of this priority. This could concern the Danubian area.
Interreg IIIC		
No mention of risk management		

Interreg programmes provide space for creative projects on risk management. Cooperation is promising in relation to hazards which cut across specific environmental conditions such as European water bodies and mountain regions. Interreg programmes could be utilised more effectively to address particular hazard clusters. In ESPON Hazards project, the following hazards have been related to Interreg IIIB areas in Europe. The ESPON Hazards project suggests that these hazards be addressed when revising Interreg programme priorities.

Transnational Interreg programmes have several interesting projects related to hazards and risk management.[12] An especially interesting Interreg project risk management is the North West Europe area "ESPACE" project (European Spatial Planning Adapting to Climate Change), which aims to ensure that adaptation to climate change is recognised and to recommend that it is incorporated within spatial planning mechanisms at the local, regional, national and European levels.

It should be recognised that these and other Interreg initiatives are an important resource for developing innovative practices in dealing with hazards. For example, the North West Europe project COMRISK is working with Integrated Coastal Zone Management (ICZM) in a cross-national setting and therefore contributing to the implementation of the EU strategy on ICZM (COM (2000) 547 final). The value of Interreg projects is also in how they build bridges across scientific research and the praxis of spatial planners and multiple other stakeholders.

Therefore, the use of Interreg in the field of risk management should be encouraged and lessons from relevant projects should inform policy-makers at European and local levels alike. Similarly, other horizontal networks (e.g. Eurocities, URBACT) and other forms of meso-regional co-operation should be used for promoting good practice in the field of risk management. The existing networks need to be further studied.

9.2.4 Procedural development: towards integrated impact assessment

In the recent years, planning and decision-making have become increasingly reflexive through the introduction of different assessment methods such as environmental impact assessment (EIA), social impact assessment (SIA), strategic environmental assessment (SEA), health impact assessment (HIA) etc. Such methods seek to foresee and prevent harmful development by studying different alternative development paths so that the best available option can be identified.

Environmental impact assessment at the project level and strategic environmental assessment at the programme and policy level are key tools for risk reduction. The purpose of the SEA-Directive (2001/42/EC) is to ensure that environmental consequences of certain plans and programmes are identified and assessed during their preparation and before their adoption. In principle, implementing the Directive provides good grounds for dealing with risks related to spatial development plans. EIA and SEA should be complemented with more specific 'safety impact assessment' (Working document on civil protection 2003).

An EU-wide harmonisation in dealing with risks on the ground of the EU directive on Strategic Environmental Assessment (2001/42/EC) would be a step forward to the territorial cohesion, which is propagated by the EU. Art. 3 ("The Union's objectives")

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12 See, e.g. the CADSES area "Hydroadria" project, monitoring surface and groundwater detecting effects of climate change; North Sea "Comrisk" addressing integrated coastal zone management and the Baltic Sea area projects "Seareg", dealing with climate change induced sea-level rise and coastal flooding. An especially interesting Interreg project risk management is the North West Europe area "ESPACE" project (European Spatial Planning Adapting to Climate Change), which aims to ensure that adaptation to climate change is recognised and to recommend that it is incorporated within spatial planning mechanisms at the local, regional, national and European levels.

paragraph 3 of the Proposal for an EU Constitution Treaty pointed out, that the Union *"[...] shall promote economic, social and territorial cohesion, and solidarity among Member States."* (CONV 850/03 from 18.7.2003).

Projects, which will be permitted by a certain plan or program, might have significant effects on the environment and increase damage potential regarding certain hazards, which threaten the area in which the project will be located. The results of a risk assessment can be integrated into the environmental report in which the likely significant effects on the environment due to the implementation of the plan or programme are identified, described and evaluated (Art 5 of the directive). The SEA is well established by legislation and can be described as an existing framework for managing the environment in general and especially risks from natural as well as technological hazard threatening the environment. This framework would be a great chance for establishing risk assessment and management as an obligatory task within every decision about a spatial plan or programme. Furthermore, it would implement the present EU policy objectives regarding environmental and civil protection (draft EU constitution treaty and ESDP) (Greiving, 2004).

The effective implementation of the SEA directive is crucial to the success of risk management efforts. At the moment, implementation varies considerably over Europe. The adequacy of the SEA processes regarding the objectives of protection of the environment, integration of environmental considerations into the planning process and transparency, will depend largely on the choices that will be made by each Member State when implementing the Directive. The general requirements prescribed by the Directive are not restrictive and leave ample room for creativity, flexibility and adaptability to suit each Member State's context. (Risse *et al.*, 2003)

The implementation of the Directive may lead to a multitude of systems that may share a lot in common but that may also differ on fundamental aspects such as the screening mechanism used to determine if a SEA is required, the public's role, the integration of SEA into the planning process, the weight given to SEA in the final decision and the monitoring approach used for plans of programmes that have been subjected to a SEA. This situation is liable to considerably complicate the European Commission's task when it evaluates the Directive's overall effectiveness in 2006 (Article 12). (Risse *et al.*, 2003)

Although differences between SEA processes in the European Union may arise, the Directive nevertheless constitutes an important incentive toward the establishment of integrated SEA processes where the public plays a determining role in decision-making and where monitoring is used as a dynamic means for improving the environmental performance of plans and programmes. An important element contributing to the quality and effectiveness of European EIA and SEA – and to the potentials of integrated impact assessment – is the development of a spatial data infrastructure under the INSPIRE initiative. If the problems related to data availability and access of spatial information could be resolved, the time and costs for preparing impact assessment reports could be significantly reduced. This would contribute to better and more transparent planning and decision-making. (Vanderhaegen and Muro, 2005.)

With the proliferation of different forms of impact assessment, there seems to be increasing receptiveness towards the integration of different kinds of assessments and methodologies under a framework of Integrated Impact Assessment (IIA). As Milner et al. (2005, 60) note, there is competition between different strands of impact assessment (e.g. environmental vs. social) and thus a need to guard the integrated impact assessment procedure against the domination of a single perspective. As a potential future development, the prospect of integrated impact assessment could facilitate balancing the different kinds of concerns over different dimensions of vulnerabilities to hazards (See chapter 4).

9.2.5 Interplay between institutions inside and outside the EU

The problem of interplay and coordination is vital across spatial scales in Europe since many developments are taking place in the field of risk management. It needs to be ensured that they are complementary and that resources are not wasted in overlapping work. In Europe the task of coordination is challenging as no central coordination unit exists comparable to, e.g. the Federal Emergency Management Agency (FEMA) in the United States. The FEMA was founded in 1979 and integrated all former disperse structured activities in the field of so called "disaster mitigation". Its mission is to reduce loss of life and property and protect critical infrastructure from all types of hazards through a comprehensive, risk-based, emergency management program of mitigation, preparedness, response and recovery.

An option that could be further studied to meet the challenge of institutional interplay is the creation of a coordination unit on the European level, the European Emergency Management Agency, similar to the Federal Emergency Management Agency (FEMA) or the European Environment Agency (EEA).

This organisation could be responsible for coordination tasks such as:

- Coordinated observation and monitoring of hazards inclusive the given interrelationships between certain hazards in the member states
- Coordination of cross-border activities between the member states and between member states and the non-member states
- The knowledge transfer from the scientific community into administration and politics. For this purpose, an advisory committee with well known scientists would be helpful
- Development of guidelines and handbooks for regional and local mitigation activities
- Development and management of disaster related funds, e. g. funding of local mitigation plans and regional arrangement of objectives
- Arranging competitions for regional and local mitigation activities
- Harmonising the methodological tools within the mitigation process (hazard maps, risk maps, weighting of risks etc.)
- Cooperation with international organisations which are working on this task (UNEP, ISR etc.) as well as other organisations of the European Union, which are related to risks.

Further, the results and developed methodologies of the entirety of ESPON projects can be used and continued in the future to establish a European wide monitoring system to observe spatial risk and its components like natural and technological hazards and economic and social vulnerability.

Beyond the EU 27+2 area, international co-operation is needed in a globalizing world. The Asian Tsunami disaster in December 2004 served as a tragic reminder of the risks related to globalisation. Together with the staggering numbers of local people who lost their lives in the disaster, a considerable number of European citizens, in the capacity of tourists, also lost their lives or were otherwise affected by the disaster. In terms of human casualties, the Asian Tsunami, thus, became the single most devastating natural disaster to face Europe in the recent years. Paradoxically, this did not take place in Europe.

Since the ESPON Programme only deals with the European territory, the Asian tsunami has not fallen under the scope of the ESPON Hazards project. Taking into consideration the effects of globalisation and increasing mobility of European citizens globally, the work in ESPON Hazards project should be complemented by research addressing the issue of global tourism studying the hazards European citizens may face abroad.

The tsunami serves as a reminder that Europe is not isolated from the rest of the world. In the light of the Asian Tsunami, the European Union needs to continue the co-operation in humanitarian assistance through its organisations such as the European Community Humanitarian Office (ECHO) with international bodies. As to strategies addressing prevention and vulnerability reduction, the EU should also cooperate actively within multilateral efforts for disaster reduction and relief. The multilateral organisations and operations of the United Nations are center-stage in this respect.

One of the key processes in this respect is the United Nations International Strategy for Disaster Reduction (UNISDR), where many European countries have participated actively. A new framework for international cooperation under the UNISDR for 2005-2015 was agreed upon in January 2005 in Hyogo, Japan. Under the Hyogo framework, titled "Building the Resilience of Nations and Communities to Disasters", key areas for developing action for the decade 2005–2015 include the following themes, based on the identification of gaps and challenges in the earlier Yokohama strategy (1994):

- Governance: organizational, legal and policy frameworks;
- Risk identification, assessment, monitoring and early warning;
- Knowledge management and education;
- Reducing underlying risk factors;
- Preparedness for effective response and recovery.

Likewise, the activities related to the promotion of sustainable development at the international level also require continued attention. The Johannesburg Plan of Implementation of the World Summit of Sustainable Development (August-September 2002) includes the goal of factoring an integrated multi-hazard approach to disaster risk reduction into policies, planning and programming related to sustainable development, relief, rehabilitation and recovery activities.[13]

As to the specific issue of climate change, the EU should promote a dual strategy of combining climate change mitigation and adaptation efforts to address both the drivers of climate change (green house gas emissions) and the mitigation efforts vis-a-vis the hazards it is likely to alter (See chapter 7 above). International exhange of information and joint research efforts shoulg be promoted in this field.[14] Europe has much to offer to the international community – but it also has much to learn from countries, which have experiences of living with and learning from hazards.

Finally, it should be noted that the effects of globalization constitutes a new set of issues relevant for risk mitigation. The socio-economic and ecological changes resulting from globalisation leading to new patterns of vulnerability (e.g. the mega-cities phenomenon) should be better understood, also in their spatial distribution, so that effective measures could be taken.

13 For a list of multilateral developments in disaster risk reduction, see the annex of the Hyogo Framework document: http://www.unisdr.org/news/OUTCOME-FINAL-as-separate-non-official-document.pdf

14 A good example of such co-operation was the INDO-EU Workshop on Climate Change & Natural Disasters, in September 06-10, 2004, University of Hyderabad, Hyderabad, India. Http://202.41.85.116/indo-eu-ccnd/

9.3 Recommendations for regional and local planning

Policy recommendations go beyond the improvement of the work within existing administrative structures or the existing planning system. This chapter on resilient regional planning focuses on policy recommendations that are of spatial relevance and that extend the present set of strategies, concepts or instruments.

These recommendations are discussed in length under chapter 11 (Guidelines on spatial planning for risk reduction – outline of a handbook on risk assessment and management) which includes a more detailed account on development of planning procedure and risk mitigation plans attached to the SEA directive. The idea behind Chapter 11 is to show how planning recommendations developed by the ESPON Hazards project can be integrated into the spatial planning process. This chapter will focus more on the aspect of processes, which are widely usable, independently from national or regional settings and regulations.

9.3.1 Space-type-concept

The space-type concept is valid for Member States with an institutionalised regional planning that includes legally binding regional plans or other forms of binding effects.[15] The space-type-concept is designed to prohibit and/or restrict settlement within hazardous areas. By these means further additional damage potentials can be prevented.

- *Priority zones (e. g. for flood prevention):* Exclusion of all uses, which are inconsistent with the priority function. Priority in these terms means that there is a land-use priority for a certain hazard – or in other words: because of the possible occurrence of (a) certain hazard(s), no other land-use will be allowed. This means a strict settlement prohibition in threatened areas which is binding for local land-use planning as well as other planning divisions (e. g. transport planning etc.).
- *Reserve zones:* Settlement restrictions, consideration of given threats through building protection or exclusion of especially threatened (e. g. schools, hospitals) and hazardous (e. g. chemical plants) facilities.

The basis for those binding designations should be suitable hazard and risk maps. Such a system has already been implemented in Switzerland and partly in Germany. However, this concept is primarily single hazard oriented, whereas spatial planning should be space oriented. Hence, a further development for fulfilling a multi hazard approach would be desirable on the ground of synthetic risk maps which are based on the specific risk situation in a region. For this purpose also, the Delphi method was used in the case study regions.

The main idea of the multi hazard, spatial oriented concept is based on the given interrelationships between the several hazards on the one hand and the interaction with the spatial structures (settlement, transport network etc.) on the other hand. According to the classification of regional planning it is also valid for category A countries (see 2nd Interim Report, p. 146).

15 According to the classification of regional planning in Europe, these countries belong to category A (see ESPON 1.3.1, 2nd Interim Report, p. 146).

- *Risk priority zones:* Similar to the above described space-type-concept the spatial oriented concept deals with settlement restrictions. Those areas which have been identified as high risk areas, threatened by a single hazard and/or a combination of different hazards which are strongly interlinked (e. g. earthquakes and great dams) should be designated as risk priority zones. For this purpose, a normative decision about the highest acceptable risk has to be done. Within those zones, which cross this boundary of acceptance, any settlement should be prohibited, that is able to increase the present damage potential.
- *Risk suitability zones:* Vice versa, risk suitability zones could be designated. This type is characterised by a risk level below average (e. g. low population density, absence of certain natural hazards like earthquakes etc.). Due to this fact, those areas are principally suitable for the allocation of risky infrastructure, which is fragile on the one hand and/or could de dangerous for its surroundings, if a disaster occurs (e. g. nuclear power plants).

This has to be carried out by regional planning authorities and regulated in a legally binding regional plan. Although such a spatial oriented concept has not been implemented yet there are already research efforts going on in this field (e. g. Faculty of Spatial Planning, University of Dortmund, Germany, supervised by Stefan Greiving).

9.3.2 Arrangement of objectives

The concept of arrangement of objectives is applicable for all Member States with or without an institutionalised regional planning and with or without binding regional plans. A pilot project was carried out in Switzerland (Baumann and Haering, 2000).The setting of protection goals for given regions, which are threatened by specific hazards, was described as an important task within the ideal risk management process (see chapter 3.2). One could understand this as a political task which should be carried out on a superior level (e. g. for a whole catchment area or the national level).

The main idea behind the setting of protection goals is to produce arrangements in combination with a quantitative output-control instead of inefficient funding of single projects, without any care for results. The government has to take care of the financial funding, the regional level takes the responsibility for the fulfilment of the arranged protection goals.

An important characteristic of this strategy consists in the regional responsibility for the choice of certain measures, which are all suitable to fulfil the fixed goals at the same time. Mostly, regional actors are more likely able to find appropriate solutions than the national government, which is less informed about the relevant regional circumstances. Furthermore, the regional actors in many cases represent at the same time the communities, which are threatened by a certain hazard.

An additional advantage consists in the possible integration of non-governmental organisations and private stakeholders (e. g. companies), which are obligated by spatial plans in those countries where an institutionalised regional planning with legally binding plans exists. In opposite to the restrictive procedure of binding plans, the proposed model offers a moderate, consensual way with self-binding effects. Therefore, one can understand those product arrangements as a kind of regional governance.

The following table figures out how this kind of product arrangements could be implemented by the example of flood hazards. Principally the procedure could be used as a part of a risk mitigation strategy for every combination of hazards which threaten a certain area.

Table 42: Arrangement of objectives – example

Arrangement element (goal)	Objective		Indicator
Reduction of the probability of occurrence	Improvement of the storage capacity in a certain part of a catchment area in cubic metres	by means of a central reservoir (alternative 1)	Realised storage capacity in cubic metres
		by means of decentralised water storage (alternative 2)	Realised storage capacity in cubic metres
	Construction and/or improvement of dikes		Amount of the protected facilities in €
Reduction of the damage potential	Improvement of individual building protection		Amount of the protected facilities in €
	Funding of private out-settlement activities		Realised reduction of the damage potential in €

9.3.3 Mitigation plan

A mitigation plan is the summary of scientific results and political decisions to mitigate natural and technological hazards. After assessing the problem, setting goals and objectives and reviewing all the possible solutions, the most appropriate actions have to be selected and recommended. This effort culminates in the written plan – a series of recommendations detailing what will be done, by whom and when. It is the key output of the risk management process. Although not only restricted to spatial issues, a mitigation plan offers the possibility to integrate sectoral and spatial goals, objectives and measures and therefore is an important element of resilient spatial planning. A mitigation plan should ideally be made on the regional level so it can provide authorities on lower levels (communities) with information about risks and hazards. Nevertheless, it can be also made on the national level (if no regional level exists) or on the community level (then binding for the citizens etc.).

To date, no examples exist of a comprehensive mitigation plan in any country in Europe. Other countries – like the U.S. or Japan – have experience with mitigation plans and provide information for regional and local authorities how to set up such a plan. An appropriate possibility to integrate mitigation plans and spatial plans on an EU wide level will be the implementation of the Strategic Environmental Assessment (SEA), which came into force by EU directive 2001/42/EC in 2001.

9.4 Summary of the policy recommendations

I. Guiding principles:

1. Risk management should be made an integral and explicit part of EU cohesion policy, since the different hazards maps have shown how omnipresent hazards are in the territory of the EU. This calls for better coordination of policy measures at all spatial scales.

2. Stress *vulnerability reduction* as a key strategy in policy and planning. Recognize that vulnerability concerns the human and social side of risk, including their spatial patterns, as visible on the integrated vulnerability map.

3. Aim for polycentric spatial development to balance patterns of vulnerability in Europe. Ensure that all the aspects of vulnerability (economic, social, ecological) as considered in the integrated vulnerability map are taken into account.

4. Include both substantive goals and procedural rules related to vulnerability reduction and risk mitigation into policies and programmes

II. EU-level instruments

5. Coordinate the use of Structural Funds for risk management: a) Use criteria relevant to risk and vulnerability to identify a region as eligible to funding through the Structural Fund objectives 1, 2 or 3 (e.g. highly sensitive areas, identified by the aggregated risk map); b) Direct structural assistance to projects that reduce the hazard potential and the damage potential or that increase the coping capacity; c) Monitor the risk and safety impacts of structural assistance.

6. Implement the recommendations of the 6th Environmental Action Programme in broadening the scope of the SEVESO II Directive.

7. Ensure the effective implementation of the strategic environmental assessment (SEA) directive. Integrate risk mitigation principles for planning into its implementation (in countries where not yet implemented) (see also chapter 11).

8. Ensure fluent co-operation between different ongoing initiatives in the field of hazard and risk management, including legislative and financial instruments; especially in those areas which are affected by the same hazard cluster, identified in chapter 6.2 or belong to the same natural unit like a catchment area, which is threatened by a river flood.

9. Secure EU cooperation in risk mitigation in the international arena through multilateral cooperation, taking into account the effects of globalization such as increasing mobility of European citizens. This is in particular important for dealing with technological hazards related with transport infrastructure, as shown in the chapters 2.2.1 and 2.2.4.

10. Provide guidance and information on risk mitigation. Support the publication of a “European handbook for Risk Mitigation” A step-by-step guidance paper for regions and communities about how to mitigate to natural and technological risks (see chapter 11 for an outline).

III. Meso-level (national, transnational co-operation, Interreg)

11. National authorities should recognize the upgraded status of risk mitigation in the remodelled cohesion policy for the period 2007-2013 and include principles of vulnerability reduction and risk mitigation in the programme guidelines. Programme guidelines can be changed to this direction already prior to 2007. Pay special attention to the identified hazard clusters and adapt the programme guidelines in the several Interreg regions in accordance with the given hazard potential (e. g. winter storm - storm surge interaction, Interreg NWE, see chapter 6.3).

12. The implementation of the Strategic Environmental Assessment directive (2001/42/EC) should be ensured by member states, preferrably in a uniform fashion across Europe, broadening the scope of all plans and programmes with potential effects on risk and vulnerability. The dimension of risk assessment should be integrated to other impact assessment methods.

13. Enhance the use of the Water Framework Directive (2000/60/EC) for integrating land use planning and water resources management in support of risk management (not only water quality) purposes, to make use of potential synergies of the Water Framework Directive and of flood risk management plans as elements of integrated river basin management; as mentioned in the Council Conclusions of October 2004.

14. Improve integration and co-operation between spatial planning experts and civil protection authorities. (This applies to other spatial levels as well) Support the process of drafting common civil protection guidelines in the EU, while strengthening the aspects related to spatial planning and risk prevention. Concentrate on concepts, which refer to highly sensitive areas as identified in the aggregated risk maps.

15. Create and support governance networks to address risk management in regions with special environmental characteristics and related challenges as figured out in the aggregated hazard maps and the hazard cluster map (e. g. coastal areas, mountain areas). Establish and use European Groupings of Cross-Border Cooperation (EGCCs), envisaged by the revised cohesion policy, to oversee cross-border risk mitigation efforts.

IV. Regional and local level

16. Adopt and implement regional mitigation plans, allowing for “subsidiarity” by taking into account both the extent of different hazards and the best information and expertise is situated. The mitigation plans should be based on solid scientific and geographical information and they should designate hazard priority and reserve zones, as suggested by *space-type concept* as outlined in (see chapter 11.2.)

17. In order to support regional mitigation plans, adopt measures in the new Thematic Strategy on the Urban Environment (COM 2004, 60 final).

18. Enhance horizontal co-operation between regions and urban areas (e.g. through networks such as Interreg initiatives, EUROCITIES etc.) in the fields risk management and civil protection.

19. Enhance public awareness of hazards and encourage public participation in risk reduction efforts.

20. Pay special attention to technological hazards in central and urban regions, since they are highly affected and at the same time vulnerable (see aggregated technological hazard map). Take the vulnerability of the surrounded area into account by allocating hazardous infrastructure. Such an obligation has been implemented so far only for major accident hazards.

21. Adopt local mitigation plans based on the best available knowledge on hazards. Criteria for the quality and funding of these plans should include the following:
    - Multi-hazard approach, including "domino" effects
    - Integration of the relevant vulnerability components
    - Facing all elements from prevention oriented mitigation to preparedness, response, recovery (i.e. the DPSIR chain).
    - Public participation; integration of private stakeholders in risk assessment, decision making, choice of measures and implementation

22. Accept and enforce the mitigation plan as a guideline for all other municipal activities with a relation to hazard exposure and vulnerability (e. g. local land-use plans, investments in public infrastructure etc.).

V. Monitoring and research

23. The results and developed methodologies of the entirety of ESPON projects should be used and developed to establish a European wide monitoring system to observe spatial risk and its components like natural and technological hazards and economic and social vulnerability. This monitoring system should further develop hazard interactions and cumulative effects like outlined in the hazard cluster map in order to cover multi-risk settings. This effort should be coordinated with the INSPIRE initiative.

24. Improve European hazard monitoring systems at spatial scales suitable to the type of different hazards. Monitor damage potentials and coping capacities at the European level (in the context of European cohesion), at the national or regional level (coping capacity) and respectively on the regional or local level (damage potential).

25. Expand the ESPON Hazards project's exercise to study the effects of hazards pertaining to issues of globalisation as a driving force for vulnerability to hazards. This should include a study of European tourists to hazards, as exemplified by the tragedy of the Asian tsunami in December 2004.

10 Summary of European Case Studies

10.1 Case studies within ESPON Hazards project

In the ESPON Hazards project case studies are integrated with the aim of deriving knowledge on issues, which are beyond the possibilities of the EU-wide approach of the project. Case study investigations refer especially to the screening of spatial planning responses and the development of methodologies for regional risk review. Concrete sites offer the opportunity of uncovering the reality of risk management in spatial planning. This provides information relevant for the development of indicators and for testing their limitations in practice. Four case studies are used to extract information important in different parts and phases of the ESPON Hazards project:

- Dresden Region, Ge
- Centre Region of Portugal, Pt
- Itä-Uusimaa, Fi
- Ruhr District, Ge

The case studies allow methodological tests and detailed investigations including document reviews and stakeholder interviews (e.g. spatial planning administrations) enlighting specific aspects of regional hazards, vulnerability, coping strategies, awareness, official response, administrative capacity, etc. These investigations are important for methodological advancement such as the development of a weighting method for hazards and the development of a vulnerability index. Furthermore, findings regarding planning reality lead towards specific recommendations for future development of risk management by means of spatial planning and development in Europe. As reference level for case study investigation NUTS3 level as the one widely used for regional planning was chosen.

Case studies have mainly been employed for three purposes:

- Review of the reality of spatial planning response in the field of risk management
- Testing and advancement of the Delphi method for the weighting of hazards and vulnerability indicators
- Realisation of exemplary inner regional risk reviews

Detailed case study reports are included with Annex 2 of the report.

10.2 Review of spatial planning response

Of special interest for the ESPON Hazards project is the spatial planning response as part of the overall risk management. Its review has been accomplished by ESPON Hazards project partners in cooperation with regional planning authorities mainly by document analysis and interviews with stakeholders of regional planning. The goal was to enlighten selected aspects of existing regional planning as far as it is related to risk management. The review does not claim to be complete as its aim is to indicate main features describing the spatial planning reality of response to risk.

The case study areas show different planning responses to risks. In the following, main characteristics of the pilot sites with relation to risk management by means of spatial planning are presented. The review is based on case study findings and is performed in the scope of a Strengths-Weaknesses-Opportunities-Threats framework

(SWOT). In this scope main characteristics are listed relating to the regional planning system and its relation to risk management.

Main mutuality of the regions is the observation that while planning systems offer an effective framework for spatial planning, the consideration of risks is systematically underdeveloped. All case studies report about only selected treatment of hazards. Whereas risk related planning only rudimentary exists also methodological and data gaps offer only limited potential for risk assessment and prevent from systematic integration of risk management aspects into spatial planning.

The availability of implementation tools and controlling mechanisms seems differently developed in different planning systems. The settlement of regional planning at different administrative levels and its different legal backing enables different coordinating and enforcement power of regional planning. Public participation at the operational level of spatial planning may play an important role for the acceptance of spatial planning.

Main opportunities lie in the partially growing sensitivity to risk and in the emerging risk management approaches in practice. Established administrative capacity and effective implementation of European regulations paves the path towards European-wide introduction of systematic (multi-) risk management by means of spatial planning. However, growing sensitivity and methodological advancements threat to fail in case if risk management remains exclusive to selected hazards and if insufficient capacity for their implementation and controlling are developed.

10.3 Applying the Delphi method for inner-regional weighting of hazards

The background for the Delphi method and its application to multi-hazard cases has been presented in chapter 3. All aspects relevant for case study investigation are addressed there. For this reason, no further comments are made here.

Preparing the application of the Delphi method, it was tested and its operation advanced in pilot sites. Here the method was mainly used for weighting different hazards relevant for the pilot region. Hazards have been selected within the case study areas based on a joint set of hazards. From these, particularly relevant hazards could be selected, or the full set of hazards could be presented to the expert panel.

Varying from the set of hazard presented in chapter 2 in pilot areas a different set was used, as dam failures were included. In some pilot areas also vulnerability indicators were weighted, using population density and GDP per capita. Due to data availability in the Center Region of Portugal it was possible to select additional resp. alternative indicators for testing at the inner-regional level (Annex 2).

Table 43: SWOT analysis of regional planning response in case study areas

	Strengths	Weaknesses	Opportunities	Threats
Region of Dresden (applies likewise to Ruhr District)	Well developed hierarchical planning system and planning culture Sound legislative planning background Clearly distributed competences Various spatial planning tools available at different levels Area-wide spatial planning at different levels Hazard prevention and mitigation included in various legal acts Well developed control mechanisms integral to plan development Acceptance of once approved spatial planning regulations	Missing systematic consideration of risk in spatial planning Missing requirements for integration of risk issues in spatial planning Disperse risk related regulations Selective treatment of hazards Missing consideration of vulnerability issues Missing data basis for assessment of hazards and vulnerability Missing practice of systematic and comprehensive risk management	Growing sensitiveness to risk issues Developing risk management approach with regard to floods Availability of approved spatial planning instruments for development control, applicable to risk issues Well developed administrative commitment Effective implementation of European regulations	Limitation of risk management approach to most present risks omitting systematic multi-risk thinking Failing to establish sufficient administrative capacity for risk related planning Failing to establish sufficient legislative and political backing for risk related development control
Centre Region of Portugal	Planning system developed at different levels Regional planning backed by national legislation Good legislative basis for flood risk management Existing data base for Flood risk management Emergency plans developed at different levels and for different hazards	Missing area-wide strategic plans Limited binding character of regional plans Missing risk documentation for planning issues Missing systematic risk assessment Missing systematic risk management	Central planning level (NUTS II) allows balance of local interests in the scope of risk management Developing risk management approaches (e.g. floods, forest fires, uranium mining)	Failing to establish systematic risk management approach covering all risks Limitation of advancement of risk management approach to selected hazards
Region of Itä-Uusimaa	Well developed hierarchical planning system and planning culture Sound legislative planning background Clearly distributed competences Area-wide spatial planning at different levels	Missing systematic consideration of risk in spatial planning Disperse risk related regulations Missing data basis for assessment of hazards and vulnerability Missing practice of systematic and comprehensive risk management Missing data basis for risk evaluation Limited binding character of regional plans	Well developed spatial planning cooperation between municipalities Well established public participation in spatial planning Effective implementation of European regulations	Failing to establish systematic risk management approach covering all risks

10.4 Method for inner-regional risk review using weighting results

Weighting results derived by the Delphi method are used as additional information when drawing inner-regional risk profiles of each case study area. This was an important step for testing and advancing the methodology as well as for producing first indicative results as basis for further case study investigation including partners from regional planning and risk management practice.

The method for generating inner-regional risk profiles is based on the risk concept applied by ESPON Hazards project, which sees risk as the coincidence of hazard and vulnerability (chapter 4.4). This is accomplished by combination of hazard information with vulnerability represented by two indicators. Both factors are considered weighted, while mainly hazards are weighted by the use of the Delphi method. In the following, the method is described as a sequence of steps leading towards the regional risk class. An overview is presented in Figure 15.

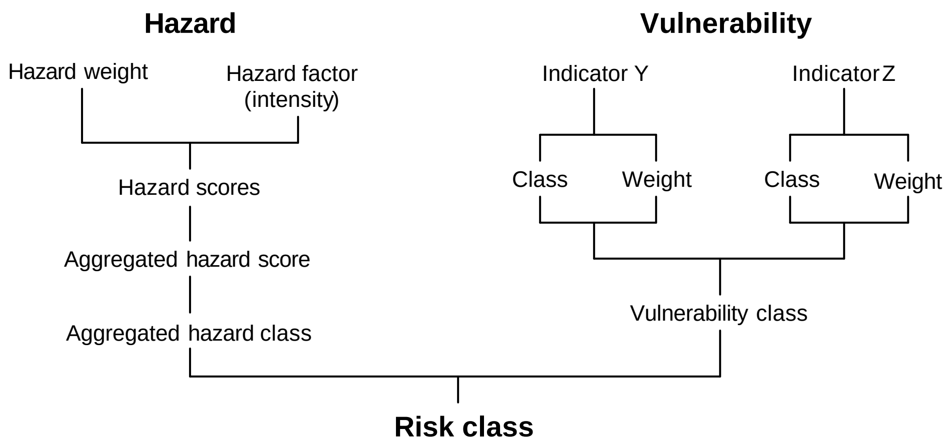

Figure 15: Procedure of derivation of risk classes

<u>1) Preparation of relative weights assigned by the panel of experts to each single hazard</u>

Weights are provided within each case study chapter in the shape of a summary table.

<u>2) Deriving the hazard factor</u>

The *hazard factor* is derived from the regional intensity class of each hazard (Table 44). Different methods for hazard assessment exist in practice. In the ESPON Hazards project hazard intensity classes were established by combination of statistical probability of event and the magnitude of past events. The hazard factor is used as a multiplier for establishing the weighted hazard score (Table 44).

Table 44: Hazard intensity classes and the corresponding hazard factor

Hazard intensity class	Hazard factor
1	0,2
2	0,4
3	0,6
4	0,8
5	1

3) Aggregating the weighted hazard scores

The weighted hazard score is obtained by the combination of single hazard weights and the assumed hazard intensity on NUTS3 level. However, not for every hazard scientifically based information about the intensity of reference is available. The missing values were estimated relative to the existing data with experts' help. Weighting factors for each hazard and hazard factors obtained from the potential hazard intensity are multiplied to obtain the individual weighted hazard score for each hazard (see also table 45):

weighted hazard score

=

individual hazard weight * single hazard factor

By adding the individual hazard potentials the aggregated *weighted hazard score* of the region is obtained. The expected outcome (sum of all hazards potentials) delivers a figure between 20 % (in case if all hazard intensities are class 1) and 100 % in case that all hazards have the intensity class 5. As an example, in the Dresden region the scores sum up to 38,6 (table 45).

Table 45: Establishing and aggregating weighted hazard scores

Hazard (extract from Dresden region)	Weight	Hazard intensity class*	Hazard factor	Weighted hazard score
Volcanic eruptions	0,2	1	0,2	0,0
Floods	24,8	3	0,6	14,9
Landslides/Avalanches	2,8	1	0,2	0,6
Earthquakes	0,4	1	0,2	0,1
(...)	(...)	(...)	(...)	(23,0)
sum	100			38,6

4) Classifying the aggregated hazard

To obtain the aggregated hazard class, the calculated aggregated weighted hazard score is classified on the basis of a 5 classes scale (table 46).

Table 46: Classification of the aggregated hazard class

Aggregated hazard class	Obtained aggr. hazard scores
1	20 – 35
2	> 35 – 50
3	> 50 – 65
4	> 65 – 80
5	> 80 - 100

5) Derivation of the vulnerability class

Decisive for the differentiation between the sub-regions is vulnerability information at the sub-regional level and weighted as resulted from the weighting procedure. Vulnerability is represented by a simplified vulnerability class for each area of reference:

Vulnerability class

=

Indicator Y * indicator weight + Indicator Z * indicator weight

Table 47 shows the calculation of the vulnerability class for a sub-region of the Dresden region using the indicators 'GDP per capita' and 'Population density'. The result is a weighted vulnerability class for each NUTS3 region within the case study area.

Table 47: Derivation of vulnerability class (example from Dresden Region)

NUTS3 level Districts (extract from Dresden Region)	**Population density (55 %)**			**GDP per capita (45 %)**			**Vulnerability class** Weight 55 : 45 %
	Value (pers/km^2)	% (EU 15 average = 100)	class	value*	% (EU 15 average = 100)	class	
City of Dresden	1.455	1.233	V	23.145	112	III	**IV**

6) Derivation of risk classes

The derivation of risk classes is the final step, which is accomplished through the combination of the aggregated hazard class with the obtained vulnerability class. This is done by the use of a matrix (Table 48). Both hazard and vulnerability are weighted 50/50 and therefore, no further calculation is necessary.

Table 48: Derivation of the regional risk profile through combination of hazard and vulnerability

Aggr. Hazard (class)	**Degree of vulnerability (class)** (example from Dresden Region)				
	I	**II**	**III**	**IV**	**V**
I	2	3	4	5	6
II	3	4 • Riesa-Großenhain • Sächsische Schweiz • Weißeritztalkreis	5 • Meißen	6 • Dresden	7
III	4	5	6	7	8
IV	5	6	7	8	9
V	6	7	8	9	10

Regional risk profiles are drawn for the chosen areas of reference. In dependence of data availability the presented procedure allows to refine the risk profiles to different levels such as for NUTS3, 4 or 5 levels. Due to limitations of existing data, in the case study areas NUTS3 level was chosen as the level of reference. Exemplary synthetic risk maps for the pilot regions are provided with the case study reports (Annex 2).

10.5 Conclusions from weighting and generation of regional risk profiles

Conclusions presented in this chapter might overlap with those presented in chapter 3. Conclusions presented in the following relate specifically to testing in case study areas and partially reflect intermediate lessons learned from methodological tests, which in effect led to the application of the Delphi method at the European level.

A consensus based regional risk profile can be a helpful information basis for regional planning. Relative weighting in multi-hazard hazard cases is a valuable contribution to transparency in decision-making in spatial planning and could lead to better acceptance of mitigating measures. As a consequence, the currently prevailing selective consideration of single hazards is put into perspective. The proposed procedure for derivation of a regional risk profile has review character and offers a screening that may be a step towards a systematic risk assessment.

Applied to the weighting of hazards, the Delphi method offers indicative and subjective information. However, accepting that the question of weight is uncertain and to a certain degree subjective (chapter 3) the chosen way of weighting appears a good compromise. It is important to ensure good quality of results by careful selection of participants for the expert panel. Quality of results relies not only on the acquaintance of experts with the issue, but also with used concepts (e.g. risk, vulnerability) and the preparedness to fully accept the inquiry method. Not least the clearness of the matter of weighting is decisive about the comparativeness of replies. For example, certain hazards may be perceived as overlapping if not precisely defined and delimited against each other. In case study investigations, potential interferences were found between the hazards 'extreme precipitations' and 'floods' as well as between 'extreme temperatures' and 'droughts'.

With respect to weighting, potential sources of distortion must be considered. One of those is possible overestimation due to the presence of recent events. This seemed to be the case in the Dresden region where the enquiry was done few months after the August 2002 flood. Another source is underestimation due to unawareness of risk e.g. in case of infrequent events. Also missing knowledge of hazard propagation can lead to distortion in either direction.

The biggest obstacle on the way to reliable risk profiles remains the lacking availability and limited resolution of impartial data on hazard and vulnerability. Hazard intensities had partly to be estimated to enable the methodology test. Therefore, the representativeness of applied information remains limited. This is especially true the more heterogeneous (naturally and societally) the reference area is. Particularly vulnerability indicators need further advancement to allow for comprehensive and representative consideration of damage potential, exposure and coping capacity. The chosen reference level (NUTS3) used as basis for the Delphi investigation in the case studies does not offer the appropriate spatial scope for detailed (small-scaled) information which are needed for operational, local level of planning. As an answer, the Ruhr District case offers some ideas for a more detailed risk assessment based on the analysis of the given hazard intensities and including thematic information leading to more detailed results.

Nevertheless, the Delphi method and the applied procedure for deriving inner-regional risk profiles offer valuable indicative information for subordinate administrative levels even though much potential remains for further development which is in the first instance related to the availability of impartial data.

11 Outline of a Handbook on Risk Asessment and Management

Dealing with spatially relevant risks has two components: risk assessment and risk management (see Figure 16):

- *Risk assessment:* Risk assessment is the result of the assessment process of risk analysis and risk evaluation. Risk analysis is a result of the hazard and the vulnerability analysis. It can be understood as a description of certain hazards, respectively their elements frequency and magnitude of occurrence (hazard component) and their impacts (risk component). Risk evaluation is concerned with determining the significance of the analysed risks for those who are affected. It therefore includes the element of risk perception (the overall view of risk held by a person or group and includes both feeling and judgement). Risk assessment in general follows analytical procedures.
- *Risk management:* Risk management is defined as adjustment policies which intensify efforts to lower the potential for loss from future extreme events (related to the definition of Mileti *et al.*, 1981; Nigg and Mileti, 2002). Such adjustment policies refer to a broad range of guidelines, legislation and plans that help to minimise hazards and vulnerabilities (i.e. minimising the exposure to a hazard or maximising coping capacity of a region or community by, e.g. guaranteeing resources and preparing adequate plans for pre-disaster mitigation and post-disaster response measures).

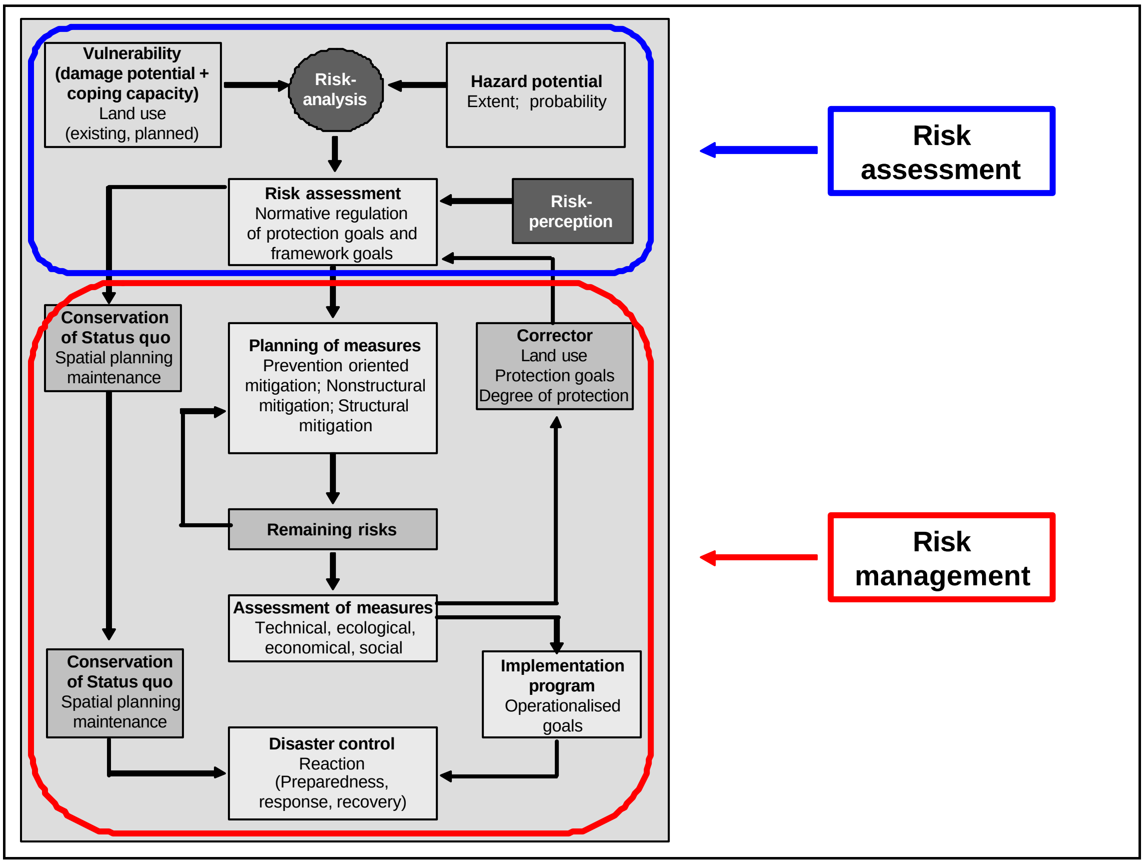

Figure 16: Dealing with risks: Risk assessment and risk management and its elements. (Greiving 2002, p. 248)

This distinction between risk assessment and risk management also finds its expression in the DPSIR indicator model the ESPON Hazards project follows:

- *Driving force (D), pressure (P), state (S), and impact (I):* These indicators belong to the elements of the risk assessment process which in the following will be covered by the suggested procedural steps of the SEA directive (European Union, 2001).
- *Response (R):* Response indicators belong to the area of risk management which can be divided into mitigation (prevention oriented, structural, and non-structural mitigation) and reaction (preparedness, response, and recovery).

In the ESPON Hazards project, mitigation – as a part of risk management – is defined as "a proactive strategy to gear immediate action to long-term goals and objectives". Risk mitigation is the combination of the two approaches of managing the hazard side and managing the vulnerability side (damage potential and coping capacity) of risk. The question, which approach should be emphasised more depends on the specific regional or local circumstances. In some cases it might be more important to manage the hazard, e.g. when existing values are threatened. In other cases, it makes more sense to manage vulnerability. It is easier, e.g. to avoid floodplains than to build structures to control flooding. Thus, there are a variety of mitigation strategies and measures that can manage the hazards and the vulnerability of a region or a municipality.

This report mainly concentrated on the assessment of hazards, vulnerabilities and risks on a European wide spatial level. Indicators that were developed in this context thus belong to the first group of driving forces, pressures, states, and impacts. Chapter 11 deals with responses to natural and technological hazards and the risks that result from them. The aim of this chapter is to suggest and discuss possible contents of a framework for dealing with risks in European regions and towns. This framework can be seen as a guideline for a handbook for dealing with spatially relevant risks. Until today no such idea has been developed on a European level. Nevertheless there are several examples of handbooks on risk mitigation from some Member States and also from non-European countries, e.g.:

- *United States, Federal Emergency Management Agency:* The Federal Emergency Management Agency (FEMA) published a series of so called "how-to guides" for mitigation planning on the state and local level. The core guides cover the basics of developing a mitigation planning process (FEMA, 2002), hazard identification (FEMA, 2001), identification of actions and implementation strategies (FEMA, 2003a), and implementation of a mitigation plan (FEMA, 2003b).
- *United States, Portland, Oregon Metropolitan Area:* The Portland, Oregon Metropolitan Area developed a regional hazard mitigation policy and planning guide which was funded by FEMA (POMA, 1999). It also covers the main steps of a hazard mitigation process.
- *France:* The French government published a general guide for the development of prevention plans (plans de prévention des risques, PPR) for natural risks (Ministère de l'environnement, Ministère de l'équipement, 1997a) as well as several methodological guides that aim at the development of prevention plans for coastal risks (Ministère de l'environnement, Ministère de l'équipement, 1997b), risks of forest fires (Ministère de l'écologie, 2002), seismic risks (Ministère de l'équipement, 2002), and flood risks (Ministère de l'environnement, Ministère de l'équipement, 1999).

The idea behind Chapter 11 is to show how planning recommendations developed by the ESPON Hazards project can be integrated into the spatial planning process. This, of course, can only be done in a general way. Thus, the aim and the degree of detail of Chapter 11 are not to develop a handbook of risk mitigation that is applicable anywhere in Europe. Such a handbook would have to take into account all specific national (and regional) regulations and would simply not be suitable within this project, which aims at addressees at the European level. Therefore this chapter aims at setting guidelines or a framework of aspects that should have to be taken into account when developing a handbook for risk mitigation. For this reason this chapter will focus more on the aspect of "processes", which are widely usable, independently from national or regional settings and regulations. The structure of this chapter is as follows:

- *Analytic part (Chapter 11.1.):* Risk assessment methodologies have a general validity and therefore risk assessment is valid for all spatial levels, including the regional and local ones. Consequently, risk assessment will be only discussed in general and not for specific planning levels.
- *Normative part (11.2):* The normative risk management part will be presented for the regional and local level separately, keeping in mind the given differences in scale, instruments and decision making.
- "*Tool" part (Chapter 11.3):* This part mainly reflects on the SEA directive as a given legal and procedural framework for an ideal risk assessment and management process,
- *Summary and outlook (Chapter 11.4).*

11.1 Risk assessment

The purpose of a spatial related risk assessment is to summarise all information available about hazards and vulnerability and to provide the necessary scientific foundation for decisions about tolerating or altering risks. Before a risk assessment starts, though, the *identification of relevant hazards* and of their eventual cumulative and/or transboundary effects has to be undertaken. As mentioned before, risk assessment is an analytic task. It consists of the outcome of risk analysis as the scientific basis and risk evaluation as a result of political and social values.

In the end of an assessment an objective weighting of all significant effects on the environment will be carried out. This assessment is an essential task for the spatial planning authority and has to be integrated into the weighting process. Such a risk assessment can be structured similar to the steps required according to the SEA directive where one of the criteria for determining significance of effects are the characteristics of the effects on the environment and of the area likely to be affected (see Chapter 11.3).

11.1.1 Hazard identification

The starting point for any risk assessment is the identification of hazards. The purpose of the hazard identification is to inform the relevant stakeholders about the nature and extent of natural and technological hazards capable of affecting the region and the municipalities and to provide a basis for policies, goals, objectives and measures to minimise future losses from the effects of such hazards.

The hazard identification therefore first asks which hazards should be considered in a risk mitigation process and is based on the *probability, duration and frequency* of possible hazards. Further, the *cumulative nature of the hazards* and the *transboundary nature of the hazards* have to be shown.

The task of hazard identification is mainly a determination based on scientific and technical findings. Identification as well as analysis of hazards and risks are mainly tasks for experts in the non-spatial planning field like safety managers, sectoral planning divisions and authorities due to their specific competences. For that reason, an early and full coordination between the spatial planning authority (which is in charge of a certain plan) and the relevant other authorities that are involved, is an essential prerequisite for an effective planning process.

Handbook contents, Part 1

1. Identification of hazards
Question: Which natural and technological hazards exist inside the area of concern (region, municipality)?
Whom to ask: Environmental and risk related authorities, safety managers, sectoral planning divisions, insurance and re-insurance companies.

2. Cumulative nature of hazards
Question: Do the existing hazards in the area of concern cumulate in typical sets and are they characterised by typical interrelations?
Whom to ask: Environmental and risk related authorities, safety managers, sectoral planning divisions, insurance and re-insurance companies, evaluation of historical reports/regional or local archives/newspaper archives on hazards.

3. Transboundary nature of hazards
Question: Do the hazards in the area of concern cross national, regional or municipal borders?
Whom to ask: Environmental and risk related authorities, safety managers, sectoral planning divisions, insurance and re-insurance companies, neighbouring regional or local authorities.

11.1.2 Risk analysis

Risk analysis is carried out in three steps by (1) analysing the hazard side, (2) analysing the vulnerability side and (3) combining both to identify the risk to the people and their environment in the area of concern. Many methodologies exist to analyse risk. They differ quite largely but all follow a common logic. In the context of spatial planning an indispensable requirement is to take an aggregated view of risk, i.e. to consider all relevant hazards or risks within an area. Only few methodologies fulfil these requirements, among them the "Integrated Risk Assessment of Multi-Hazards" as described in Chapter 5 (a different methodology of risk analysis is described by Cutter, Mitchell and Scott, 1997, p.12 ff.).

When analysing the hazard side of risk, the *magnitude and spatial extent* of the hazards *(geographical area likely to be affected in which intensity)* have to be identified. Analysing the regional or local vulnerability means to estimate *value and vulnerability of the area (e.g. size of the population) likely to be affected* by the identified hazards (damage potential) due to *(a) special natural characteristics or cultural heritage, (b) exceeded environmental quality standards or limit values and (c) intensive land-use*. From a theoretical point of view, the estimation of the regional vulnerability further comprises the identification of the coping capacity to mitigate risks within an area. For practical reasons, however, coping capacity often is not considered within risk analysis but is regarded separately as an essential part of the risk management elements. Finally, the result of any risk analysis allows a statement on the existing *risks to human health or the environment (e.g. due to accidents)* and *the effects on areas or landscapes, which have a recognised national, European Community or international protection status*. A weighting of hazards and vulnerability factors may help to adjust the results of the risk assessment according to the real situation. This weighting can be done by a carefully selected group of experts in order to stress certain elements within the risk evaluation process. Such a weighting process could be done by the use of the Delphi method (Chapter 3.1).

Handbook contents, Part 2

4. Hazard analysis
Question: Which is the magnitude and spatial extent of the hazards (geographical area likely to be affected in which intensity)?
Whom to ask: Environmental and risk related authorities, safety managers, sectoral planning divisions, sectoral planning divisions, insurance and re-insurance companies.

5. Vulnerability analysis
Question: Where are vulnerable areas and which degree of vulnerability does exist there (values or size of the population or environment likely to be affected due to special natural characteristics or cultural heritage, exceeded environmental quality standards or limit values and intensive land-use)?
Whom to ask: Environmental and risk related authorities, sectoral planning divisions, insurance and re-insurance companies, spatial planning authorities, national, regional or local statistical authorities.

6. Risk analysis
Question: What is the degree of risk to human health or the environment or economic values and how should hazards and vulnerability factors be weighted?
Whom to ask: Environmental and risk related authorities, safety managers, sectoral planning divisions, insurance and re-insurance companies, spatial planning authorities.

11.1.3 Risk evaluation and assessment

Risk evaluation is concerned with determining the significance of the analysed risks for those who are affected. It therefore includes the element of risk perception (the overall view of risk held by a person or group and includes both feeling and judgement). On its own, risk analysis is in reality partly subjective because the precise knowledge to be truly objective is rarely available (e.g. full information about frequency and magnitude). So it may well be right that decisions are made partly in response to pressures generated by perceptions of risk. This requires an extensive participation of the public but also experts from spatial and sectoral planning divisions.

An agreement on the relevance of certain risks is essential in order to reach an agreement on goals and solutions within a risk management process. In this context the Delphi method – like described in Chapter 3 could be useful to evaluate the significance of risks to the public and decision makers.

Handbook contents, Part 3

7. Risk evaluation
Question: How do experts and the public evaluate the existing risks on the basis of individual and/or collective risk perceptions?
Whom to ask: Experts from environmental and risk related authorities, sectoral planning divisions, insurance and re-insurance companies, spatial planning authorities, and the public.

Risk assessment consists of the outcome of risk analysis and risk evaluation. It summarises all information available about hazards and vulnerability and provides in such a way the necessary scientific foundation for the following implementing decisions about tolerating or altering risks. In the end of this assessment an objective weighting of all significant effects on the environment will be carried out. This assessment is an essential task for the spatial planning authority and has to be integrated into the weighting process.

Handbook contents, Part 4

8. Risk assessment
Question: How can all information that has been gathered in the risk analysis and evaluation be weighted to form a basis for the implementation of decisions for a risk management?
Whom to ask: Experts from environmental and risk related authorities, sectoral planning divisions, spatial planning authorities, politicians.

11.2 Risk management

Risk management is defined as adjustment policies, which intensify efforts to lower the potential for loss from future extreme events. This definition shows that risk management is characterised by decisions of stakeholders. In contrast to the subsequent steps, decision making is a normative, politically influenced strategy about tolerating or altering risks. The authority which is in charge (democratically legitimised) has to decide about the main planning goals which are related to the way how to deal with hazards The action decided upon is the result of a weighting process. The following questions are of concern in this context:

- Which is the level of risk is the society (or any stakeholder) willing to accept?
- What are the protection goals for the different protection objects, which are threatened by specific hazards or vice versa what are the foreseeable environmental effects from a planned object in the case of an occurred hazard?

When talking about risk management we always have to decide between the regional and local level. Therefore it must be clearly indicated which objectives, instruments, etc. can be applied on the regional or local level.

11.2.1 Objectives in a risk management process

Chapter 11.3 describes how risk related (general) goals can be set up in the course of a Strategic Environmental Assessment. These goals are general statements of directions and have to be specified in order to get all those who are involved in the risk mitigation process to agree on certain measures and actions. Thus, concrete objectives – as more specific targets – have to be set. These objectives have to be distinguished according to the state of risk that should be reached (protection objectives) and to the plans and measures that should be implemented to reach the protection objective (action objectives):

- *Protection objectives:* Protection objectives characterise a desired state of a system and connect the scientific state of knowledge (risk analysis) with the assessment of protection goals (risk assessment) by the public. In the context of risk mitigation, protection objectives thus describe the aimed state of risk within the area of concern, or in other words the maximum level of risk that will be accepted on the background of the guiding principle of “disaster resiliency”. Protection objectives are generally indicated quantitatively in absolute or relative terms like “reduction of the damage potential in area A by X € or X%”. In the spatial context this could be “spatial protection objectives”.

- *Action objectives:* Action objectives give statements about the degree of the required changes to reach a protection goal. In the context of risk mitigation action objectives describe the necessary reduction of risk as the surplus between the present state of risk and the maximum level of risk that will be accepted. An example of an action objective could be “reduction of the damage potential in area A by 10% until 2005 and by 25% by 2020”. Ideally, action objectives should be derived from protection objectives because they specify the demands to reach a protection objective.

It is often easy to reach agreement on overall goals, but it is not unusual to take a long time to reach consensus on specific objectives as they relate to particular areas or individual properties. Typical lines of disagreement can be found vertically between the regional and local level or horizontally between stakeholders with different interests on the regional or local level. These differences in opinions have to be overcome in a successful agreement process. Generally, “agreement” means consensus or something everyone can live with (POMA, 1999, Appendix One, p. 10).

From a general cost-benefit point of view it is indispensable to set the protection objectives in relation to the protection objects. While it makes sense to protect a highly vulnerable industrial facility or a settlement area against rarely occurring extreme events, a protection of single estates or farmland areas is more or less inefficient. However, it is obvious that any kind of decision in this field needs an adequate information basis, which has to be taken into account in the decision making process.

Handbook contents, Part 5

9. Set protection objectives
Question: Which is the acceptable level of risk?
Whom to ask: Persons/authorities responsible for conducting the risk analysis, politicians, the public.
Remarks: Objectives and other potentially controversial issues may have been resolved in previous efforts that resulted in other local plans. More likely, those involved in the risk mitigation planning process need to identify and clarify their concerns and goals so an agreement can be reached on the formulation of objectives.

10. Set action objectives
Question: Which is the level of risk that we are willing to accept?
Whom to ask: Persons/authorities responsible for conducting the risk analysis, politicians, the public.

11.2.2 Catalogue of instruments

Seen from the broader risk management viewpoint, risk management consists of mitigation, preparedness, response and recovery. At the same time, planning responses at the several planning levels can be attributed to the respective risk management strategies. The table below differentiates between regional planning, land-use planning and sectoral planning. Further, supporting instruments are mentioned.

Table 49: Contribution of spatial oriented planning and supporting instruments to risk management strategies, Source: ESPON Hazards project

Risk management strategy	A. Regional planning	B. Local land-use planning	C. Sectoral planning	D. Supporting instruments
1. Prevention oriented mitigation	E.g. planning settlement and transport structures that cause less greenhouse gas emissions	Supporting of the use of regenerative energies	Strategies for reducing greenhouse gas emissions (e.g. transport structures)	Kyoto protocol; strategies for reducing greenhouse gas emissions; tax system
2. Nonstructural mitigation (a): reducing hazard impacts	Maintenance of protective features of the natural environment that absorb or reduce hazard impacts (retention areas, sand dunes)	Local rain water infiltration	Flood protection plans; coastal protection plans; reforestation; adapted land cultivation	Interregional co-operation; economic instruments; information management
3. Nonstructural mitigation (b): reducing damage potential	Designations in regional plans like flood hazard areas	Zoning instruments	adequate allocation of threatened infrastructure.	
4. Structural mitigation	Secure the availability of space for protective infrastructure	Prevention measures as a part of building permissions	Engineering design, Protective infrastructure (shoreline dams)	
5. Reaction: preparedness, response, recovery	–	Rebuilding planning	Emergency plans, e.g. SEVESO II safety report	Information and training to support public awareness and emergency management;

In the following, the different instruments, mentioned above, will be described more in detail:

A) Regional Planning

1. Prevention oriented mitigation

In this context, spatial planning on the whole plays only a minor role. At most, settlement and transport structures that cause less greenhouse gas emissions could be from use. This is mainly of importance for regional planning due the given task of steering the main settlement structures. This may include spatial order categories, a central place system and development axes taking care of a concentrated development aiming at supporting public transport networks and minimising distances between residential, recreation and working areas.

2. Non-structural mitigation (a): reducing hazard impacts

It is a clear matter of fact, that that reducing hazard impacts has to be understood in the first instance as a task for the responsible sectoral planning division which owns appropriate instruments and the necessary knowledge. Nevertheless, regional planning can function as a supporting actor in this field of action (shown by the example of river floods).

The following measures, carried out by the water management authorities, should be supported by appropriate designations in the regional plan aiming at binding effects regarding municipalities and other sectoral planning divisions:

- Protection of existing retention areas (to maintain protective features of the natural environment that absorb or reduce hazard impacts),
- Extension of retention areas.

3. Non-structural mitigation (b): reducing damage potential

Avoiding hazardous areas can be understood as the key task for spatial planning and especially the regional level. The most important element consists of settlement restrictions by means of so called “priority zones” due to the given damage potential within highly populated areas. The designation of priority zones allows regional planning to keep hazardous areas free of competing demands. With such stipulations, land-use decisions of the local level can be directly controlled by the regional level. By “reserve zones” it is possible to improve the awareness for appropriate judgement in local land-use decisions. A direct protection of these areas is not possible within regional planning, but within the several sectoral planning divisions.

However, the concept of setting up priority zones is until now only oriented on single hazards like floods. Due to the given spatial orientation of spatial planning, a multi-hazard approach seems to be more suitable because it takes into consideration all spatially relevant hazards, which might threaten a certain area.

In this context, the *space-type concept*, discussed in the following, might be able to fulfil these demands. The space-type concept is valid for Member States with an institutionalised regional planning that includes legally binding regional plans or other forms of binding effects. According to the classification of regional planning in Europe, these countries belong to Category A. The space-type-concept is designed to prohibit and/or restrict settlement within hazardous areas. By these means further additional damage potentials can be prevented.

- *Risk priority zones:* Exclusion of all uses, which are inconsistent with the priority function. Priority in these terms means that there is a land-use priority for a certain hazard – or in other words: because of the possible occurrence of (a) certain hazard(s), no other form of land-use will be allowed. This means a strict settlement prohibition in threatened areas, which is binding for local land-use planning as well as other planning divisions (e.g. transport planning etc.).
- *Risk reserve zones:* Settlement restrictions, consideration of given threats through building protection or exclusion of especially threatened (e.g. schools, hospitals) and hazardous (e.g. chemical plants) facilities.

The basis for those binding designations should be suitable hazard and risk maps. Such a system has already been implemented in Switzerland and partly in Germany. However, this concept is primarily single hazard oriented, whereas spatial planning should be space oriented. Hence, a further development for fulfilling a multi hazard approach would be desirable on the ground of aggregated risk maps, which are based on the specific risk situation in a region (see Chapter 4.4). For this purpose also, the Delphi method was used in the case study regions (see Annex 2).

The main idea of the multi hazard, *spatial oriented concept* is based on the given interrelations between the several hazards on the one hand and the interaction with the spatial structures (settlement, transport network etc.) on the other hand. According to the classification of regional planning it is also valid for Category A countries *Risk priority zones:* Similar to the above described space-type-concept the spatial oriented concept deals with settlement restrictions. Those areas which have been identified as high risk areas, threatened by a single hazard and/or a combination of different hazards which are strongly interlinked (e.g. earthquakes and large dams) should be designated as risk priority zones. For this purpose, a normative decision about the highest acceptable risk has to be done. Within those zones, which cross this boundary of acceptance, any settlement should be prohibited, that would increase the present damage potential.

- *Risk suitability zones:* Vice versa, risk suitability zones could be designated. This type is characterised by a risk level below average (e.g. low population density, absence of certain natural hazards like earthquakes etc.). Due to this fact, those areas are principally suitable for the allocation of risky infrastructure, which is fragile on the one hand and/or could de dangerous for its surroundings if a disaster occurs (e.g. nuclear power plants).

This has to be carried out by regional planning authorities and regulated in a legally binding regional plan.

4. Structural mitigation

Similar to the reduction of hazard impacts structural mitigation has to be understood as a task for the responsible sectoral planning divisions. Regional planning functions as a supporting actor in this field of action (shown again by the example of river floods):

- Allocation of new detention ponds (to improve the storage capacity),
- Relocation of dams or dikes.

For both cases, the protection of potentially suitable areas for those measures can be described as tasks for regional planning in order to avoid functions or facilities, which might hinder the planned infrastructure.

5. Reaction: preparedness, response, recovery

Not relevant for the regional level due to the necessary concrete scale of such instruments which act primarily on local level and below (single facilities).

B) Local land-use planning

1 Prevention oriented mitigation

In this context, local land-use planning plays only a very modest role due the given limitation on local affairs. However, land-use planning can act as a supporting instrument, e.g. by means of pushing of the use of regenerative energies in order to reduce the emission of climatic relevant fossil fuels.

2. Non-structural mitigation (a): reducing hazard impacts

Although the different sectoral planning divisions are the most important actors in this field, local land-use planning is able to support these actions. The more the impact can be limited to local areas the greater the potential influence of local activities is.

Especially when regarding the contribution of settlement areas to the surface run-off, the support of local rain water infiltration activities has to be taken into consideration. In this way, local flash floods could be managed better by means of local activities, which are under the responsibility of the municipalities. Another possibility for local influence can be highlighted by the example of avalanches. Local reforestation activities may help to avoid avalanches.

3. Non-structural mitigation (b): reducing damage potential

Zoning instruments: Especially for the enforcement of restrictions of land use at the level of municipal land use planning hazard maps with a scale of about 1:2,000 – 1:10,000 are necessary. However, there are several possible types of zoning related instruments which might be able to improve non-structural mitigation, as discussed in the table below:

Table 50: Possibilities of the presentation of natural hazards within a local land use plan, Source: based on Böhm *et al.* 2002, p. 61

	Co-ordinated zoning in general land use plan	Specific hazard zones map in general land use plan with direct binding character	Independent map without a direct binding character to landowners
Description	Consideration of the hazard areas during the compiling or the review of the local land use plan by the suitable allocation of types of land use and intensity.	The hazard zones are displayed as a separate map, which has a direct effect on land ownership rights – property owners have the right to object to the hazard zone classification shown. (Hazard zones as determined content).	Definition of hazard zones within the scope of expert planning („hazard zone plan") – objections may be raised to decisions that are made on the basis. (Hazard zones as notification content).
Advantages	At the local level, no new instruments are necessary.	The hazard can be considered in a uniform manner for the complete local planning area. The definitions of the hazard zones can be applied directly in building approval procedures.	A simple alteration of a hazard zone plan is possible. Restrictions can be made according to the latest information. The administrative expenditure is low. Suitable for a cooperative strategy aiming at influencing existing building structures by means of individual building protection.
Disadvantages	Land-use plans only contain information about hazard areas when a special reference is made to these. An alteration of the danger situation means that the zone plan must be adapted accordingly.	An alteration of the danger situation means that the complete zone plan has to be adapted accordingly. For legally binding effects a very carefully and exact mapping is needed.	No effectiveness in case of an unwillingness of private stakeholders to participate.

4. Structural mitigation

Structural mitigation on a local level can be primarily understood as a task for building permissions aiming at special obligations in order to protect buildings or other facilities against potential hazard impacts (e.g. flooding, avalanches, high wind speed, earthquakes etc.). However, keeping in mind that building regulations often are under the responsibility of special state authorities, urban land-use planning offers the possibility for the municipality to influence building permissions.

For that purpose, first the preparatory land-use plan should designate potentially hazardous zones. Based on this information, it would be useful to integrate special obligations within a legally binding land-use plan aiming at the protection of buildings, which might be developed within threatened areas. This could mean, that any kinds of souterrain or basement rooms are prohibited or an obligation for a strengthened outside wall that might be primarily affected by avalanches.

5. Reaction: preparedness, response, recovery

Whereas mitigation aims at long-term preventive activities, reaction is a short-term activity immediately before or after a disaster occurs. Due to the fact, that spatial planning is by the nature of the thing a long-term, future oriented activity, local land-use planning cannot be understood as a key actor in this field of action. Reaction is primarily a task for the emergency response units. Nevertheless two elements can be identified, where local land-use planning plays a decisive role:

1. The necessary integration of emergency response related interests within settlement and infrastructure activities: A residential area as well as an industrial facility must be reachable in an appropriate time by response units. In addition, in case of the allocation of emergency response stations, land-use planning has to take into consideration potential hazard impacts as well as a suitable attainability by the different transport modals.
2. Urban land-use planning can be understood as a key actor in case of recovery activities after a disaster has occurred. The necessary rebuilding of houses and infrastructure has to be coordinated by planning – ideally oriented on key risk management principles like avoiding hazardous areas.

C) Sectoral planning

Although the ESPON hazards project aims at a spatial planning response, the important role of the different sectoral planning divisions cannot be neglected. It will be discussed briefly in the following.

1. Prevention oriented mitigation

Sectoral planning influences to a wide extent several driving forces for (meteorological) hazards, because of its responsibility for transport infrastructure, industrial facilities and the energy sectors which are the main causer of the emission of carbonic gases. In consequence, the main instruments for reducing these emissions are under control of sectoral planning. Under the prerequisite of a political willingness, the several sectoral planning divisions would be responsible for influencing emissions which might affect different environmental media (water, air, soil) by push and pull oriented instruments.

2. Non-structural mitigation (a): reducing hazard impacts

A specific sectoral planning authority is normally responsible for agriculture and forestry. In this context, the water storage capacity of these areas should be highlighted. Adequate land cultivation could help to reduce the surface run-off as well as avalanche prone areas. Such kind of measure could be part of hazard protection plans, carried out by sectoral planning (e.g. flood action plan, coastal protection plans etc.).

3. Non-structural mitigation (b): reducing damage potential

As already mentioned, spatial planning is the mainly responsible actor in this field of action. However, in the context of special project approval procedures, which might be necessary for infrastructure projects, the relevant sectoral planning division is in charge of an adequate building protection. In addition, sectoral planning is responsible for hazard mapping as a fundament for e.g. zoning ordinances, carried out by local land-use planning.

4. Structural mitigation

It is a clear matter of fact that extreme events cannot be avoided. In consequence, the protection of vulnerable settlement and infrastructure is still indispensable. Sectoral planning is in charge of planning and implementation of any kind of protective infrastructure (shoreline dams, river dikes etc.).

5. Reaction: preparedness, response, recovery

Emergency response can be understood as a sectoral planning activity. In this context, emergency plans and evacuation concepts have to show rescue areas.

Special attention should be paid to major accident hazards in the context of the SEVESO II Directive (Council Directive 96/82/EC; European Union 1996) which aims at the prevention of major accidents involving dangerous substances and the limitation of their consequences. The directive sets out basic principles and requirements for policies and management systems, suitable for the prevention, control and mitigation of major accident hazards. There is a requirement for lower tier establishments to draw up a Major Accident Prevention Policy (MAPP), designed to guarantee a high level of protection for man and the environment by appropriate means including appropriate management systems, taking account of the principles contained in Annex III of the directive.

In addition, requirements for land-use planning (Art. 12, SEVESO II Directive, European Union 1996) are newly introduced into Community legislation on major-accident hazards. The context is elaborated by substantiation (22) to the Seveso II Directive which states: *"Whereas, in order to provide greater protection for residential areas, areas of substantial public use and areas of particular natural interest or sensitivity, it is necessary for land-use and/or other relevant policies applied in the Member States to take account of the need, in the long term, to keep a suitable distance between such areas and establishments presenting such hazards and, where existing establishments are concerned, to take account of additional technical measures so that the risk to persons is not increased."*

D) Supporting instruments

Spatial planning aims only at future land uses. However, the already existing settlement and infrastructure facilities have to be taken into consideration due to their given damage potential. In consequence, appropriate instruments and measures have to be selected, aiming at influencing the individual behaviour of private stakeholders. In addition, spatial planning needs financial support in order to implement the elaborated concepts and measures. In this context, an innovative concept will be discussed more in detail.

1. Prevention oriented mitigation

In this context a taxation system aiming at the reduction of climatic relevant emissions would be very helpful to influence driving forces for meteorological hazards.

2.–4. Non-structural mitigation (a – reducing hazard impacts, b – reducing damage potential) and structural mitigation

The concept of the *arrangement of objectives* is applicable for all Member States with or without institutionalised regional planning and with or without binding regional plans. A pilot project was carried out in Switzerland (Baumann and Haering, 2000). The concept integrates non-structural and structural mitigation activities. This procedure has to be understood as a political task which should be carried out on a superior level (for a threatened area as a whole, e.g. a catchment area).

The main idea behind the setting of protection goals is to produce arrangements in combination with a quantitative output-control instead of inefficient funding of single projects, without any care for results. The government has to take care of the financial funding; the regional level takes the responsibility for the fulfilment of the arranged protection goals.

An important characteristic of this strategy consists in the regional responsibility for the choice of certain measures, which are all suitable to fulfil the fixed goals at the same time. Mostly, regional actors are more likely able to find appropriate solutions than the national government, which is less informed about the relevant regional circumstances. Furthermore, the regional actors in many cases represent at the same time the communities, which are threatened by a certain hazard.

An additional advantage consists in the possible integration of non-governmental organisations and private stakeholders (e.g. companies), which are obligated by spatial plans in those countries where an institutionalised regional planning with legally binding plans exists. In opposite to the restrictive procedure of binding plans, the proposed model offers a moderate, consensual way with self-binding effects. Therefore, one can understand those product arrangements as a kind of regional governance.

The following table figures out how this kind of product arrangements could be implemented by the example of flood hazards. Principally the procedure could be used as a part of a risk mitigation strategy for every combination of hazards, which threaten a certain area. This strategy offers for the first time a possibility for a direct competition between different suitable measures, which aim to mitigate risks by means of a cost-benefit-analysis.

Table 51: Arrangement of objectives: the example of flood risk management, Source: Greiving, 2004.

Arrangement element (goal)	Objective		Effectiveness indicator	Efficiency indicator
Reduction of the probability of occurrence, resp. reduction of maximum run-off by x m^3/s????	Improvement of the storage capacity in a certain part of a catchment area by x m^3	by means of a central reservoir (alternative 1)	Realised storage capacity in m^3	Cost of x € per m^3 realised storage capacity
		by means of decentralised water storage (alternative 2)	Realised storage capacity in m^3	Cost of x € per m^3 realised storage capacity
	Construction and/or improvement of dikes		Amount of the protected facilities in €	Cost of x € per € amount of the protected facilities
Reduction of the damage potential by x €	Improvement of individual structural mitigation (e.g. building protection)		Amount of the protected facilities in €	Cost of x € per € amount of the protected facilities
	Financing of resettlement activities out of threatened areas		Realised reduction of the damage potential in €	Cost of x € per € reduced damage potential
	Cancellation of building rights in threatened areas		Realised avoidance of additional damage potential in €	Cost of x € per € avoided additional damage potential

5. Reaction: preparedness, response, recovery

Information and training belong to complementary actions within a risk management process that are an important part of supporting the society's preparedness towards disasters. Information, its provision and exchange (e.g. by training activities) belong to the risk communication process which has to fulfil three main objectives (Renn, 1998, p. 7):

- ensure that all receivers of a risk message are able and capable to understand its meaning,
- persuade receivers of such message to change attitudes towards the risk and their behaviour,
- provide the basis of a two-way communication process that helps to solve risk conflicts (also enhance the public participation in the emergency decision-making process.

The aim of providing people with information is to broaden their view on hazards and risks. The logic behind this is the fact that only those hazards and risks can be mitigated that are known. This should finally lead to a change in the people's behaviour into a direction where they can actively respond to risks. Training still goes further as it provides citizens and experts (like politicians, planners etc.) with the knowledge how to adequately react in case of hazardous events. In other words: training increases the ability of people to use the information adequately in order to reduce risks. Information and training covers the following:

- information and training courses for citizens to strengthen mitigation, preparedness and response in the communities (information facilities/events),
- training courses to prepare experts on risk assessment and management (e.g., in Portugal there are no such experts), eventually organised on the EU level/financed from the European Union.

The following *information instruments* can be used in order to raise the awareness of citizens, land owners and policy makers. Further, Böhm *et al.* (2002, pp. 160 ff.) give an overview of instruments for increasing public awareness for preventive flood management:

- *Maps of hazards, vulnerability, and risks:* Maps are an important information tool because they connect possible hazardous events with the well known local and regional environment (own house, infrastructure, sensitive installations like schools, hospitals etc.). Such maps have to be made accessible to the public. Additionally maps can include information about evacuation routes or rescue centres in case of a disaster.
- *Internet:* The internet offers a platform to present and distribute information to many people. These can be contacts to information and emergency hotlines, statistics and maps (GIS based). The main advantages of the internet are that the information can be accessed from nearly everywhere and that it can be used interactively (Example: interactive mapping system of Rockland County, http://idsigis.com/rockland/start.asp?tfw=400).
- *PR activities:* The direct contact of planners, politicians, risk management and disaster control units with the public is very important. This can be done by public meetings or the distribution of flyers. Some authors suggest having an annual "hazard preparedness day" in the town or region where everything around risk management can be presented on a forum (extra issue of newspaper, TV reports, participation of school classes etc.; Steinberg *et al.*, 2004, p. 168).
- *Visualisation of previous disaster events:* The extent of previous disasters should be visualised in daily life like high-water level marks on bridges and house, preservation of damaged buildings due to an earthquake as a memorial or museum etc.

Training courses should comprise all aspects of the response action like mitigation (prevention oriented, structural, non-structural) and reaction (preparedness, response, recovery). Training courses should be offered to different groups and concerning different topics:

- *Training courses for local planners and politicians:* Show, which are the threats but also the own possibilities. Introduction to the process of risk management (needed capacity etc.). They need this knowledge to make adequate decisions for the restriction of development or the improvement of protection measures.

- *Training courses for schools:* Teachers should be trained about main issues of the regional hazards and risk management. This should enable teachers to teach (mandatory) classes about how to behave in case of a disaster, and other aspects of mitigation and reaction.

<u>**Handbook contents, Part 6**</u>

11. Select appropriate instruments for the regional and local level
Question: Which instruments should be chosen from the box of risk management tools?
Whom to ask: Persons/authorities responsible for conducting the risk management process, politicians.
Remarks: The section above has shown a large variety of possible instruments which can be chosen in a risk management process. They range from different planning levels to different risk management elements. The final choice depends on the local or regional circumstances (political decisions, existing hazards, funding possibilities etc.).

11.2.3 Organisational aspects

<u>A) Setting up the mitigation plan</u>

A mitigation plan summarises scientific results and political decisions to mitigate natural and technological hazards. A mitigation plan could be characterised as an informal, open platform for a discursive process aiming at dealing with hazards and risks. This allows a cooperative, voluntary process between partners of equal rights, which are engaged in a mutually beneficial exchange. Although not only restricted to spatial issues, a mitigation plan offers the possibility to integrate sectoral and spatial goals, objectives and measures and therefore is an important element of resilient spatial planning. Decisions about goals and objectives should be made on the ground of a common agreement. This self-binding procedure aims at the integration of companies and private stakeholders, which cannot be bound by law in terms of their private, economic decisions (e.g. in the context of building protection).

After identifying hazards, setting goals and objectives and assessing possible solutions, the most appropriate actions have to be selected and recommended. This effort culminates in the written plan that recommends what will be done, by whom and when. A mitigation plan should ideally be made on the regional level so it can provide authorities on lower levels (communities) with information about risks and hazards. Nevertheless, it can be also made on the national level (if no regional level exists) or on the community level (then binding for the citizens etc.).

An example of a mitigation plan organisation is shown in the following figure. Such a mitigation plan should include at a minimum (POMA, 1999, Appendix One, p. 13 f.):

1. *A description of how the plan was prepared:* This helps readers (and potential funding agencies) to understand the background and rationale of the plan and how public input was obtained.
2. *Recommendations for action:* The plan should clearly identify what will be done, by whom, by what date it will be started and how it will be financed. It can be a list of projects and project assignments – the more specific, the better.
3. *A budget:* The plan should explain how its recommendations will be financed. It should note those recommendations, such as policies and public information activities, that can be implemented without special funding as part of a community's or organisation's normal operations (like regional and land-use planning).

1. Introduction
   a. Why there is a plan
   b. How it was prepared
   c. Who was involved
2. Problem description
   a. Flooding, earthquake, etc.
   b. Recreation needs
   c. Fish and wildlife
   d. Etc.
3. Goals and Objectives
4. Alternative measures
5. Recommended measures
   a. Measure #1
      i.
      ii.
      iii.
      iv.
      v.
      vi.
   b. Measure #2
6. Implementation and evaluation
   a. Adoption
   b. Implementation schedule
   c. Monitoring
   d. Evaluation and revision

Figure 17: Example of a mitigation plan organisation, Source: POMA, 1999, Appendix One, p. 13

Until today, there is no example for a comprehensive mitigation plan in any country in Europe. Other countries – like the U.S. or Japan – have experience with mitigation plans and provide information for regional and local authorities how to set up such a plan. Although not yet in discussion, an appropriate possibility to integrate mitigation plans and spatial plans on an EU wide level will be the implementation of the Strategic Environmental Assessment (SEA), which came into force by EU directive 2001/42/EC in 2001 (see Chapter 11.3).

B) Decision making

In contrast to risk assessment, decision making can be characterised as a normative process about tolerating or altering risks. Risk related aspects have to be weighted up with other interests, represented by the several involved stakeholders. It should be stressed, that several legal issues may support and make this decision process and the implementation of measures compulsory (SEA, EIA, SEVESO II, FFH directive, Natura 2000). In this context, decisions about the content of the mitigation plan itself on the one hand and the integration of the plan or certain elements within legal/formal plans, programmes or permissions on the other hand have to be distinguished.

Every decision that influences individual rights, which are protected by law, needs a formal legitimating act on the ground of democratic procedures, laid down by specific material legal acts (e.g. by means of the building law). In this context, cooperative procedures come up against limiting factors. Representative structures can be understood as a kind of replacement of consensual decisions of affected people. It has to be stressed, that usually several authorities with own rights and competences are involved in the complex field of risk assessment and management. Especially the implementation of measures has to be understood as an integrated part of the implementation of the plan or program by the planning authority and/or sectoral planning authorities. For that reason sectoral planning divisions as well as emergency control units should be part of this implementation process.

An appropriate way of dealing with this situation would be a coordinative process. This means a process of bringing different tasks and interests of the involved authorities into a proper relation. In this context, a superior authority has to be in charge of the coordination process between the different actors and should be authorised for the decision-making.

<u>C) Financing</u>

Two aspects stand in the foreground concerning financial aspects in a risk mitigation process: First, focused on measures, the question if certain projects are worth the expense and second the general question how to get the necessary money for the planned measures. These questions are becoming the more crucial the more a project or measure costs. Thus, the need for a detailed analysis increases with the height of the supposed costs. To ensure that the measures that will be proposed in a mitigation plan are worth the expenses, a cost-benefit analysis could be conducted before deciding on a certain measure. Alternatively, the recommendation of a certain measure could be conditioned on the availability of funding.

- *Cost-benefit analysis:* A cost-benefit analysis is a method to determine the feasibility of a project or plan by quantifying its costs and benefits. One has to be aware, that an only economic review of costs and benefits should not be the only determinant of whether a measure should be considered right for the situation (see also Chapter 11.2.2, D 2.–4., arrangement of objectives).
- *Funding opportunities:* Funding opportunities vary in the Member States and even from region to region. In any special case it has to be checked which public and private programs are willing to fund worthy projects. It can be expected that these programs have several prerequisites, such as a written plan, a budget and an explanation of the benefits. Apart from the national funding possibility, the funding of risk mitigation plans and their implementation might become an upcoming task in EU regional policy. Funding possibilities can be identified on different levels:
- *Contact relevant organisations on the national level:* Talk to the funding organisations that have been identified as important to understanding and reducing future losses and evaluate possibilities of having projects funded.
- *Contact local stakeholders:* Businesses and local groups will frequently support projects that benefit their customers, employees or members or that offer positive public relations opportunities.
- *Activate voluntary potentials:* In many cases cash may not be needed to implement some mitigation measures. Instead of paying for the maintenance of certain installations, a service organisation could maintain the area with volunteers. In some cases, even, services can be counted toward the local share needed to match an outside source of funds.

<u>Handbook contents, Part 7</u>

12. Setting up the mitigation plan
Question: How to coordinate mitigation goals, measures and responsibilities?
How to answer: Set up a mitigation plan that recommends what will be done, by whom and when.

13. Ensure decisions that are widely accepted
Question: How can it be managed that decisions will be accepted by involved stakeholders?
How to answer: Organise the decision making process in a coordinative way.

14. Determine the feasibility of measures and detect funding opportunities
Question: Is the measure worth the expense? How can the planned measures be financed?
*How to answer: E.g. c*onduct a cost-benefit analysis. Analyse funding programmes and possibilities on European, national or local level

11.2.4 Monitoring and evaluation

<u>Monitoring</u>

An important part of a risk management process consists in the monitoring of the effects of implemented measures. It represents the way in which the outcome of the risk assessment has been confirmed or not confirmed in comparison to the original data base. For such a monitoring, an indicator based concept would be suitable, which distinguishes between the hazards and protection objects. Such controlling mechanisms (such as inspection and supervision to the unities of environment control; see also SEA directive, Chapter 11.3) should be installed. Monitoring can be distinguished as follows:

- *Monitoring of reached goals and objectives:* Such indicators should answer the question whether the chosen measures are able to fulfil the determined protection goals or not. For the case of given differences between goals and observed effects, a reformulation of goals or the development of new measures should be taken into consideration. Indicators in this respect could, e.g. measure risk and its components to see if the implemented measures have led to a reduction of the overall risk (risk assessment indicators).
- *Monitoring of plan realisation:* The monitoring of the realisation of the mitigation plan helps to ensure that the responsible persons remember their assignments and project timelines. Thus, a mitigation plan should have a formal process to measure progress, assess how things are proceeding and – as a result – recommend needed changes. Indicators in this respect measure if a certain step within the process has been fully reached within the required deadlines (risk management indicators).

<u>Evaluation</u>

Even with full implementation, any mitigation plan should be evaluated in light of progress and changed conditions.

<u>Handbook contents, Part 8</u>

15. Monitoring of goals and objectives
Question: Have goals and objectives been reached within the required time?
How to answer: Set up of a monitoring system with appropriate indicators.

16. Monitoring of plan realisation
Question: Have the necessary steps of the mitigation process been done within the required time?
How to answer: Set up of a monitoring system with appropriate indicators.

17. Evaluation of mitigation plan
Question: Did the implemented plan succeed and does a change of conditions call for a change in the planned measures?
How to answer: Guarantee a thorough evaluation after measures have been implemented.

11.3 The SEA directive as a framework for risk assessment

Chapter 11.2.4 has shown that risk assessment and management can be incorporated into the spatial planning process. This aims at a greater sustainability and at least resiliency of the society's development by means of procedural requirements. In the following, the Strategic Environmental Assessment directive which came into force on 27 June 2001 (SEA, European Union 2001) as a given legal and procedural framework for an ideal risk assessment and management process will be described.

11.3.1 Integrating spatial planning and risk management

For reaching the purpose of integrating spatial planning and risk management a formal framework which has to take care for following this approach is needed. In this context, the so-called SEA directive should be highlighted. The key task of the SEA is in accordance with Art. 3 EU directive 2001/42/EC the assessment of the *"significant effects on the environment, including on issues such as biodiversity, population, human health, fauna, flora, soil, water, air, climatic factors, material assets, cultural heritage including architectural and archaeological heritage, landscape and the interrelationship between the above factors"* (European Union 2001, Annex 1, Letter f). The results of this assessment, summarised in the environmental report, have to be taken into account in decision-making about specific plans or programs (European Union 2001, Art. 2b and 2c).

Vulnerability as the key term of the risk definition can be understood as a relevant issue, covered by the SEA issues "human health", "material assets", "cultural heritage" (European Union 2001, Annex I). Annex II of the directive, which points out the characteristics of the effects and the area likely to be affected, indicates the following risk-related aspects as relevant for the assessment of significant effects on the environment:

- the probability, duration, frequency and reversibility of the effects,
- the cumulative nature of the effects,
- the risks to human health or the environment (e.g. due to accidents),
- the magnitude and spatial extent of the effects,
- the value and vulnerability of the area.

In the light of these requirements carried out by Annex I and II, a material interrelationship between risk assessment and the key targets of the SEA should be indicated: First, many terms corresponding with the above mentioned definitions of hazard and risk are used. Thus, a risk related basic approach of the directive itself is quite obvious. Second, the assessment of certain risks as a task for spatial planning as the responsible authority for certain plans (European Union 2001, Art. 2a) can be identified due to the clearly visible spatial approach of the directive ("spatial extent", "vulnerability of the area", European Union 2001, Annex II). Third, projects, which have to be permitted on the ground of a certain plan or program, might have significant effects on the environment because of certain consequences: an increasing damage potential regarding certain hazards that threaten the area, where the project is planned to be located (Greiving 2002, p. 227).

In this context it is of great interest that a new working document, published by the Directorate-General Environment of the European Commission, has highlighted the potential relevance of the SEA for risk assessment: *"Community legislation already provides that major projects or programmes have to be accompanied by an environmental impact assessment. It is also important to ensure that projects and programmes do not unduly increase the risk to people or the environment. For this reason, a flexible tool should be conceived to ensure that proper account has been taken of the risk"* (European Commission 2003, p. 4, Chapter 4.2).

Following the causation principle, which is essential for the environmental policy in general and especially the SEA, the compensation of risk has to be taken into account. Art. 7, paragraph 2 of the directive indicates that „measures envisaged to reduce or eliminate such effects [on the environment]" have to be taken into consideration within the decision-making, whenever a plan or programme should be approved. Despite of the fact that preventive oriented mitigation would be the best alternative for dealing with hazards, the decision making might lead to plan related designations (e.g. for infrastructure projects, industrial areas etc.) which certainly have significant environmental effects within hazardous areas (an increased damage potential). In such cases, the responsible authority decides as a result of a weighting-up of different interests, that the increase of risk has to be accepted. In the consequence, reduction and compensation measures should be discussed. This means, that the causer of an increased damage potential has to take care for reduction measures on the place and/or for compensation measures elsewhere (e.g. an additional storage capacity upstream).

11.3.2 Integrating risk assessment and management into SEA procedure

In the following it will be discussed, how the risk related requirements could be integrated into the procedural regulations of the SEA. In this context it should be stressed, that the general requirements prescribed by the SEA directive are not restrictive and leave ample room for creativity, flexibility and adaptability to suit each Member State (Risse *et al.*, 2003, p. 454). In the consequence, the integration of risk related elements within the SEA seem to be permissible.

In accordance with Art. 5, paragraph 1 of the SEA directive *"an environmental report shall be prepared in which the likely significant effects on the environment of implementing the plan or programme, and reasonable alternatives taking into account the objectives and the geographical scope of the plan or programme, are identified, described and evaluated".* This obligation respectively the identification, description and evaluation of significant effects can be described as similar to the usually practised steps of hazard identification, risk analysis and risk evaluation as relevant parts of a risk assessment process (see for this process Greiving, 2002, p. 248). Furthermore, risk management can be seen as a part of decision-making in the sense of Art. 8 of the SEA directive.

Due to these facts, the integration of the requirements of the SEA as well as the risk assessment and management into one combined process should not be difficult. This environmental risk assessment and management process could be described as follows (see Table below):

Table 52: Comparison of procedural requirements, Source: Greiving 2004, p. 14

Risk Assessment and Management Process	Corresponding procedural obligations of the SEA
Hazard Identification	Identification of significant effects on the environment (Art. 5 ,p. 1) Consultation of authorities (Art. 6, p. 3)
Risk Analysis	Description of significant effects on the environment (Art. 5 ,p. 1)
Risk Evaluation	Evaluation of significant effects on the environment (Art. 5, p. 1) Consultation of the public (Art. 6, p. 4)
Risk Assessment	Assessment of the significant effects (Art. 3)
Risk Management	Integration of environmental considerations into the plan or program (Art. 8, 9)
Planning of Measures	Reasonable Alternatives (Art. 5, p. 1) „Measures envisaged to reduce or eliminate such effects [on the environment]" (Art. 7, p. 2).
Monitoring	Monitor the significant environmental effects of the implementation of plans and programmes (Art. 10, p. 1)

Every step intended within the EU directive 2001/42/EC, corresponds to a similar one within a risk assessment and management process. However, the environmental report and its contents are after all only one of many aspects, which has to be taken into account within a decision-making process. Thus, there is no guarantee, that the environmental risk-related approaches will be heeded in a certain plan or programme.

However, whereas the SEA guarantees the fulfilment of common procedural requirements, a homogenous methodological framework for risk assessment is needed for an adequate dealing with spatial relevant risks. In this context, it should be stressed that DG environment has the intention to establish a new EU directive that aims at harmonising hazard and risk mapping within the EU. In this context, it has to be mentioned, that a first working document on civil protection has aimed already at a so called "safety impact assessment" (European Commission 2003, p. 4): *"Community legislation already provides that major projects or programmes have to be accompanied by an environmental impact assessment. It is also important to ensure that projects and programmes do not unduly increase the risk to people or the environment. For this reason, a flexible tool should be conceived to ensure that proper account has been taken of the risk."* This tool should provide comparable standards in risk assessment all over Europe. However, further research is needed aiming at the harmonisation of methodological aspects of risk assessment in general and especially in relation to multi-risk aspects, taking into account the special view of spatial planning on hazards and risks. The current 6th Framework Programme contains such research activities, like the project ARMONIA ("Applied Multi Risk Mapping of Natural Hazards for Impact Assessment") which started in October 2004.

11.4 Summary and outlook

The following table summarises the contents of this chapter as it gives an overview of the elements of dealing with spatially relevant risks on the regional and local level. These are ideal spatial planning and risk management processes that were developed by the ESPON hazards project. The table holds references to the respective parts within Chapter 11.

Table 53: Overview of the elements of dealing with spatially relevant risks, Source: ESPON Hazards project

Risk assessment – the scientific basis		
	Region	Municipality
Hazard identification *Handbook contents, Part 1, No. 1-3)*	Inform the relevant stakeholders and the municipalities within the region about the nature and extent of natural and technological hazards (mainly "source of the hazard", "area affected") Provide a basis for policies, goals, objectives and measures to minimise future losses from the effects of hazards on the regional and local level Identify cumulative and transboundary effects	Inform the relevant stakeholders within the municipality about the nature and extent of natural and technological hazards (mainly "threat to life and safety" and "property damage") Identify cumulative and transboundary effects
Risk analysis *Handbook contents, Part 2, No. 4-6)*	Identification of spatial risk by calculating hazard frequency of occurrence and vulnerability scores: combine the hazards map and the vulnerability map to produce the overall *regional risk analysis*	*Local risk analysis*: carried out like the regional risk analysis but in more detail, especially concerning the vulnerability (spatial hazards are geographically specific, this probability of occurrence has to be assigned to a specific area or hazard zone) Integration in the SEA process
Risk evaluation and risk assessment *Handbook contents, Part 3, No. 7)* *Handbook contents, Part 4, No. 8)*	Participation process to evaluate risk by taking the aspect of risk perception into account (on the regional level mainly experts from spatial and sectoral planning divisions) Weighting / identification of the relevance of risks on the regional level (e. g. by means of the Delphi method, like described and successfully applied in the case study regions, see Chapter XXX)	Participation process to evaluate risk by taking the aspect of risk perception into account (on the local level the public but also experts from spatial and sectoral planning divisions) Make use hazard analysis made by sectoral planning divisions Weighting / identification of the relevance of risks on the local level (by use of micro-scaled methods that counter damage potentials on real estate level aiming at legally binding regulations)

Continuation of table 53:

Risk management – political decisions		
	Region	Municipality
Risk related planning goals and measures *Handbook contents, Part 5, No. 9-10)* *Handbook contents, Part 6, No. 11)* *(A)*	Set up of planning goals and objectives (may already have been resolved in previous efforts that resulted in other local plans; positive goal statements provide people more incentives to work on the mitigation plan than do negative statements about the community); *Handbook contents, Part 5, No. 9-10)* Select appropriate instruments and measures for the local level *(A), (D))* Reach consensus among all relevant actors (municipalities, sectoral planning divisions, certain private stakeholders like companies) Set up regional mitigation plan *(A)*	Responsible for the selection of appropriate measures and their implementation which aim to fulfil the fixed goals because of detailed knowledge about the local situation (hazard as well as vulnerability related issues) and the responsibility for appropriate instruments (local land-use planning, building permission etc.) Select appropriate instruments and measures for the local level. A collection of possible measures can be used as a checklist to ensure that every possible measure will be considered*((B).* Integration of land-use oriented measures in the legally binding land-use plans Integration of building protection measures in the building permission Set up local mitigation plan *(A)*
Coordination between spatial planning authorities and sectoral planning divisions *(C)* *(B); Handbook contents, Part 7, No. 13)*	Coordinate activities of sectoral and comprehensive planning Install a regional data pool, containing relevant hazard and vulnerability data (the gathering of data, their verification and interpretation will only be possible if spatial planning authorities as well as sectoral planning divisions work hand in hand on this topic – this has to be coordinated among the different institutions)	Coordinate activities of sectoral and comprehensive planning Many of the databases used for identifying hazards and vulnerabilities need additional verification especially at the local level Use of existing local data pools (e. g. land-use, land register, environment etc.)

Continuation of table 53:

Risk management – implementation process		
	Region	Municipality
Involvement of public and private stakeholders in the implementation process *(B); Handbook contents, Part 7, No. 12-13*	Draft regional mitigation plan made available for review by the residents and businesses who will be affected, appropriate municipal departments, interested organisations, state and federal agencies and neighbouring municipalities Distribute responsibilities for fulfilling of goals and objectives to persons and institutions	Selection of measures made under involvement and based on a good information policy for the residents and businesses who will be affected, appropriate municipal departments, interested organisations and neighbouring municipalities Distribute responsibilities for the implementation of measures to persons and institutions
Financing *(C); Handbook contents, Part 7, No. 14*	Guarantee funding of regional mitigation plan and other instruments	Guarantee funding of local mitigation plan and other instruments
Monitoring and evaluation of implementation process *(C); Handbook contents, Part 8, No. 15-16*	Plan should have a formal process to measure progress, assess how things are proceeding and recommend needed changes: monitoring system helps ensure that people remember their assignments and project timelines to reach goals and objectives Even with full implementation, the plan should be evaluated in light of progress and changed conditions	Monitoring system helps ensure that people remember their assignments and project timelines when implementing measures Even with full implementation, the measures should be evaluated in light of progress and changed conditions

<u>Outlook: Risk assessment and management handbook for European regions and towns</u>

A handbook for risk assessment and management can complement the EU strategies to reduce spatial risks within the Member States. It therefore has to be strongly connected with the policy recommendations that are discussed above. From an EU point of view, a handbook for risk assessment and management can be seen as a means to an end to encourage European regions to produce risk mitigation plans. Thus, the main interest of the EU would be to guarantee that the necessary measures will be implemented to fulfil the protection goals. This can be strengthened by installing certain implementation incentives, like e.g.:

- *Funding of the setting up of mitigation plans by the EU:* E.g. funding activities for certain plans or maybe for the exemplary implementation of the SEA directive.
- *Integration of the setup of mitigation plans and their implementation into the Interreg activities:* There already might be examples of implementation oriented projects among the Interreg activities.
- *Regional competitions/contests of risk mitigation:* The handbook could be a guidance and provide the criteria for the jury of such a competition. The winning regions would have the chance to have their proposed projects funded by the regional funds.

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EUROPEAN SPATIAL PLANNING OBSERVATION NETWORK

The Spatial Effects and Management of Natural and Technological Hazards in Europe

ESPON 1.3.1

ANNEXES

Co-financed by the European Community through the Interreg III ESPON Programme

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Edited by
Philipp Schmidt-Thomé

GEOLOGIAN TUTKIMUSKESKUS
GEOLOGISKA FORSKNINGSCENTRALEN
GEOLOGICAL SURVEY OF FINLAND

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Foreword

This report presents the results of the project "1.3.1 - The spatial effects and management of natural and technological hazards in general and in relation to climate change", which was conducted within the ESPON 2000-2006 Programme. The project was co-ordinated by the **Geological Survey of Finland (GTK)** in cooperation with the following institutions:

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Institute of Ecological and Regional Development (IOER), Germany

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The content of this report does not necessarily reflect the opinion of the ESPON Monitoring Committee

1 ANNEX I: GLOSSARY

Adaptation: Adjustment in natural or human systems in response to actual or expected natural hazards or their effects, which moderates harm or exploits beneficial opportunities. Various types of adaptation can be distinguished, including anticipatory and reactive adaptation, private and public adaptation, and autonomous and planned adaptation.

Adaptive capacity: The ability of a system to adjust to and to limit the consequences of natural hazards and to moderate potential damages, to take advantage of opportunities, or to cope with the consequences.

Consequence: An impact such as economic, social or environmental damage/improvement that may result from a hazard. It may be expressed quantitatively (e.g. monetary value), by category (e.g. High, Medium, Low) or descriptively.

Coping capacity: The manner in which organisations and or societies are able to withstand and/or cope with unusual, abnormal, and adverse conditions of a natural hazards or potentially harmful natural process.

Damage: The amount of destruction or damage, either in health, financial, environmental functional and/or other terms as a consequence of an occurred hazard.

Damage potential: The amount of potential destruction in a defined area.

Disaster: A hazard might lead to a disaster. A disaster by itself is an impact of a hazard on a community or area – usually defined as an event that overwhelms that capacity to cope with.

Exposure: The degree to which a (natural or socio-economic) system or (natural or socio-economic) community is exposed to potential natural hazards.

Hazard (please see **Natural Hazard**)

Impacts: Consequences on natural and human systems. Depending on the consideration of adaptation, adaptive and coping capacity one can distinguish between potential and residual impacts.

Land-use planning: Creation of policies at local/municipal level that guide the land and resource use (inside administrative borders of a municipality). The main instrument of land-use planning is zoning or zoning ordinances, respectively. Land-use planning is situated below the regional planning level.

Losses: The amount of realized damages as a consequence of an occurred natural hazard.

Mitigation or disaster mitigation: A strategy on actions and/or interventions focusing on long-term goals and objectives to prevent adverse effects of natural hazards and/or potentially harmful processes**.**

Natural hazard: An extreme natural event (of the average environmental, meteorological, hydrological or other natural conditions) that is statistically rare (≤10th or 90th percentile) at a particular place and time. A natural hazard can be a source of risk but does not necessarily imply potential degree or frequency of occurrence. A natural hazard produces risk only if exposures create the possibility of adverse consequences.

Preparedness: Readiness for short-term activities, such as evacuation and temporary property protection, undertaken when a disaster warning is received.

Reaction: While mitigation is characterised by long-term actions, reaction aims at short-term actions in case of an occurring disaster. Reaction comprises preparedness, response and recovery.

Recovery: Post disaster actions, such as rebuilding or retrofitting of damaged structures.

Regional plan: The spatial plan of an administrative area (superior to the municipal level) that is part of an official planning system. The regional plan makes statements and/or determinations referring to the spatial and/or physical structure and development of a region (spatial distribution of land use: infrastructure, settlement, nature conservation areas etc.). It has impacts on the subordinate levels of planning hierarchy (local level, e.g. municipal land use plans etc.). Its textual and cartographic determinations and information often range in the scales of 1:50 000 to 1:100 000.

Regional Planning: Regional planning is the task of settling the spatial or physical structure and development by drawing up regional plans as an integrated part of a formalized planning system of a state. Regional planning is required to specify aims of spatial planning, which are drawn up for an upper, state, or federal statewide level. The regional level represents the vital link between a statewide perspective for development and the concrete decisions on the land use taken at local level within the land-use planning of the municipalities.

Response: The sum of long-term actions (mitigation in terms of planning responses) and short-term actions (reaction) to prevent adverse effects of natural hazards or mitigate their impacts.

Risk: A combination of the probability (or frequency) of occurrence of a natural hazard and the extent of the consequences of the impacts. A risk is a function of the exposure of assets and the perception of potential impacts as perceived by a community or system.

Risk analysis: The mathematical calculation including the analysis of a hazard (frequency, magnitude) and its consequences (damage potential).

Risk assessment: A combination of risk estimation and risk evaluation.

Risk estimation: Approximation of risk consequences in combination with the probability of occurrence.

Risk evaluation: Determining the significance of the estimated risks for those affected, including the element of risk perception.

Risk perception: The overall view of risk as perceived by a person or group including feeling, judgement and culture.

Risk reduction: The "consequence of adjustment policies which intensify efforts to lower the potential for loss from future environmentally extreme events." (Mileti, et al. 1981; Nigg and Mileti. 2002). Such adjustment policies may refer to a broad range of guidelines, legislation and plans that help to minimize damage potential (i.e. exposure to a hazard or maximizing coping capacity of a region or community by, e.g. guaranteeing resources and preparing adequate plans for pre-disaster mitigation and post-disaster response measures). Risk reduction involves both policy/regulatory issues and planning practices, i.e. it is the result of risk management related response (prevention orientated mitigation, non-structural mitigation, structural mitigation, and reaction).

Sectoral planning: 'Sector' in terms of 'sectoral planning' is spatial planning under consideration of only one planning criteria (e.g. traffic, environmental heritage, etc.). Sectoral as well as comprehensive planning can take place on different administrative levels.

Sensitivity: The degree to which a community or a system is affected by the impacts and consequences of natural hazards

Social vulnerability: the risk of being exposed to a stress situation (probability of occurrence); the risk of not being able to respond to a stress event with suitable coping strategies (risk modulators); and the risk that the stress has severe consequences upon the population groups and regions affected (extent of damage).

Susceptibility: The inherent response of a particular receptor.

Technological hazard: A hazard of anthropogenic origin that can harm people, the environment or facilities. The emission from a technological hazard may leak out of a production facility, a deposit, a stockpile, a transport corridor etc. through specific transmission media (water, air, soil).

Typology: The clustering of a large number of items (variety of descriptions) into smaller groups by virtue of shared characteristics. Examples for typologies are:

- *Hazard typology:* Clustering of hazards that are somehow interrelated to each other.

- *Spatial typology:* The result of a clustering process that is based on relevant spatial data.

Typology of risk / risk typologisation: Clustering risks into groups by the characteristics of probability (and certainty of assessment), extent of damage (and certainty of assessment), ubiquity, persistancy, irreversibility, delay effect and mobilisation potential.

Vulnerability: Vulnerability is the degree of fragility of a (natural or socio-economic) community or a (natural or socio economic) system towards natural hazards. It is a set of conditions and processes resulting from physical, social, economical and environmental factors, which increase the susceptibility of the impact and the consequences of natural hazards. Vulnerability is determined by the potential of a natural hazard, the resulting risk and the potential to react to and/or to withstand it, i.e. its adaptability, adaptive capacity and/or coping capacity.

Zoning: Zoning is a local governments' tool that regulates land-use, promotes orderly growth, and protects existing property owners by ensuring a convenient, attractive and functional community. Zoning is the way the local governments control the physical development of land and the kinds of uses to which each individual property may be put.

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2 ANNEX II CASE STUDY AREAS

Annex IIA The Dresden Region

1 Regional background

The Planning Region Oberes Elbtal / Osterzgebirge (Dresden Region) is one of five planning regions in Saxony. It comprises five sub-regions at NUTS level III incl. the urban district of Dresden (City of Dresden), District of Saxon Switzerland, Weißeritz District, District Meißen, and District Riesa-Großenhain. The biggest share in population (46 %) and simultaneously the by far highest population density (1455 persons/km²) is recorded for the City of Dresden (RPS 2004). In total over 67 % populate 'densely populated areas', a spatial category, which is only assigned to 10 municipalities out of 87 in the region. In its south the region is bordering the Czech Republic.

Over the past 15 years spatial patterns in the region have undergone considerable change, which still continues. The reason is the transition from a centralised to a federal planning system with guaranteed self-government at the local level and major economic trasitions, both induced by German Unification in 1990. As major effects considerable economic transformation as well as loss and redistribution of population takes place. Loss of population in inner city and in rural areas is accompanied with urban sprawl at the edge of urbanised areas.

Most important business branches of the region corrently are information technology, engineering incl. aviation automotive industries, food processing, glass and ceramics industry, paper industry, publishing and printing which together make up about 80 % of employees in the manufacturing industries. Most industries are concentrated in and around the city of Dresden (Figure 1). Being the capital of the Freestate the city of Dresden also is an important centre of administrative employment.

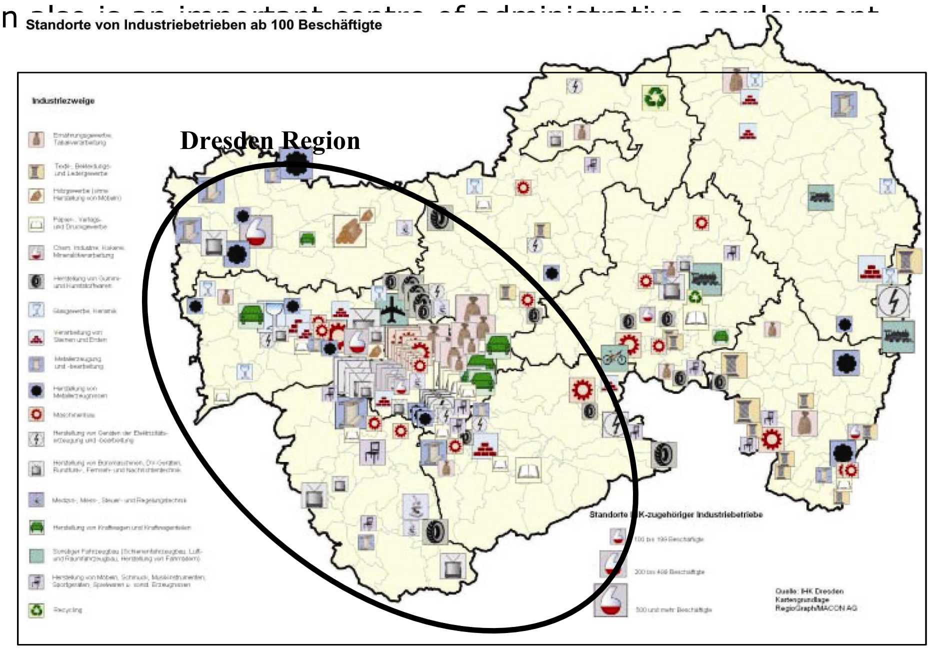

Figure 1: Industrial plants in the Dresden Region with more than 100 employees (RPV, 2001)

Due to a polymorphic landscape, persisting industries, high population density in urban areas and the proximity of the region to other potential sources of hazards various natural and technological hazards play a role in the Dresden region.

A special feature with relevance to hazards is the valley of the Elbe River, which, originating in the Czech Republic flows through several towns like Bad Schandau, Pirna, Dresden, Meißen, Riesa and Torgau. The narrow river valley in the sandstone area in the south widens shortly before Pirna, passes with a wide valley the City of Dresden, narrows again near the town of Meißen and widens right after Meißen to the lowland region. The discharge of the river Elbe is mainly influenced by precipitation and by the outlet from large dams in the Czech Republic.

Natural hazards

The most present natural hazards in the region are floods and wind storms. The region was heavily hit by the August 2002 flood which resulted from extreme precipitation in Saxony and the Czech Republic (Schanze, 2002, DKKV, 2003) combining severe flash floods in the tributaries and an enormous plain flood along the Elbe river valley. Another known natural hazard refers to special geological situation in the south of the planning region. In the Sandstone area of the Saxon Switzerland the steep relief collapses of rock forming the steep relief regularly occurs. Sometimes also landslides happen However, while floods and wind storms affect large areas, rock collapses and land slides in the region occur on a very local level. Therefore, these hazards do not have a relevance at regional level.

Technological hazards

The Dresden Region is historically densely industrialised (see above). Potential sources of technological hazards are single production plants of *chemical and manufacturing industries* that deal with hazardous substances, respectively hazardous combinations of substances, the inland harbours along the Elbe river and the airport. In 1998 344 industrial plants were registered under the German Emergency Ordinance (UBA, 2000, p. 48). Figure 1 indicates the distribution of relevant plants in the region.

In the past also coal and ore mining were important in the region. Whereas most of the mining was finished decades ago in two localities uranium mining had continued until early 1990s. Relicts of mining activities on the one hand are often not totally known and mapped cavities (RPV, 2001). From the past, no catastrophic collapses of cavities are known. Land subsidence hazards caused by cavities from mining in the past have shown that these may have spatial importance but which has not been sufficiently explored and documented. Only local subsidence areas in ancient mining locations are known. For the time being, no mapping of source areas or potentially exposed areas is available.

On the other hand mining relicts are represented by countless waste *heaps from non-ferrous metal mining* (zinc, silver, bismuth, cobalt and nickel) *mining and uranium mining* as well as sites with deposits from uranium extraction plants (RPV, 2001). The impacts of the latter is not yet fully explored. There are several possible risk paths by which the area surrounding these structures can be exposed to the hazard (SSK, 1990):

- direct radiation
- exceeded radon exhalation
- erosion by wind from heaps or dried out settling pits
- leachate into the ground water

Most of the ancient heaps and pits are not visible any more but still can cause locally relevant Radon exhalations (the extent of ground water exposure is not yet defined) though direct radiation and deflation is regarded less important (SSK, 1990). There are no nuclear power plants in or close to the region. The Research Centre Rossendorf with its nuclear physics department is a single structure situated close to Dresden dealing with radioactive substances.

Taking into account the potential 'hazard path' along the Elbe river valley, also *chemical plants along the Elbe and Vltava rivers in Czech Republic* have relevance for the Dresden region. Several plants situated in the floodplains of the rivers with considerable amounts of hazardous substances potentially exposed to flood waters.

Small and large dams in the tributaries and the main valley of the Elbe River are a special technological feature in the mountainous part of the Dresden region. More than 3000 dams and weirs are known in the waters of Saxony several hundreds of those in the planning region (LfL, 2004). Several major structures[1] dam the Elbe and Vltava rivers in Czech Republic. The importance of this hazard was proven during the August 2002 flood when deaths where caused by the break of a retention basin and flood waves in virtually all rivers exceeded storage capacities of dams by far and the operation of some large dams run out of control.

2 Spatial Planning and hazard mitigation

2.1 The spatial planning system and instruments

The German planning system is based on the *Constitution* (Basic Law, 2002) providing the general societal context as a framework for development and ensuring the so called self government right of municipalities (the lowest level in the administrative structure). With its section 75 Nr. 4 the constitution assigns the national level a so called 'framework competence' to set a framework for spatial planning in Germany. Nevertheless, spatial planning and development takes place and is influenced by regulations at different administrative levels (see Appendix 2) and is carried out by various institutions (see Appendix 3). While municipalities physically implement the spatial planning and development, much regulation and coordination takes place at the regional levels.

A central feature of the planning system is the so-called subsidiarity principle. On the one hand, this means that decisions relevant for spatial development are passed as far as possible "down" to the subsequent levels. On the other hand, a relevant decision taken by one document is usually implicitly considered in further documents, but not explicitly repeated.

Spatial Planning as relevant for Saxony takes place in a multiple-step approach:

- The federal government provides framework legislature and general spatial development guidelines and formulates aims and principles for spatial development.
- The Freestate of Saxony (NUTS II) transmits federal requirements for spatial development into the Länder context, sets the larger spatial development framework legislation provides statements on how the territory is to be developed. The Comprehensive Plan (CP) designates central places, main

[1] 'Large dams' as defined by the International Commission on Large Dams (ICOLD): height ≥ 15 m, capacity ≥ 1 Million m^3, flood discharge at least ≥ 2000 m^3/s, see www.icold-cigb.net.

development axes, and major transportation axes are named and areas of super regional or federal interest.

- The actual regional planning in Saxony takes place at the level of the so-called planning regions (covering several NUTS III areas). Here, the statements from the Länder level, especially those of the CP are specified in Regional Plans (RP) and serve together as legally binding statements for municipal planning.
- Finally, municipalities (NUTS IV) are the operative level, where planning and development activities are implemented.

Various implementation strategies at regional level and instruments of implementation at local level support the materialisation of spatial planning (Table 1):

Table 1: Regional implementation strategies and local instruments

Regional implementation strategies	**Local instruments**
Regional (joint) land use plans	Landscape Plans
Regional Planning boards	Legally binding land use plans
Cooperation strategies	Priority areas
Public participation	Reserve areas
Publi	Water Protection Areas
	Flood Zones
	Construction restriction zones

2.2 Hazard mitigation in regional planning practice

The German planning system at all planning levels requires the integration of various concerns. This is realised through elaboration of sectoral plans. Whereas a large number of sectoral plans finally make up 'the spatial plan' for the time being, no explicit 'risk' or 'hazard plan' does exist. Rather, spatial planning integrates issues dealt with in different, often binding documents, such as (thematic) laws valid for various (potentially hazardous) issues (e.g. Emissions Protection Law; Federal Environment Law, etc.). These documents are usually not directly dedicated to risk mitigation often contain requirements on security issues and are to be considered in the course of approval procedures for so called spatially significant development projects. Due to the subsidiarity principle, most such regulations are integral to spatial plans, but not directly visible.

Implicit hazard mitigation takes place for instance in the fields of droughts and storms or heavy precipitation by integrating these issues into spatial development recommendations (e.g. aiming at changing the tree species combination in certain forest areas to mitigate drought or storm risks or to reduce surface runoff). Permitting authorities also would seek to avoid new housing development in the very vicinity of a hazardous industrial plant and vice versa, but rather based on a single case basis than on systematic hazard or risk prevention approach.

Therefore, the analysis of regional planning documentation in Saxony may lead to the impression that hardly any elements of risk prevention are included. Indeed, in practice no systematic risk analysis, assessment or mitigation (cf. Plate, 1999) is being performed by spatial planning authorities. Consequently, no systematic information (e.g.

hazard maps, vulnerability maps, risk maps) about spatial planning relevant risks is available. So far hazard and risk identification takes place only in the field of environmental hazards (e.g. soil erosion or deflation). Though being relevant for spatial planning action, these are rather creeping hazards that do not show sudden or accidental appearance and are therefore not considered in this scope.

In practice, continuous cooperation exists between spatial planning authorities and sectoral authorities, which are in charge of phenomena related to hazards (e.g. the State Institute for Environment and Geology). There are also instruments available for dealing with hazardous areas (see above). The issue largely relies on the initiative from spatial planning partners but lacks systematic basis.

The two for the case study region relevant regional planning documents, CP of Saxony and Regional Plan of the Dresden Region, both hardly refer to hazards. If so, information is on purely descriptive and qualitative basis.

The *Comprehensive Plan* traditionally contains only few direct statements relating to hazard issues. Also the aims of spatial development do not contain statements that would allow to interpreted as meaning risk prevention. The current CP (SMI, 2003) recognises particular call for action in the context of :

- Safe usability of former coal-mining areas (goals 3.3.7. – 3.3.9)
- Preventive protection of the drinking water resources (goal 4.3.1.)
- Preventive flood protection measures (principle 4.3.7, goals 4.3.8.-4.3.9.)
- Limitation of land use in ecologically sensitive areas (principle 4.1.3-4.1.4)
- Rehabilitation of former industrial areas for safe land use (principle 4.4.3.)
- Pronunciation of precautionary hazard prevention, especially flood protection, in terms of a sustainable development strategy (p. 108)

In this sense the current CP does not show considerable advancements compared to the previous (SMI, 1994), which only referred to the following issues:

- Preventive protection of water resources usable for drinking water abstraction (so called Water Protection Areas, B-64)
- Hazard prevention in location with probability of landslides due to past surface coal mining (B-104)
- Hazard prevention in areas of past uranium mining where direct radiation may exposed (B-104)
- Protection of the population against immission of noise, vibrancies and air pollution (B-136)

Most of the statements are made rather from the perspective of technical means of environmental protection than from a systematic risk prevention resp. risk management perspective.

Also the Regional plan of the Dresden Region contains only scarce reference to spatially relevant hazards. Basically these references are limited to general statements about flood protection as shown by Table 2.

Table 2: Direct and indirect statements related to flood protection in the RP for the Dresden region

Instrument	**Cartographic display**	**Summary / aim or principle**
Priority areas for flood protection	Map of spatial uses 1:100000 Symbol (usual retention capacities smaller and larger than 1 Mio m^3)	**Aim** 4.4.6: Completion of the system of flood retention structures in the Eastern Ore Mountains and in the Müglitz river valley. **Requirement** 4.4.6: Environmentally sound flood protection
Flood zones (assigned and planned)	Map Maintenance, Development and Restoration of the landscape 1:100000	**Principle** 4.2.2.6: Clearing and reopening of natural paddles along the Elbe river, allowing for ground protection in case of floods, etc.

The situation is starting to change with regard to the flood hazard. After the disastrous flood events in August 2002 the hazard maps are being prepared, sub-basin based flood protection plans are elaborated and legislature adapted. The new Environment Protection Law urges the delimitation of flood prone areas as basis for spatial planning and development and defines restrictions on land uses there (BMU, 2003). The process is supported by the newly issued Flood Protection Program of Saxony. In this scope also maps of so called 'flood source areas' are under preparation. As the only sectoral documents prepared for the purpose of risk mitigation maps displaying flood zones along rivers and water protection areas will soon serve as basis for integrating these issues systematically in spatial planning.

For other hazards hardly any information is available and usually no responsibilities can be traced. Thus, systematic consideration of risk issues takes place as early as at the level of disaster mitigation (see Table 3).

Table 3: Levels and instruments of disaster mitigation in Germany (Grünewald and Sündermann, 2001)

		General	**Flood related**
Foundation of disaster-protection in German laws.		Basic Law Civil protection law Laws of the states (i.e. Disaster protection law)	Water management law Specific laws of the states
Responsibilities in disaster protection		In duty of the states Supported by the federation	Ministry of the interior as the supreme disaster-protection authority; Districts and district less cities as the local disaster-protection authority
Instruments and actors of disaster-protection	**Disaster prevention**	Disaster protection plans (districts, main cities)	Flood-prevention plans (cities, districts); Plans for management and maintenance of flood prevention constructions and flood prediction
	Disaster management	Volunteers, Aid organisations, Units of extended disaster response, Fire-fighters, Technical Aid (THW), in case of requirement: border police, custom, army	Additionally State Environmental Agency, volunteers, private companies

3 Exemplary Risk Review for the Case Study Region

For investigating the potential inner-regional risk profile the Dresden Region is particularly promising due to extensive social and economic disparities between the five NUTS IIII sub-regions. Whereas the City d Dresden is a densely populated economic centre with over regional importance, the surrounding sub-regions are characterised by low population density and a peripheral economic situation. This diversity is promising for the application of the new method.

3.1 Choice of experts

The choice of experts was the most difficult step to take before starting the test. As systematic risk assessment is still not developed only few practitioners endue extensive knowledge of natural and technological hazards with a good overview of the case study area. However, due to the presence of past events (see above) experts showed particular interest to constructively participate in the Delphi panel.

The method application was repeated with two discrete groups of seven experts from four resp. five different institutions. For the first expert group mainly planners and administrative experts dealing with planning and plan approval issues were considered. In the second expert group scientific expertise in regional and hazard related phenomena was emphasised. Lacking the 'perfect expert' specialists where chosen combining as much as possible expertise on the case study area and spatial planning resp. hazard related phenomena and risk assessment. Provenance of experts from the second group ranged from specialised research institutes and public authorities to state ministries. It has been tried to avoid special relationship of experts to single hazards. Though professional homogeneity was a particularly important criterion of choice, a certain degree of inhomogeneity in terms of personal attitude to the topic could not be totally excluded.

3.2 Choice of hazards and indicators

The unchanged set of hazards was applied for the weighting procedure. This accepted that certain hazards are not necessarily relevant for the region. The expectation was that irrelevant hazards would be scored zero by the panel.

Two main indicators where chosen as proxy for economic damage potential to represent the regional vulnerability: 'Population density' and 'GDP per capita'.

3.3 Application of the Delphi Method

The Delphi enquiry in both expert groups was conducted through three rounds. Prior to the enquiry the experts were informed about the background of the test and emphasising the attitude of the method used. All experts were also contacted personally by telephone to ensure that no questions remained open and to increase the personal commitment of the participants.

The experts were asked to estimate (weight) the relevance of twelve hazards for the Dresden region. 'Hazard potential' was taken as basis for the weighting process. A weighting has also been conducted for the vulnerability indicators. The obtained percentages in both cases had to result in 100 %. In the first round estimations had to be delivered uninfluenced. In round two and three experts were acquainted with the mean result from the previous round respectively.

3.4 Weighting the hazards

Against the expectation all proposed hazards received at least a very low consideration of relevance in both repeats (see Table 4 and Table 5). The reason may be seen in the assumed relevance of distant events that may impact the region. However, it became apparent that most importance is attached to natural hazards (first/second repeat 79/75 %) with Floods (25/26 %), Extreme precipitation (16/16 %) and Storms (13/13 %) on the top of the estimation (Table 4). Technological hazards in total received only 21/25 % with industrial production plants (6/9 %) on top.

Despite a purposefully different composition of expert groups results derived from both expert groups are very close in terms of scores and dynamics of assessment through the rounds. Measuring the change in estimation from round 1 to round 3 in percent the largest relative change experienced the estimations for the hazards Volcanic eruptions and Landslides/Avalanches as well as Earthquakes and Nuclear power plants (Table 4). These hazards, however, are at the same time the four lowest (absolutely) estimated hazards with given percentages between 0,2 % and 2,8 %. The relative changes in estimation for the other, higher ranked, natural and technological hazards changed only by up to 6,6 % (Forest fires) from Round 1 to Round 3.

The seemingly non mentionable influence of the several rounds on the final result, however, has to be seen in the light of the *coordination process* induced by the use of the Delphi method. To evaluate the progress the 'coefficient of variation' has been used (Table 5). This measure is reliant on average estimations and the 'standard deviation' of single responses and shows a clear 'coordination effect' through the rounds. With exception of the hazard 'extreme temperatures' in the first Expert group the coefficient constantly decreased through the rounds by 15 % (Volcanic eruptions) to over 50 % (Extreme precipitation).

Table 4: Average estimations and their change in two expert groups

Hazards		Average estimation Expert group 1			Average estimation Expert group 2			Change in estimation Round 3 / Round 1 (%) Expert group 1	Change in estimation Round 3 / Round 1 (%) Expert group 2
		Round 1	Round 2	Round 3	Round 1	Round 2	Round 3		
Natural Hazards	Volcanic eruptions	0,3	0,2	0,2	0,0	0,0	0,0	65,0	-
	Floods	24,4	24,9	24,8	26,7	27,0	26,0	101,5	97,3
	Landslides/Avalanches	3,9	2,6	2,8	2,3	2,6	2,2	72,0	97,5
	Earthquakes	0,4	0,3	0,4	0,7	0,7	0,7	83,1	94,0
	Droughts	9,6	9,1	9,1	6,4	5,7	6,1	95,1	95,6
	Forest Fires	8,6	9,0	9,2	7,7	7,6	7,7	106,6	100,0
	Storms	12,9	13,6	13,1	11,3	11,4	12,9	102,2	113,9
	Extreme precipitation	14,6	14,9	15,0	14,3	14,6	15,6	103,0	109,0
	Extreme temperatures	4,0	4,0	4,0	4,0	4,1	4,1	100,0	103,6
Technological hazards	Nuclear power plants	1,7	2,0	2,1	2,1	1,3	1,1	124,0	53,3
	Production plants	5,8	5,7	5,6	8,9	9,7	9,1	96,6	102,7
	Waste deposits	4,1	3,9	4,1	5,3	5,8	5,4	100,0	102,7
	Marine/inland waterway transport	3,8	3,4	3,5	6,6	6,5	6,3	92,6	95,7
	Dams	6,0	6,5	6,1	3,7	3,0	2,7	102,8	73,1
	sum	100,0	100,0	100,0	100,0	100,0	100,0		

Table 5: Measuring the coordination effect - the coefficient of variation

Hazards		**Coefficient of variation Expert group 1**			**Coefficient of variation Expert group 2**		
		Round 1	**Round 2**	**Round 3**	**Round 1**	**Round 2**	**Round 3**
Natural Hazards	Volcanic eruptions	163,0	141,4	**139,6**	-	-	**-**
	Floods	62,1	52,5	**49,0**	65,6	36,7	**35,2**
	Landslides/Avalanches	97,6	64,0	**52,6**	86,5	38,0	**31,7**
	Earthquakes	100,3	122,2	**82,4**	105,8	68,3	**70,2**
	Droughts	38,0	27,8	**26,3**	112,1	89,1	**78,9**
	Forest Fires	39,1	30,8	**26,1**	50,6	46,3	**48,9**
	Storms	35,7	30,3	**27,4**	77,0	67,6	**55,1**
	Extreme precipitation	28,1	18,1	**13,3**	55,7	52,2	**45,4**
	Extreme temperatures	30,6	35,4	**35,4**	81,6	40,5	**38,0**
Technological hazards	Nuclear power plants	99,0	70,7	**62,1**	148,6	132,6	**128,1**
	Production plants	70,5	62,1	**51,4**	67,2	57,2	**54,4**
	Waste deposits	72,3	66,6	**57,2**	106,9	65,8	**48,6**
	Marine/inland waterway transport	48,0	45,4	**32,3**	79,0	54,9	**40,8**
	Dams	85,2	48,7	**53,1**	45,9	50,9	**46,2**

3.5 Weighting vulnerability indicators

A widely agreed consensus existed among the experts in the question of the proposed vulnerability indicators 'Population density' and 'GDP per capita'. However, weighting results change more than in case of hazards. Whereas the first expert group agreed on a weight distribution 55 % and 45 %, the second expert group awarded the indicators with scores of 61 % and 39 % respectively (Table 6). It may however be assumed, that this unexpected consensus in the first expert group was influenced by different pre-information (first group knew about the previously used weighting factors 50/50). Also variation of responses practically did not change through the enquiry. However, in the second expert group variation of responses began and ended about three times as high (Table 7).

Table 6: Weighting of vulnerability indicators: average estimations and changes in estimation

Indicators of vulnerability	**Average estimation Expert group 1**			**Average estimation Expert group 2**			Change in estimation Round 3 / Round 1 (%) Expert group 1	Change in estimation Round 3 / Round 1 (%) Expert group 2
	Round 1	**Round 2**	**Round 3**	**Round 1**	**Round 2**	**Round 3**		
Population density	54,3	54,7	55,3	59,3	61,9	61,1	**101,8**	**103,1**
GDP per capita	45,7	45,3	44,7	40,7	38,1	38,9	**97,8**	**95,4**
sum	**100,0**	**100,0**	**100,0**	**100,0**	**100,0**	**100,0**		

Table 7: Weighting of vulnerability indicators: measuring the coordination effect, coefficient of variation

Indicators of vulnerability	**Coefficient of variation Expert group 1**			**Coefficient of variation Expert group 2**		
	Round 1	**Round 2**	**Round 3**	**Round 1**	**Round 2**	**Round 3**
Population density	12,2	10,9	9,0	33,9	23,0	22,7
GDP per capita	14,5	13,1	11,2	49,3	37,3	35,7

In general received average estimations from both groups did not substantially differentiate from each other. This may be taken as proving the general suitability of the method.

3.6 Risk profile of the Dresden Region

Applying the ESPON Hazards approach an aggregated hazard potential for the Dresden region is obtained amounting to 38,6 % (Table 8) of a potential maximum of 100 %. This corresponds with aggregated hazard class II.

Table 8: aggregated hazard potential in the Dresden region

Hazard		Weight	Hazarrd intensity in the region*	Hazard factor	Individual hazard score
Natural Hazards	Volcanic eruptions	**0,2**	1	0,2	**0,0**
	Floods	**24,8**	3	0,6	**14,9**
	Landslides/Avalanches	**2,8**	1	0,2	**0,6**
	Earthquakes	**0,4**	1	0,2	**0,1**
	Droughts**	**9,1**	2	0,4	**3,7**
	Forest Fires	**9,2**	1	0,2	**1,8**
	Storms**	**13,1**	2	0,4	**5,3**
	Extreme precipitation**	**15,0**	2	0,4	**6,0**
	Extreme temperatures**	**4,0**	1	0,2	**0,8**
Technological hazards	Nuclear power plants**	**2,1**	1	0,2	**0,4**
	Production plants**	**5,6**	1	0,2	**1,1**
	Waste deposits**	**4,1**	1	0,2	**0,8**
	oil spills**	**3,5**	1	0,2	**0,7**
	Dams**	**6,1**	2	0,4	**2,5**
	sum	**100**			**38,6**

* hazard intensities as used in the ESPON Hazards project

** comparative assumption lacking scientific data

Considering weighting factors of vulnerability indicators the final vulnerability class is determined for each of the five sub-regions at NUTS level 3 (Table 9).

Weighting proportions of 55/45 (first Expert group) resp. 61/39 (second Expert group) lead to similar results (Figure 2). Considering weighting proportions from both Expert groups on a differentiated nine class risk matrix (Schmidt.Thomé and Jaarva, 2003) two of five sub regions belong to risk class VI, three sub regions are awarded risk class III. A significant difference in the risk only occurs, if the share of the vulnerability indicators changes beyond the mark of 50/50. This clearly indicates the stability of the results. However, in case that changing risk perception would lead to a considerable change in weighting of vulnerability indicators, a different risk map of the region could be the result. This is represented by Figure 2 where a fictional distribution of weighting factors 45/55 (transposition of results from the first expert group). This underlines Delphi's specific applicability for the consideration of subjective issues of risk perception in more or less homogeneous regions.

Table1: Derivation of vulnerability classes in the Dresden region (NUTS level III)

NUTS level III Districts (No NUTS V areas)**	**Population density**			**GDP per capita**			**Vulnerability class** Pop. Dens * GDP	
	Value** (pers./km²)	% (EU 15 average = 100)	class	value*	% (EU 15 average = 100)	class	Results 55/45 and 61/39	Fictional weights 45/55
Dresden Stadt (1)	1.455	1.233	V	23.145	112	III	**IV**	IV
Meißen (17)	242	205	IV	16.149	78	III	**IV**	III
Riesa-Großenhain (23)	149	126	III	14.991	73	II	**III**	II
Sächsische Schweiz (26)	166	141	III	13.025	63	II	**III**	II
Weißeritzkreis (20)	164	139	III	12.012	58	II	**III**	II
EU 15 (100%)***	**118**	**100**		**20.613**	**100**			

* StLA, 2000, except for ***

** RPS, 2004, except for ***

*** EC, 2000

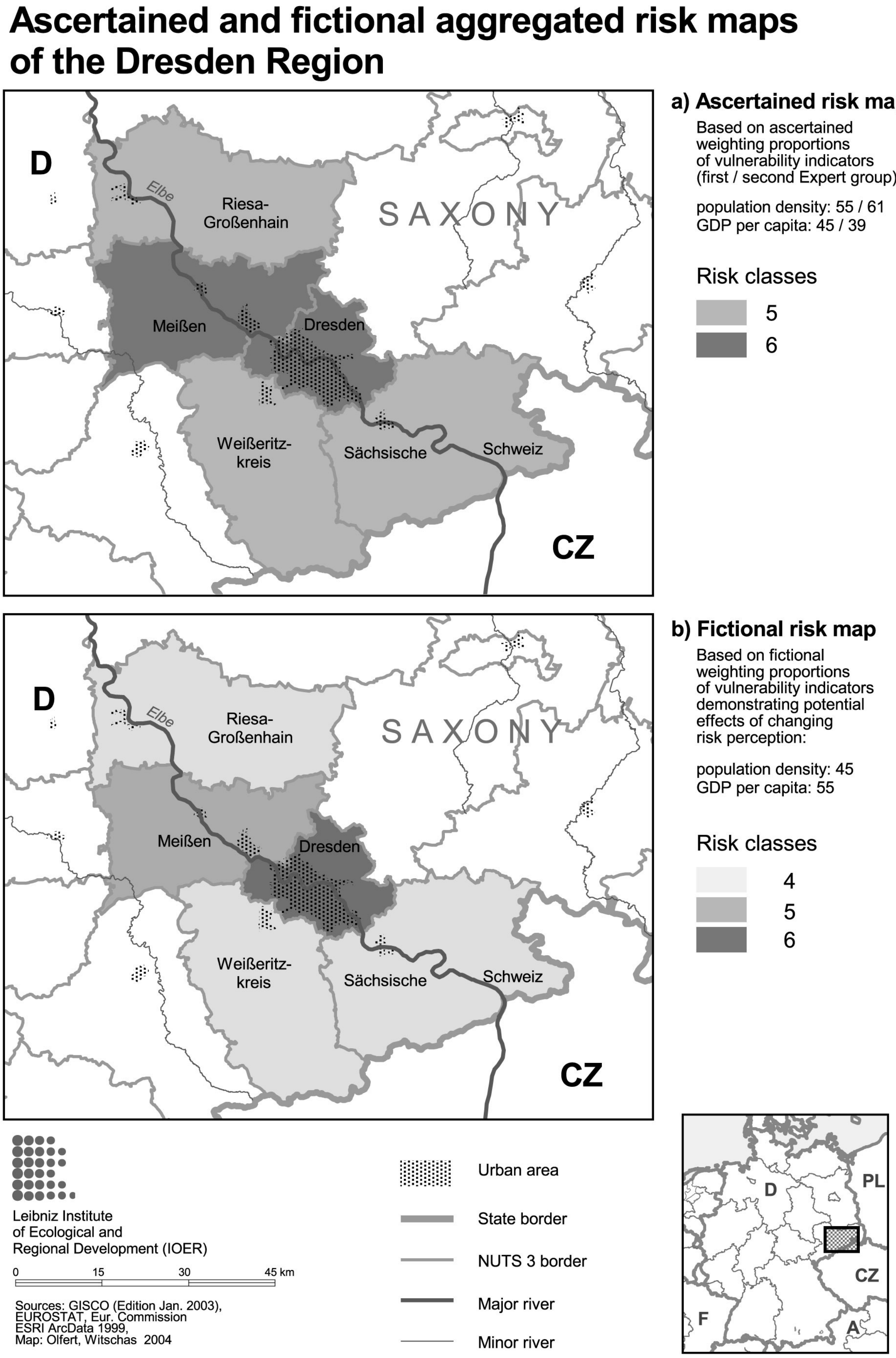

Figure 2: Ascertained (a) and Fictional (b) aggregated risk map of the Dresden region

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Appendices

Appendix 1: Definitions of terms

Spatial Planning *(Raumordnung)* is referred to as the general term describing the super-sectoral planning approaches in Germany at the regional, state or national levels including the Comprehensive Plan and 'Regional Plan'. Spatial Planning at the federal level sets the planning and development framework for the subordinated planning levels. A practical spatial planning competence in Germany is passed from the Federal Government to the Federal States (Länder).

Comprehensive Plan (CP) *(Landesentwicklungsplan)* is an official plan within the spatial planning system on the basis of the federal spatial planning act. It has to be developed for any German Land in order to apply federal requirements to the operational level of the Länder. The CP as the planning instrument of the Länder spatial planning legislation sets the planning framework for regional planning and prescribes goals and principles for further specification in the subordinated spatial development plans of the so-called planning regions further referred to as 'Regional Plan'.

Regional Plan (RP) (*Regionalplan*) as defined above

Land use planning (*Bauleitplanung*) represents the most detailed kind of spatial development planning at the municipal level based on the Federal Building Code.

Preparatory land use plans (*Flächennutzungsplan – vorbereitender Bauleitplan*) provide information on potential types of land uses (housing, green areas etc.).

Binding land use plans (*Bebauungsplan – verbindlicher Bauleitplan*) define precisely the extent to which a type of land use can be performed in a given area (e.g. how many stories, set back, maximum and minimum size of building etc.).

Aims of Regional Planning (*Ziele der Regionalplanung*) are included in the Federal Building Code. They are binding statements about spatial development requirements to be realised at the municipal level.

Principles of Regional Planning (*Grundsätze der Regionalplanung*) are included in the Federal Building Code as well. They are rather guidelines giving the scope of the spatial development requirements to be realised at the municipal level.

Sectoral planning / Planning sectors *(Fachplanung*) 'sector' in terms of 'sectoral planning' means the spatial planning under consideration of only one planning criteria (e.g. traffic, invironmental heritage, etc.). Sectoral approaches are (in the ideal case) weighted, balanced and merged in the context of comprehensive development planning (creation of plans at different planning levels). Sectoral as well as comprehensive planning can take place at different administrative levels.

Land or (pl.) Länder (*Bundesland*) - see 'Spatial Planning'.

Free State (*Freistaat*) – a Land with a special constitutionary status.

Regional Council (*Regierungpräsidium*) NUTS level 2

Region (*Planungsregion*) - planning region for which regional plans are elaborated.

District (*Landkreis*) - administrative area with a specific authority that has been assigned certain super-municipal administrative competencies of the Länder. NUTS level 3

Municipality (*Gemeinde*) - lowest and at the same time most concrete level in the planning hierarchy. Level of land use planning. Municipalities have a guaranteed right of self-government according to article 28 of the German constitution.

Federal level (*Bundesebene*) – national level.

Länder level (*Landesebene*) - administrative level for issues of spatial planning that concern one Land.

Regional level (*Regionalebene*) – level of spatial relevance that is superior to local level (applies for instances to issues like natural or technical hazards that reach an extent which exceeds the ability of a municipality to manage the incident and/or that happens in an area bigger than that of one municipality).

Binding character (*Verbindlichkeit*) – Planning documents of the Länder are legally binding for those on the regional level which in turn are legally binding for those on the local level.

Priority area/site (*Vorranggebiet*) – an instrument of the German planning system. Priority areas or sites can be designated in structural planning in case the local or regional situation requires that a particular function (e.g. recreation, nature/landscape, mining, urban expansion) shall have priority on that area or site. Any planning or action must be compatible with this priority purpose (following a definition of UBA 1995).

Reserve area/site (*Vorbehaltsgebiet*) – an instrument of the German planning system Reserve areas or sites can be designated in structural planning in case the local or regional situation requires that an area shall be reserved for a particular function (e.g. nature/landscape, mining, flood zone). Any planning or action must be compatible with this priority purpose.

Spatial categories (*Raumkategorien*) – **1)** Densely populated area, **2)** Periphery of a densely populated area, **3)** Rural area with signs of densification, **4)** Rural area without any signs of densification (*1. Verdichtungsraum, 2. Randzone eines Verdichtungsraumes, 3. Ländlicher Raum mit Verdichtungsansätzen, 4. Ländlicher Raum ohne Verdichtungsansätze*) - Territorial classification according to the Saxon Regional Planning Law.

Appendix 2: Selected hazard related regulations at different administrative levels especially in Saxony and the Dresden Region

EU – Level

An important document urging national actors to consider major industrial risks in the legislature is the *Council Directive 96/82/EC* of 9th December 1996 (SEVESO II Directive, EC 1996) on the control of major-accident hazards involving dangerous substances.

Regulations concerning natural hazards are missing on European level.

Federal Level

With the *Federal Spatial Planning Law* the federal level provides this framework for spatial planning at the regional levels (Länder and planning regions) and obliging the Länder to enforce regional planning.

The *Federal Building Code* sets the legal framework for the planning and implementation of planning documents at the operative (local/municipal) level. Section 1 Nr. 4 of the code obliges municipal plans to be in co ordinance with aims of spatial planning.

Federal Nature Protection Act (Bundesnaturschutzgesetz – BNatSchG) setting the basic legal framework for the sectoral „Landscape Planning" (Landschaftsplanung) in Germany.

Federal Immission Protection Law (Bundesimmissionsschutzgesetz – BimSchG) – delegates the regulatory power to establish security areas around dangerous structures (through special ordinances) to the Länder (sections 49 and 50, relating to Council Directive 96/82/EC).

Emergency ordinance (Störfallverordnung – BImSchV 12) – based on the Federal Immission Protection Law the Ordinance (section 15) regulates that the responsible boards (e.g. regional councils) estimate the probability of hazards (single case based) to avoid domino effects in emergency situations.

Regional level (federal state and planning region)

Spatial planning is performed and steered at the federal state level. Each federal state is obliged to develop laws and ordinances for the regional planning setting goals and making provisions for the implementation. The most important respective document for the Free State of Saxony is the *Spatial Planning Law of the Free State of Saxony* setting the Framework for the elaboration of the Comprehensive Plan and the Regional Plans (RPs).

The *Comprehensive Plan* (CP), having legislation status *(ordinance)*, is the basis for the elaboration of Spatial Plans of the Planning Regions of Saxony (Regional Plans).

Environmental Protection Law of the Free State of Saxony (Landesnaturschutzgesetz – SächsNatSchG) – sets the legal planning requirements for Landscape Framework Planning in Saxony, in particular as relates the elaboration of so called Landscape Programs (Länder level) and Landscape framework plans (regional level).

Saxon Law for the management of emergencies from accidents with dangerous substances (Sächsisches Gefahren- und Unfallgesetz – SächsGefUnfallG) – Implementing Emergency ordinance.

Regional Plans (RP's), in concert with CP's, are documents (Ordinances by Regional Planning Associations) setting legally binding so called 'aims' and 'principles' for the elaboration of municipal land use plans.

Furthermore, *singular ordinances* regulate special issues of interest in selected facilities. Exp.: *Saxon Harbour Ordinance* (Sächsische Hafenverordnung, SächsHafVO) – regulating security areas around harbours with hazardous substances.

Municipal level

The municipalities provide organise the elaboration and implementation of so called preparatory and binding plans, which have *ordinance* status.

Appendix 3:Selected authorities involved into hazard mitigation and related spatial planning in Germany and especially in Saxony and the Dresden Region

<u>Federal level</u>

Bundesamt für Katastrophenschutz

<u>Regional level</u>

Saxony State Ministry of Internal Affairs (NUTS level 2)**:** elaborating CP and approving Regional Plans. Authority in charge of disaster management and preparedness for civil protection.

Regional Planning Board (below NUTS level 3): Working board of the Regional Planning Association elaborating and updating Regional Plans and monitors their implementation through municipal land use planning.

Regional Council (NUTS level 3): covers a larger area than a planning region (in Saxony three regional council areas). Authority for Approvals of municipal development policies (legally binding municipal plans) in general and large development project if certain project size is exceeded and thus watching the implementation of regional planning policy (RPs and CPs).

State Environmental boards (NUTS level 2): cover the same area as regional councils and provide sectoral information for Landscape planning (in important sectoral planning step at any planning level).

Mining authority (Bergamt, NUTS level 2): responsible for data related to mining locations, cavities and related issues.

Districts and major cities have the assigned responsibility for proclamation of the state of emergency.

<u>Local level</u>

Municipalities (NUTS level 4): Municipalities of a region establish the Regional Planning Association with elected steering board. Furthermore, local disaster officers can be appointed and separate disaster protection offices run (e.g. City of Dresden).

Annex IIB The Centre Region of Portugal

1 Regional Background

The Centre Region of Portugal is one of the five planning and coordination regions in Continental Portugal. It occupies an area of 23,668 km^2 (25,7 % of the Portuguese land area) and includes 78 municipalities in 10 sub-regions at NUT III level.

This region holds important soil potential for agricultural purposes, ornamental rock resources particularly granite, which is capable of being used in many industrial and commercial activities, on top of an extensive and complex botanical and fauna of great environmental, scientific and tourist interest. Additionally, the region is characterised by extensive swathes of forest, particularly of pine and eucalyptus, representing 1/3 of the Portuguese forestry area.

Population: The population is almost 1,8 million inhabitants (17,2 % of the national total), of which 65 % is made up of population considered active.

Education: An increasing search for the valorisation and training of human resources through the established education system, which special note for the three universities and six polytechnic institutes, which area spread evenly through the region. Today about 76.000 students attend higher education, of which 89 % are public teaching establishments.

Table 1: Population and size of Sub-regions in the planning Centre Region

Sub-regions	**No. of municipa-lities**	**Population (2001)**		**size**		**population density**	**GDP/pc 2001**	**GPD 2001**
		number	%	km²	%	(persons/km²)	10^3 Euro	10^6 Euro
Baixo Vouga	12	385 434	21,6	1 806,96	7,6	213,3	10,9	4 201
Baixo Mondego	8	339 666	19,1	2 062,40	8,7	164,7	11	3 736
Pinhal Litoral	5	248 931	14,0	1 740,83	7,4	143,0	11,8	2 937
Dão Lafões	15	285 680	16,1	3 483,33	14,7	83,0	6,9	1 971
Pinhal Interior Norte	14	138 652	7,8	2 617,47	11,1	53,0	7,6	1 054
Pinhal Interior Sul	5	44 833	2,5	1 906,00	8,1	23,5	7,3	327
Serra da Estrela	3	49 902	2,8	871,64	3,7	57,3	6,6	329
Beira Interior Norte	9	114 872	6,5	4 068,82	17,2	28,2	8	919
Beira Interior Sul	4	78 248	4,4	3 738,10	15,8	20,9	10,6	829
Cova da Beira	3	93 454	5,2	1 372,64	5,8	68,1	8,6	804
Total (Central Region)	**78**	**1 779 672**	**100**	**23 668,19**	**100**	**75,2**	**9,7**	**17 107**

Agricultural and forestry: A strong heritage of small cattle and poultry farming and forestry that, despite the profound transformations undergone, continues to play a relevant role in regional economy. Small farms dominate, integrated and made viable within a family-based traditional economy. Wine, olive oil, fruit, milk and wood are still important products in the regional economy. Animal breeding and raising in Pinhal Litoral and Dão-Lafões are also very important activities with a growing impact in this regions.

Industry: The region has stood out due to its diversity, development and innovation, particularly in areas of manufacturing industry, and moulds the growth of which has been both quantitative and qualitative. Although the introduction of new areas is evident, among which one should highlight telecommunications, the new information technologies and, up to a certain extent, components for the automobile industry, it has been in the sectors with a more or less long tradition in the region, such as ceramics and glass, that the greatest progress in innovation has been observed, both in the products and in the processes.

Chemical industry and metalomecanics are also important sectors in especially in Baixo Vouga region where population density is also the highest.

Tourism: Tourism, in its multiplicity of markets segments, is a field of the regional economy with excellent prospects, the qualitative and quantitative emergence of which is already evident, both in the Beira Litoral and in the Beira Interior NUTS III regions, in terms of supply and demand.

The diversity of tourist resources forms the region's major strength. Strategically, it is in the coming together of history and nature, expressed as culture, in many forms, that lays the greatest raw material on which the development of a quality tourist industry is based.

2 Natural and technological hazards

<u>Natural hazards</u>

a. Floods The lower part of Mondego valley downstream from Coimbra, was until the 80's of twenty century affected by frequent floods almost annual floods. This situation was corrected with the construction of Aguieira Dam that permitted to low the frequency of floods to 1 to 25 years in small floods and 1 to 100 years in bigger floods. In the Mondego River valley there is a well-marked delimitation of an area, which is normally affected by the century flood and an emergency action plan was devised accordingly, by the district civil protection services.

The valleys of Vouga e Liz are frequently affected by floods especially the Águeda River basin affluent of Vouga River, which is almost annual, flood frequent. Improper land use in floodplain areas, forest fires upstream and no dam protection upstream from the flooding area are the main identified reasons for so frequent flooding.

b. Forest fires Most of Centre region is classified as high and very high risk of forest fires occurrence by LD n.º 1056/2004 (August 19th) and LD nº 1060/2004 (August 21). To prevent fire events the Instituto Português de Meteorologia releases on a daily bases, in the dry season, the Canadian Index on forest fires vulnerability, from which the national fire brigades draw indicators to their emergency plans for acting on forest fires hazard. Nowadays is questionable if forest fires are only a question of natural hazard or if it's also the result of bad land use and bad human practices, situations more difficult to predict.

c. Landslides this hazard could become problematic in case of high values of rainfall in areas with severe relief. In the centre region the problem of severe relief in mountainous regions added to deforestation caused many times by forest fires, and bad planning of construction in the past, is now a relevant problem and there are no official plans of prevention. Emergency plans are implemented by Serviço Nacional de Bombeiros e Protecção Civil (National Fireman Services and Civil Protection).

Technological hazards

a. *Water contaminations* Industrialised areas such as chemical industry and oil refinery in Estarreja and gas storing in Ovar are industries that deal with hazardous substances, and were subject to national legislation published by article 16th of LD nº 164/2001 (Figure 1), pulp paper mill (Aveiro e Figueira da Foz), manufacturing industries and animal breeding industries in Pinhal Litoral and Dão-Lafões are also suficiently hazardous to cause death to fish in rivers when an accident happens. Measures to prevent or to punish these situations are not yet well implemented. Although, these are now subject to enforcement of the law.

b. *Radioactivity contamination* the region has no nuclear power plants but near the border in Spain exists the Almaraz nuclear power station, which could affect the centre region in case of accident. the area could be affected by spreading radioactivity through the air because the water courses are going to affect the southern region from the study area. also the existence of old uranium mining sites at the part of centre region where the 60 mines are located especially in the granitic intrusions where possible rupture of waste piles and tailings and radon exhalation in the uranium mining region can be considered a hazard of great importance with risk of water and dust spread of radionuclides and radon exhalation (figure 1). besides, there are 456 uranium mineral occurrences that also release radionuclides causing possible risk to humans.

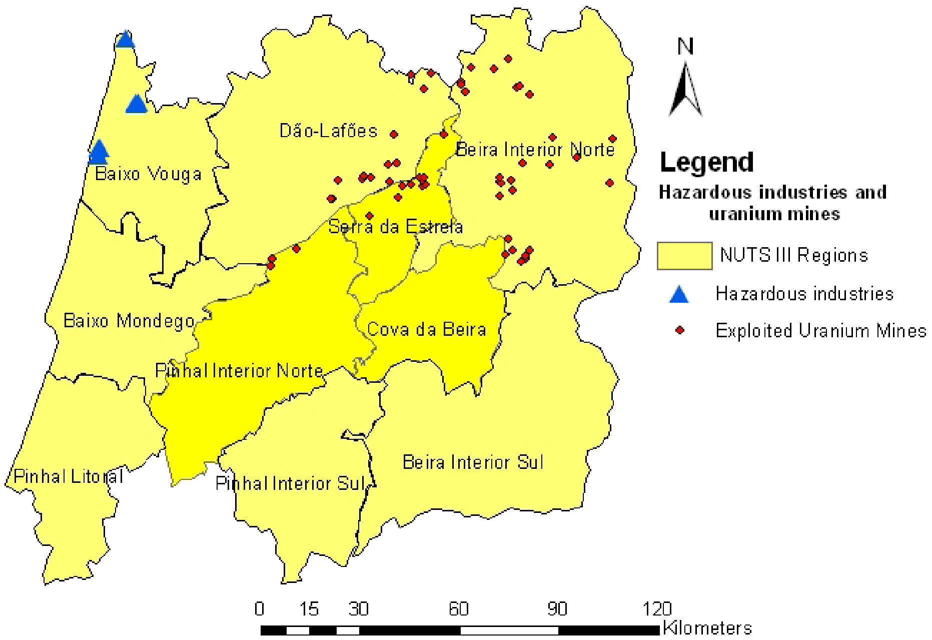

Figure 1: Hazardous Industrial plants (LD 16th nº 164/2001) and uranium mines in the Centre Region from (Serviço Nacional de Bombeiros e Protecção Civil database and SIORMINP database of INETI)

3 Spatial Planning and hazard mitigation

3.1 The spatial planning system

The Portuguese planning system is based on the Constitution of 1996, and on the law n. 48/98, establishing the guidelines for spatial planning and urban policy. It was regulated through the law - decree n. 380/99,, in which the legal system of spatial management planning instruments are drawn at national, regional and municipal levels.

The law - decree n. 555/99, which was altered by the law - decree n. 177/2001, establishes a new legal regime for urban operations at a municipality level (urban plans and detailed plans), a new legal regime for division of urban lands into parcels as well for building activities.

These three integrated (hierarchical) levels of planning aimed at ensuring the different public interests are able to express themselves spatially, in a conciliate/ agreeable manner, in order to promote a sustainable economic and social development as well as territorial cohesion.

3.2 Instruments of spatial planning

Instruments of spatial management identify human, physical and natural resources, essential for sustainable use/management of the territory as well as setting up basic criteria and minimum levels of usage of those resources in order to insure that the natural heritage are able to keep on renewing itself. Selected instruments are listed in Table 2.

Table 2: Administrative levels in the Portuguese planning system

Administrative level	Relevant documentation
Nacional Level	*The national policy programme for spatial planning* *Sectorial plans* *Special plans, inc.* ***protected areas spatial plans, coastlands spatial plans, shallow lakes spatial plans and water protected groundwater plans.***
Regional Level	*Regional spatial plans* **(NUTS level II)** *Catchment basin plans* (Mondego, Vouga and Liz rivers) **-** Coordination and advise to municipalities plans In a sub-regional level, it is able to find the so-called *Inter-municipalities plans.*
Municipal level	*Municipal spatial plans* **(NUTS level IV)** City councils strategic plans (PDMs) Urban plans (PU) Detailed plans (PP)

Only the Municipal spatial plans are able to bind public and private bodies to comply with their rules. All the others bind solely public institutions. The authorities involved in the plans are presented in Appendix 2

3.3 Hazard mitigation in spatial planning practice

The national council for emergencies and civil protection (CNPCE) is the responsible official board for the coordination of all civil protection services. Within CNPCE there are sectoral committees, which depend directly upon government even if in operational terms they depend on the president of CNPCE (Table 7 in Appendix 3).

Since the 1990's Portuguese legal rules on land-use planning changed significantly after introduction of a new regulated concept- the National Ecological Reserves (REN). Throughout the national territory, pockets of land areas have been identified, delimited and ruled in order to preserve the importance of the different biodiversity ecosystems. The outcome of such work has brought extremely important measures when reducing the potential of risk of natural and technological hazards were being concerned. These measures are referred in Appendix 2.

In the nineties, this kind of regulation was absorbed and made present in most of the City Council Strategic Plans. In order to avoid the dereliction of sensitive environmental areas, it is believed this kind of good practice has given great contributions to the risk reduction of floods and water contamination, and even, to the land derails.

While the previous one could be placed as a good practice example indicator, falling within the "Driving Force concept" of DPSIR chain, this next one, could be easily identified as a good practice example indicator of response.

The creation of artificial lagoons/shallow lakes and other similar types of constructions it was set to help to respond to this particular hazard.

The artificial lagoons of Aguieira e Fronhas were built to prevent the city of Coimbra and the village of Montemor o Velho, to be overflowed without control, by creating the possibility of accumulating high volumes of water, and therefore, decreasing the high levels of floods in the downstream trunk of Mondego river. Despite of the fact the risk of floods has been reduced, there are still the risk of overflowing due to the century flood.

4 Exemplary Risk Review for the Case Study Region

To extract the importance of potential hazards for the Centre Region, the Delphi Method was applied as a coordinating instrument (cf. Grieving et al. i.p.).

The goal of the Delphi application in the Central region is to depict an exemplary inner-regional risk profile as well as to produce a first aggregated risk map for the region. As prerequisite the relevance of chosen hazards is weighted according to Delphi and vulnerability indicators are weighted.

Additionally two steps refining and applying the results to the NUTS level IV were realised:

a) Adapted choices for NUTS IV level;

b) Transformation of results into a regional aggregated risk map for NUTS IV level.

4.1 Choice of experts

It was a challenging task to identify a sufficient number of experts who, due to the professional expertise have a good overview over the case study area and who are (or have until recently been) working in the area of spatial planning and/or hazards. The Expert group chosen for the Delphi test was formed by ten experts from six different public and private organisations.

The method application was repeated with two different groups of ten experts from six different institutions. The former was constituted by researchers and the latter by regional planning authorities, consulting companies and from Environment and Planning Ministry. It has been tried to avoid special relationship of experts to single hazards.

4.2 Choice of hazards and indicators

Relevant hazards were chosen according with previous instructions and ideas developed by the rest of the project team and in accordance with the European wide application of the method accepting that some of those would be scored 'zero' by the experts because they are not relevant in the case study area. The list of hazards is provided within the result tables below. Vulnerability indicators, although the same as the other case studies and the same as at European level were used, regional vulnerabilities were taken into account considering the data available for further detail study.

4.3 Application of the Delphi Method

The Delphi enquiry was made previously for only one group. It was decided to repeat the experience to improve the method application and to be more comparable to the European wide application. This way two groups were selected only for a specific set of hazards selected in European approach. In both expert groups was conducted through three rounds. Prior to the enquiry the experts were informed about the background of the test and emphasising the attitude of the method used. All experts were also contacted personally or by letter or mail. Experts where instructed to consider feedback information provided after the first and second repeat.

4.4 Weighting the hazards

Interesting remarks are the different relevance given by both groups to floods, forest fires and landslides. Researchers (first group) tend to give less weighting to floods and forest fires although in the third round the tendency is to raise the weighting of these two hazards. The same first group tends to give more importance to landslides than the second group (planners and regional authorities). The reason may be the frequency (more emphasised in case of forest fires) and economic impact every year that forest fires and floods tend to cause. Researchers tend to observe more the probabilities of occurrence under certain circumstances and not so much the event it self. However, it became apparent that most importance is attached to natural hazards (first/second groups 77/80 %) with Forest fires (26/37 %), Floods (20/21 %) and Landslides (10/8 %). Technological hazards in total received only 23/19 % with Major accident hazards in chemical plants in first (11/9 %). In case of technological hazards the results tend to diverge between both groups (see Table 3).

Measuring the change in estimation from Round 1 to Round 3 in percentage the largest relative change experienced the estimations for the hazards Droughts, Earthquakes and Storm Surges and the smallest for Volcanic eruptions, Snow Avalanches and Hazards from Nuclear power plants. These hazards, however, are at the same time the four lowest estimated hazards although the changes estimated in case of Droughts should be observed carefully and may have to do with the Drought definition between both groups.

Table 3: Weighting of hazards: average estimations and their change in expert groups 1 and 2

Hazards		Average estimation Expert group 1			Average estimation Expert group 2			estimation Round 3 / Round 1 (%)	estimation Round 3 / Round 1 (%)
		Round 1	**Round 2**	**Round 3**	**Round 1**	**Round 2**	**Round 3**		
Natural Hazards	Volcanic eruptions	0,0	0,0	**0,0**	0,0	0,0	**0,0**	100	100
	Large River Floods and Flash Floods	19,0	19,3	**20,9**	21,0	21,2	**20,4**	110,0	97,3
	Storm Surges	5,4	4,0	**4,1**	3,2	3,8	**3,7**	75,2	115,6
	Snow Avalanches	0,6	0,1	**0,1**	0,0	0,1	**0,0**	100,0	100,0
	Tsunamis	0,6	1,2	**0,9**	0,8	0,9	**1,1**	156,7	140,0
	Landslides	10,4	10,2	**9,4**	7,6	8,0	**8,4**	90,4	110,0
	Earthquakes	2,6	4,3	**3,6**	3,2	3,0	**3,0**	137,7	92,5
	Droughts	7,8	4,7	**4,1**	1,0	1,8	**2,3**	52,3	234,0
	Forest Fires	24,0	27,0	**28,4**	38,2	36,1	**35,4**	118,4	92,6
	Winter Storms	4,0	3,0	**2,3**	2,2	1,8	**2,0**	58,5	90,9
	Extreme temperatures	3,0	3,3	**3,2**	3,6	3,7	**4,3**	105,3	118,9
Technological hazards	Hazards from Nuclear Power Plants	3,6	2,9	**3,1**	3,7	3,5	**3,4**	87,2	93,0
	Major accident hazards	10,2	11,0	**11,4**	9,6	9,6	**9,1**	111,8	94,8
	Hazards from oil production, processing, storage and transportation, including major oil spills	7,4	7,4	**7,4**	4,6	5,2	**5,5**	100,0	119,6
	Air traffic hazards	1,4	1,5	**1,1**	1,3	1,4	**1,2**	77,1	92,3
	sum	**100,0**	**100,0**	**100,0**	**100,0**	**100,0**	**99,8**		

The *coordination process* induced by the use of the Delphi method was more effective in case of the second group where all hazards results seems to converge, which was not the case of first group where Snow Avalanches, Droughts, Forest Fires and Air Traffic diverged from the first to the third repeat. To evaluate the progress the 'coefficient of variation' has been used (Table 4). This measured value is reliant on average estimations and the 'standard deviation' of single responses and shows a clear 'coordination effect' in case of the second group of experts through the rounds.

Table 4: Weighting of hazards: measuring the coordination effect, coefficient of variation

Hazards		Coefficient of variation Expert group 1			Coefficient of variation Expert group 2		
		Round 1	**Round 2**	**Round 3**	**Round 1**	**Round 2**	**Round 3**
Natural Hazards	Volcanic Eruptions	100	100	**100**	100	100	**100**
	Large River Floods and Flash Floods	22,0	5,1	**6,0**	19,9	17,7	**12,6**
	Storm Surges	53,4	14,6	**3,3**	40,7	22,0	**12,1**
	Snow Avalanches	149,1	180,7	**223,6**		223,6	
	Tsunamis	223,6	90,6	**76,6**	223,6	111,7	**70,7**
	Landslides	40,0	21,3	**16,1**	40,1	23,8	**15,9**
	Earthquakes	123,4	49,7	**32,2**	89,5	63,5	**63,5**
	Droughts	73,9	9,8	**30,3**	141,4	91,3	**65,9**
	Forest Fires	9,3	16,8	**17,0**	33,0	19,1	**17,7**
	Winter Storms	43,3	50,0	**32,5**	103,7	99,4	**61,6**
	Extreme temperatures	47,1	31,3	**23,5**	84,7	78,4	**49,5**
Technological hazards	Hazards from Nuclear Power Plants	46,5	24,5	**15,9**	53,7	45,2	**45,1**
	Major accident hazards	92,6	12,9	**37,0**	71,6	35,0	**24,1**
	Hazards from oil production, processing, storage and transportation, including major oil spills	33,9	37,7	**31,1**	36,4	21,1	**18,2**
	Air traffic hazards	63,9	33,9	**59,1**	92,6	39,1	**48,1**

By observing the results of the two groups of Delphi inquired in this stage it is evident that both groups reach different results. But, is possible to see that the second group composed of regional authorities, decision makers and consulting company people are more coherent between then and respect with more efficiency the rules of Delphi method. Therefore, for further procedure only the results of the second expert group were used.

4.5 Risk profile of the Central Region

Applying the ESPON Hazards approach an aggregated hazard potential for the Central region of Portugal is obtained amounting to 51.7 % of a potential maximum of 100 %. This corresponds with aggregated hazard class III. Considering weighting factors of vulnerability indicators the final vulnerability class is determined for each of the ten sub-regions at NUTS level III (see Table 5 and Table 6).

At NUTS level III vulnerability is applied with the same weighting as used as used by the ESPON Hazards project for the generation of European-wide maps. Vulnerability indicators are weighted according to the methodology depicted in. The indicators used in this case were for damage potential, population density and GDP per capita, and coping capacity was used national GDP per capita (Table 5 and Table 6):

Vulnerability = Damage potential (25%+25%) - Coping capacity (50%)

Table 5: Vulnerability matrix of NUTS level III in the Centre Region of Portugal

	population density 25			**GDP per capita 25**			**vulnerability class**
Districts (NUTS 3)	**value 1999 (pers./km²)**	**% whith EU 15 average = 100%**	**class**	**value 2000 (€)**	**% whith EU 15 average = 100%**	**class**	
BEIRA INTERIOR NORTE	27	23	2	7.311	35	1	**1**
PINHAL LITORAL	131	111	3	10.104	49	1	**1**
PINHAL INTERIOR SUL	13	11	1	7.680	37	1	**1**
BEIRA INTERIOR SUL	20	17	1	8.618	42	1	**1**
COVA DA BEIRA	64	54	2	7.321	36	1	**1**
SERRA DA ESTRELA	56	47	2	5.998	29	1	**1**
DÃO LAFÕES	142	120	3	7.246	35	1	**1**
PINHAL INTERIOR NORTE	50	42	2	6.578	32	1	**1**
BAIXO MONDEGO	154	131	3	10.198	49	1	**1**
BAIXO VOUGA	196	166	3	10.568	51	2	**1**
reference (EU 15 =100)	**118**	**100**		**20.613**	**100**		

Table 6: Vulnerability matrix of NUTS level III in the Centre Region of Portugal

	National GDP per capita* 50	**vulnerability class**	**DP+CC/2**

Districts (NUTS 3)	value 2001 (€)	% whith EU 15 average = 100%	class		
BEIRA INTERIOR NORTE	12.500	56	4	2	1
PINHAL LITORAL	12.500	56	4	2	2
PINHAL INTERIOR SUL	12.500	56	4	2	1
BEIRA INTERIOR SUL	12.500	56	4	2	1
COVA DA BEIRA	12.500	56	4	2	1
SERRA DA ESTRELA	12.500	56	4	2	1
DÃO LAFÕES	12.500	56	4	2	2
PINHAL INTERIOR NORTE	12.500	56	4	2	1
BAIXO MONDEGO	12.500	56	4	2	2
BAIXO VOUGA	12.500	56	4	2	2
reference (EU 15 =100)	**22.432**	**100**			

*CCDRD data source; DP-damage potential; CC-coping capacity

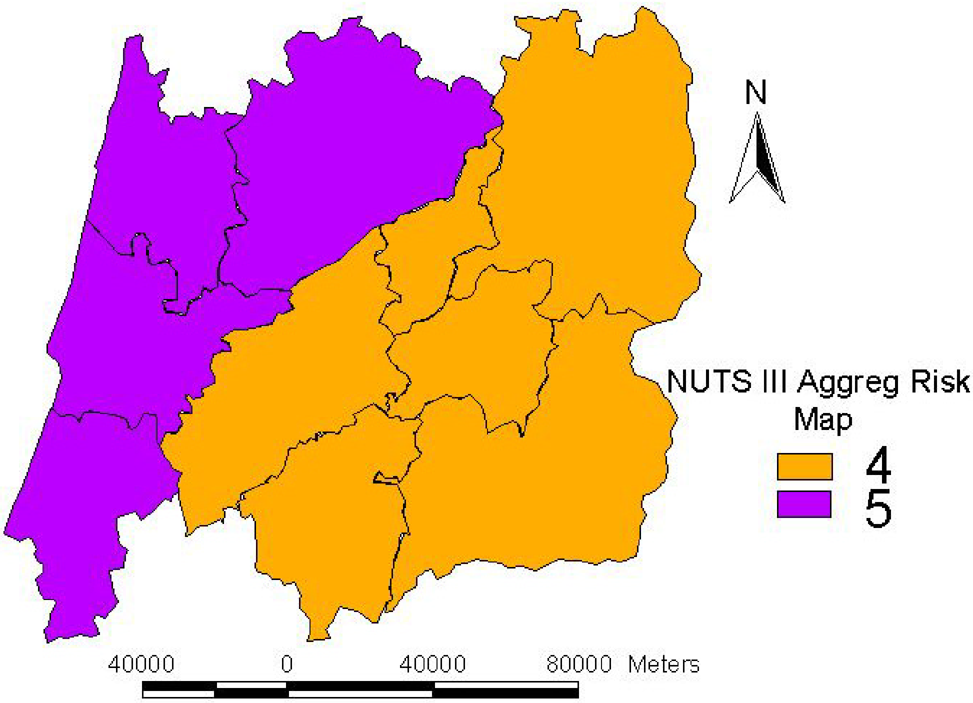

Figure 2: Aggregated risk map of the Central region of Portugal (NUTS level III) using GTK data of the European maps with National Delphi and regional and national GDP as vulnerability indicators

Considering general vulnerabilities as coping capacity and damage potential and using the same methodologies used in European maps with the exception of fragmented natural areas not used in this case, the results show that NUTS III regions near the coastline with high development have higher risk.

In contrast to other case study areas, in the Centre Region data availability allows the refinement of weighting results to NUTS level IV. For this reason an alternative set of vulnerability indicators has been used:

Damage potential: Regional GDP (2001) referred to national data; Population density (2001) referred to national data; Population Lost referred to national data.

Coping capacity: Doctors/1000 inhabitants; number of fireman/area

All vulnerability indicators were weighted as 20% but coping capacity were calculated considering the lowest number of doctors per 1000 inhabitants as 5 (the high vulnerable areas) and 1 the higher number of doctors per 1000 inhabitants as the low vulnerable areas. The same methodology was calculated for the number of fireman / areas.

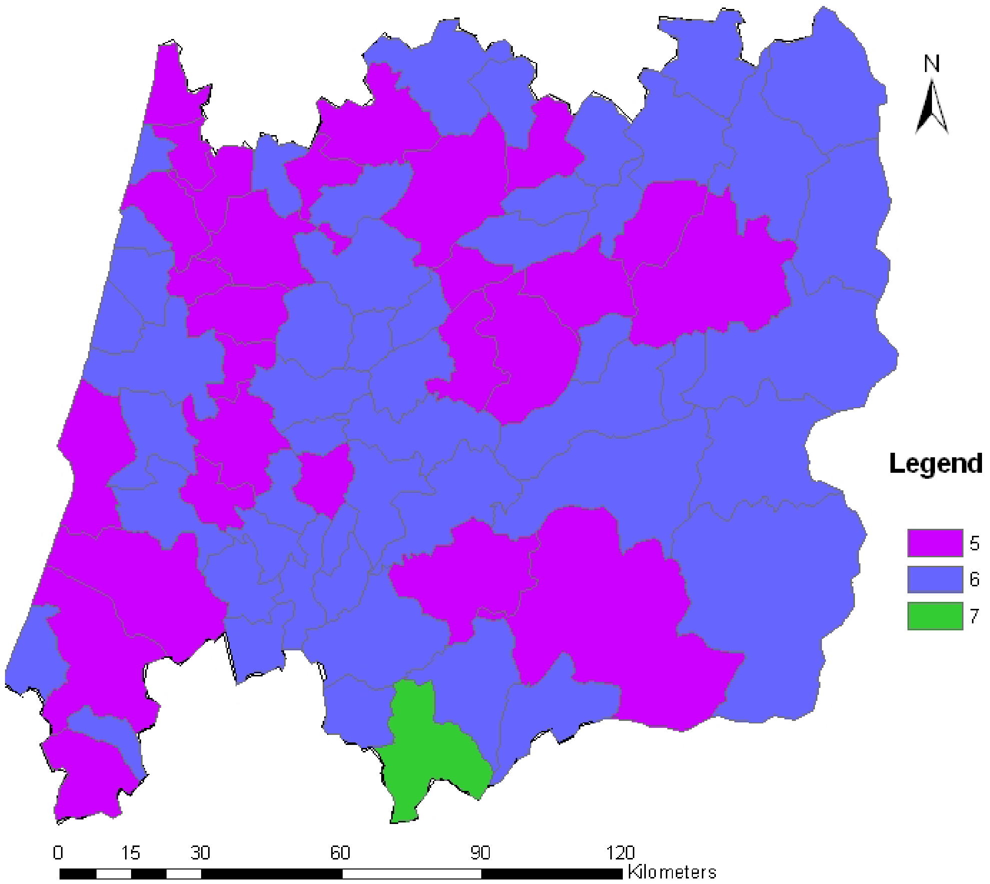

Figure 3: Aggregated risk map of the Central region of Portugal (NUTS 4 level) using GTK data of the European maps with regional vulnerability indicators

These maps are based in ESPON Hazards methodology but may not reflect in extent the real regional vulnerabilities in the future more tests and new approaches should be tried.

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Appendices

Appendix 1: Definition of terms (Centro Region of Portugal)

Spatial Planning – is referred to as the general term describing the planning approach system in Portugal at the national, regional and municipal levels. They embodied three different kinds of plans: National Plans, Regional Plans and Municipal Plans (PMOT's). In these types of documents it is laid out the spatial development major goals to be achieved in order to promote a balanced relation among human beings, activities, equipments, and further infrastructure such as accessibilities.

Regional Plan – The regional plans in Portugal can cover different length of territories. Therefore, it is possible to have regional plans covering the full length of the territory labelled as NUTs II, or those that can cover solely more than one NUTs III, and finally those which are based on parts of NUTs III territories, as it is the case of PROZAG.

Municipal Spatial Plans (PMOTs) – These plans are in nature, administrative regulations, that determines the type of usage that can be done into the different kinds of soils. It comprises the total area of the municipality or solely part of it. It comprehends other types of plans: Municipal Plan (PDM), Urban plans and Detail Plans.

Municipal Plans (PDM)- In this kind of plan, it is established the spatial structure to be applied to the full length of the municipal territory. Soils classifications, urban indexes, are to be defined according to the way that economic activities, dwellings, equipments and other types of infrastructure such as the transport system have been set in place.

Urban Plan- this is the kind of plan that covers urban and non-urban areas- that though, can become reclassified as such- in order to give an organic structure to the urban territory, by establishing: a) The outer boundary of urban areas; b) Urban criteria; c) The end usage of dwellings; d) Heritage buildings that are in need of being protected; e) Areas that are to be elected as shelter for certain kinds of equipments; f) Green areas are mapped, and finally, is where the main net of transport system is outlined.

Details Plans - as the name suggests, this is a kind of plan that distinguish itself for substantiate and define in a clearly way, the typology of occupations available when the use of municipal territory are to be concerned. In case of urban areas, the Detail Plans instruct of how to build in certain areas of the municipality, what short of requirements are to be followed in order to preserve the façade of certain types of buildings etc.

Special Spatial Plans – Portuguese Central Administration is the accountable body for setting up these kinds of plans. Special Spatial Plans provide with the principles and rules of how to occupy and transform land areas, in order to maintain and preserve public interests. They include other plans such as of those dealing with protected areas spatial plans , public shallow lakes spatial plans and Coastal spatial Plans.

National Ecological Reserve (REN) – This is a concept that often is wrongly taken for Natural Parks. At least in Portuguese terminology, this concept gains a much wider scope allowing it to comprehend natural areas, coastal areas, estuary areas, lagoons, shallow lakes, streamlets, areas of maximum infiltrations and declivous areas. All of them are part of REN.

Therefore, REN is defined as all basic types of diverse biophysics structures that through certain kinds of impediments to their usage are able to protect its own ecosystems from an unbalanced development. Nevertheless, these areas try to balance human activities and a lively, health environment.

Principles of Regional Planning - are included in the Decree-lawnº 380/99 of September 22nd of 1999. This legislation provides with the guidelines for spatial development requirements that need to be followed at the national, regional and municipal level.

Natural Area – Land with a special constitutionary status due to its importance for the nature/ecosystem conservation.

Region – Area commonly labelled as NUT II. There are 7 NUT II in Portugal: 5 in the territory of continental Portugal and the other 2 in the Açores and Madeira Island.

District – Administrative area with a specific authority, which has been assigned certain super-municipal administrative competencies.

Municipality – lowest and at the same time most concrete level in the administrative and planning hierarchy level and land use planning. Municipalities have a guarantee right of self-goverment according to the article...

Inter-municipal level Planning (matches the definition of German partner of Regional Level Planning) – level of spatial relevance that is superior to local level and inferior to the regional level (applies for instance to issues like natural or technical hazards that reach an extent which exceeds the ability of a municipality to manage the incident and/or that happens in an area bigger than of one municipality).

As it is defined in the decree-law nº 328/99 – " the inter-municipal plan of spatial planning is a territorial development instrument which guarantee a good articulation between regional spatial plans and the municipal spatial plans".

Appendix 2: Hazard mitigation in spatial planning practice and spatial plans levels (Centro Region of Portugal)

Measures taken to reduce the potential of risk of natural and technological hazards :

Bounding the "side-walk areas" of rivers preventing them to be used with building activities, or similar activities, which ultimately, would decrease the level of water infiltration on the soil, was one of those good land-use planning measures, which is believed to reduce the level of hazards, even if not always applied;

The maximum borderline of a century flood have been delimited and consequently, restrictions to the use and the type of use of those inflicted land areas have been determined.

Land areas have been classified according to their level of infiltration and guidelines have been given to the type of use of the different kind of soils.

Delimitation of the use of declivous zones (> than 30% of declivity) have been established;

The type of use of coast land areas and wetlands determined;

Involved /responsible official boards/ authorities

Listed below you will find the responsible official boards for each of the different strategic plan.

The national policy programme for spatial planning

Authority: Head office of spatial planning and urban development

Sector Plans

Authority: Ministry of an a sector

iii. Regional Spatial Plans

Authority: CCRC (Comissão de Coordenação da Região Centro)[2]

iv. Especial plans, Municipal plans and sector plans are monitored by the Regional Head Office of Environment and Spatial Planning (CCDR/DRAOT).

a. Regional Spatial Plans in the Central Region of Portugal

There is no strategic spatial plan covering the full length of all the territory of the central region of Portugal. What do exist is a shorter regional plan called **PROZAG** (Regional spatial plan for the surrounding area of three different dams of Aguieira, Coiço e Fronhas) which covers six municipalities overall.

This plan was approved in 25/09/92, bonding all public and private bodies to comply with new regulation on land-use management and water supply.

PROZAG can be regarded as an umbrella strategic plan, providing the guidelines to other "lower" plans, such as, those of cities councils involved in this area, with which they have to comply.

The major goal of this plan was to protect the water quality of shallow lands of Aguieira, Coiço e Fronhas, since it serves not only to supply a wide area of population but also to irrigate Baixo Mondego lands.

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[2] CCRC and DRAOT have merged as an unique service called CCDR(Comissão de Coordenação e Desenvolvimento Regional)

As this document was created while before the new regulation applicable to regional spatial plans came out, (Decree-law nº 380/99) it did not cover all the areas that should be object of planning. At the present moment, the regional spatial plans are being revised under the lights of this new regulation.

"Special Plans" of the Central Region of Portugal

Spatial plans for coastland areas

All the coastland of the central region of Portugal, which spreads itself through an area of 140 km2 for 3 km2 of depth, encompassing 11 municipalities, are equally object of a spatial strategic planning called "Special plan for coastland areas".

This special plan, which has been approved in October of 2000, is meant for :

a) value different usage of coastland areas;

b) protect natural ecosystems and ensure a sustainable exploitation of resources;

c) value existing settlements without disregard of the coastal dynamics;

ii. Spatial plans for artificial lagoons/ shallow lakes

There are still few others special plans for artificial lagoons in Zêzere River, particularly: those, which relates with Cabril, Stº Luzia, Bouça e Castelo de Bode artificial lagoons.

iii. Spatial plan for protected areas

Spatial planning for the Natural Parks of Serra da Estrela, serra de Aires e Candeeiros and Natural Reserves of Paul de Arzila and of dunes of S. Jacinto has been recently approved.

iv. Mondego, Vouga, Liz catchment basin plan

Spatial planning to optimise the use of water in the main river basins of Central region of Portugal.

Appendix 3: Levels and instruments of disaster mitigation in Centre Region

Table 7: Levels and instruments of disaster mitigation in Centre Region

Levels / Institution	General Responsable	Disasters / Plan
1st Level - National council for emergencies and civil protection of Portugal	Portuguese 1st Minister Ministry of the interior / (Administração Interna)	Floods, Forests fires / Water management law Specific laws
2nd Level District Centre for operations of emergency and Civil Protection	Mayor of County Council/ (Governador Civil) Coordenador Regional da Protecção Civil	Floods, Forests fires Districts
3rd Level – Municipal Centres of Emergences and Civil	Mayor of city (Presidente da Câmara)	Several disasters/ Strategic Document: Municipal Plan for Emergencies and Civil

Protection			Protection
Instruments and actors of disaster-protection	Disaster prevention	Disaster protection plans (districts, main cities)	Flood-prevention plans (cities, districts); Plans for management and maintenance of flood prevention constructions and flood prediction
	Disaster management	Volunteers, Aid organisations, Units of extended disaster response, Fire-fighters, Technical Aid (THW), in case of requirement: border police, custom, army	Additionally State Environmental Agency, volunteers, private companies

Spatial planning response to natural hazards – floods/ forest fires

The general framework works either for the flood phenomenon and forest fires, even if what it presented here is related to flood hazard.

The following structure will present the hierarchy of accountable bodies for responding to these natural hazards (not only at a planning level but also at an operational level). The figurehead of each of them and the strategic document they comprise, are going to be mentioned as well.

1st Level – Institution: National Centre of Emergencies and Civil Protection (NCECP)

Scope of Action: National Territory

Accountable body/ Figureheads:

Planning body - NCECP depends directly on the Prime Minister of Portugal;

Operation level – NCECP guides the activities of the National Services of Fire Brigades (SNB) and the National Service of Civil Protection (SNPC)

Strategic Document: National Plan for Emergencies and Civil Protection

2nd Level – Institution: District Centre for operations of Emergency and Civil Protection

Scope of Action: District Area

Accountable body/ Figureheads:

Responsible – *Governador Civil* (Mayor of County Council)

Operation level - District Services of Fire Brigades and District Service of Civil Protection, which are being merged.

Strategic Document: District Plan for Emergencies and Civil Protection, plus special emergencies plans for flooding, fire forest and seismic activity, etc.

3rd Level – **Institution:** Municipal Centres of Emergencies and Civil Protection

Scope of Action: Municipal area

Accountable body/ Figureheads:

Responsible – City's Mayor

Operation level – town councillor for Civil Protection, the chief of Fire Brigades, the chief of GNR (police operating in rural areas), director of City council Infra- structures, director of EDP (Portugal Electricity Enterprise), director of the Red Cross, director of hydric resources of INAG, director of *Misericórdias* (Charity health and social care Institution)

Strategic Document: Municipal Plan for Emergencies and Civil Protection. This plan holds information on:

Mission statement

Responsibilities of each civil protection agent in case of accidents

List of contacts of each one of those entities

List of material and human resources within the municipal area (this includes private bodies as well)

General characterizations of the main risks and the levels in which they have to mobilize the right agents according to the level of risk (green, yellow, orange and red).

In case of accident, the 3rd level is the first one that is responsible for mobilizing all necessary civil protection agents, and if proves to be insufficient due to the dimension of the phenomenon or due to the scarceness of human or material resources. They will be accountable for mobilizing the 2nd and, if necessary, the 1st level of this chain.

Flood hazards - Operation Level

The National Water Institute provides the district civil protection with water levels in a certain risk area

The district civil protection warns the municipal civil protection

Municipal civil protections warn and mobilize all the right agents, local radios and if necessary provide with personal warnings to those who live in risk areas

Forest Fires hazards - Operation Level

The National Institute of Meteorology provides the fire brigades with vulnerability indexes on fires (District Fire Brigades)

District Fire Brigades mobilize the right agents to cope with the dimension of the phenomenon, including the ones who are in watch posts.

Annex IIC Itä Uusimaa

1 Regional Background

The region of Itä-Uusimaa (Eastern Uusimaa) is situated in southern Finland, east of the country's capital and the region of Uusimaa. Itä-Uusimaa consists of 10 municipalities that have a total population of 90 000 inhabitants. The largest town and the most important centre Porvoo (45 000 inhabitants) is home to the regional council of Itä-Uusimaa. Sipoo is the second largest municipality with 18 000 inhabitants, whereas the third largest municipality, Loviisa, has a population of 7 600. The municipalities of Itä-Uusimaa are mainly rural in their nature, alhtough Porvoo and Loviisa have town centres with an urban structure. The population density varies notably between different municipalities, being 167 in the town of Loviisa and 9 in the rural communities of Lapinjärvi and Pernaja. Many of these municipalities increase their population substantially in the summertime, when people from urban areas retreat to their summer cottages.

Table 1. Population and population density (persons/km²) in the municipalities of Itä-Uusimaa. (Itä-Uusimaa region 2003)

municipality	**population**	**population density** (persons/km²)
Askola	4 446	21
Lapinjärvi	2 981	9
Liljendal	1 462	13
Loviisa	7 440	167
Myrskylä	1 992	10
Pernaja	3 823	9
Porvoo	45 730	70
Pukkila	1 949	14
Ruotsinpyhtää	2 934	11
Sipoo	18 177	50
Itä-Uusimaa	**90 934**	**33**
Finland	**5 206 000**	**17**

The proximity of Helsinki (40 kilometres west from Porvoo) and the growing capital region with over one million inhabitants creates traffic and pressure for more efficient land use in Itä-Uusimaa. The population growth in the entire Itä-Uusimaa has been moderate (13,3%) in the last twenty years. Sipoo, whose neighbouring town is Helsinki, has grown with 40% and the regional centre Porvoo with 20%. Population reduction has occurred mainly in the easternmost municipalities of Lapinjärvi, Loviisa and Ruotsinpyhtää. The largest concentrations of industry can be found in the two towns of Porvoo (oil refinery, industry cluster and port) and Loviisa (nuclear power plant and port).

Itä-Uusimaa is a predominantly low-lying and fertile region with plenty of fields and both deciduous and coniferous forests. The region is situated on the Gulf of Finland and altogether seven rivers discharge to the gulf within the region's boundaries. The condition of the rivers and lakes is generally fairly good, but many rivers adjacent to clayey agricultural regions show high concentrations of nutrients. In the last twenty years the eutrophication of the region's lakes has been noticeable, and eutrophication is also present in some inland bays and the archipelago. The water circulation is slow due to the sheltering effect of the archipelago and thus the coastal waters are especially vulnerable to the sewage waters from industry, agriculture and settlements.

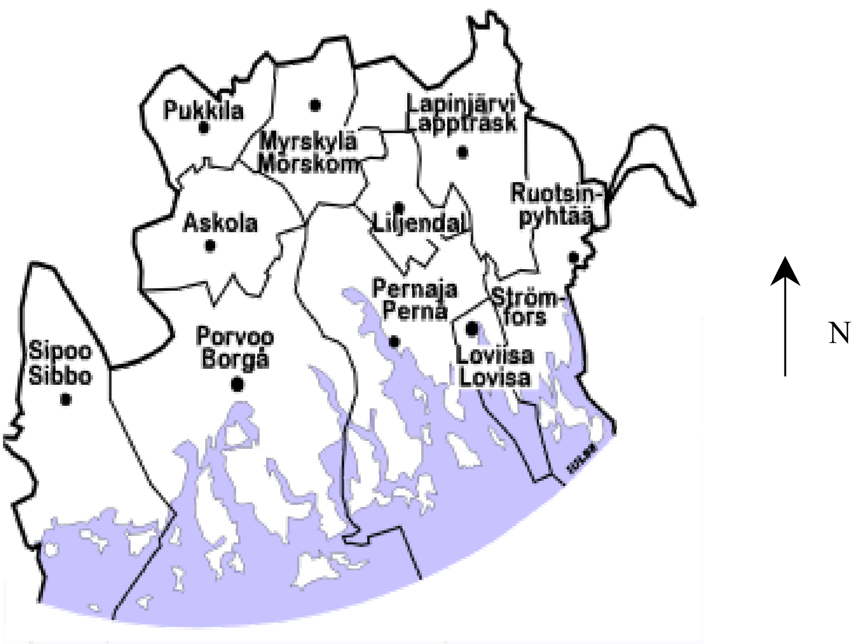

Figure 1. The region of Itä-Uusimaa and the ten municipalities. (Itä-Uusimaa region 2003)

2 Natural and technological hazards

<u>Technological hazards</u>

Although Itä-Uusimaa is a small region with a small population, it has significant technological hazards. The two most relevant potential hazard sources inside the region are the industry cluster and port in Sköldvik (Porvoo) and the nuclear power plant in Hästholmen (Loviisa). Technological hazards also threaten the region from the outside in the shape of oil transportation on the Gulf of Finland.

The nuclear power plant is situated 15 kilometres south-east from the centre of Loviisa on the island of Hästholmen. The plant meets over ten percent of the total electricity need in Finland and it employs approximately 600 people. The nuclear waste is stored in subterranean pits near the power plant. An accident in the power plant would not only threaten the town of Loviisa, but also the whole region and even more extensive areas.

The port of Sköldvik is Finland's most important port for both export and import of crude material and products of chemical industry. The port and the adjoining oil refinery are situated in the industrial area of Sköldvik approximately 12 kilometres south-west from the centre of Porvoo. Emissions of dangerous chemicals into the air are a potential risk to the population of Porvoo, whereas the environment faces a pollution risk from oil spills from the marine transportation and loading of oil and other harmful substances.

Road transportation of oil and other hazardous substances is mainly related to the industrial cluster and port in Sköldvik. A serious infrastructural weakness that intensifies this hazard is the lack of a second road connecting the industrial area. An accident on the existing road could hinder possible rescue measures. Traffic and road transportation of harmful substances poses a risk to a larger area as well, since the E18 –road from Turku to the Russian border passes through the Itä-Uusimaa region.

Potential technological hazards that threaten the region from the outside are mainly related to the marine transport of oil and other hazardous goods in the Gulf of Finland. The Russian port of Primorsk in the eastern tip of the gulf is important for exporting oil from Russia via the Baltic Sea. Oil transportation carries always a risk, but the often difficult ice conditions in the Baltic Sea, especially in the Gulf of Finland, intensify this risk when oil tankers not built for such conditions are being used. The technological risk of oil transportation is thus intensified by natural conditions.

Another hazard related to oil transportation and oil refineries in the Gulf of Finland are scattered oil spills that are difficult to detect and to prevent. It is estimated, that in the Baltic Sea there are 500-800 oil spills every year, and in 2001 the Border Guards reported 107 oil spills in or near the Finnish territorial waters. The Finnish marine Research Institute states that the continuous exposure to these oil spills can strain the Baltic maritime environment more than previous oil accidents in the Baltic sea have done.

<u>Natural Hazards</u>

Natural hazards and their impacts in Finland and in the Itä-Uusimaa region are generally mild. The region is geologically stable, and the earthquakes that occur from time to time are too mild to be considered a risk to the population, economy or environment. Most natural hazards are related to extreme weather conditions, such as extreme precipitation, storms, droughts or extremely low temperatures. However, such events are rare and even though they can cause considerable damage, they seldom cause casualties. For example forest fires, which are most common in the dry periods of the summer, seldom spread out to threaten residential areas.

Flooding is perhaps the most relevant natural hazard in Itä-Uusimaa. The flooding of rivers in Finland is often linked to the melting of snow and ice in the spring. In the region of Itä-Uusimaa, fluctuations of the discharge of rivers are fairly large due to the lack of larger lakes in the river systems. The economic damage related to river floods concerns mainly agriculture, whereas residential areas are seldom affected.

Flooding can also be caused by storms that occasionally raise the level of the Baltic Sea high. Economic damage can be high especially in coastal urban regions, but similarly to the other natural hazards in the region, casualties are not recorded.

3 Spatial Planning and hazard mitigation

3.1 The spatial planning system in Finland

The Finnish planning system includes national, regional and municipal levels (see table). National land use goals have been set by the Council of State. These goals include the building and maintenance of main infrastructure networks and the policing of natural and built-up areas of national importance. The main task of the national government is to issue guidelines and supervise the observation of laws.

Ministry of the Environment acts as the highest authority that supervises and develops planning in Finland. It promotes, guides and controls planning. Regulations of the *Land Use and Building Act* have to be used in the planning, building and land use of all regions and municipalities. In the hierarchical Finnish spatial planning system three levels of planning documentation instruct the land use in municipalities: regional plan (maakuntakaava), master plan (yleiskaava) and local detailed plan (asemakaava).

Table 2. Finnish planning framework

Level	**Responsible authority**	**Main task**	**Plan**
National level	Council of State	Sets national land use goals	
National level	Ministry of the Environment	Supervises and develops planning in Finland	
Regional level	Regional Councils	Responsible for spatial planning on the regional level	Regional plan
Municipal level	Municipal Councils	Main executive role in spatial planning in Finland	Master plan, Local detailed plans

Municipalities act as basic planning units in the Finnish spatial panning system. The responsibility for spatial planning on the regional level has been given to the 20 regions of Finland. The Regional Council, which has representation from each municipality of the region, has the highest power of decision. The Regional Government steers regional planning according to the action plans approved by the regional council. *Regional plan* is a general plan for the land use of the whole region. It acts as a guiding instrument when master and local detailed plans are drawn up on the municipal level. National and regional goals are expressed in regional plans, which are submitted for approval to the Ministry of the Environment.

The self-governing municipalities have the main *executive* part in spatial planning, while the *master plan* is the main instrument in the *steering* of spatial planning in Finland. The master plan indicates the overall guidance of land use and the siting of various activities, whereas the *local detailed plan*s indicate the detailed land use and building in the municipality. In the hierarchical planning system the regional plan steers the master plan and the master plan steers the local plan. The legal effects work in the opposite direction, since the regional plan is not valid where a more detailed master plan exists, and the master plan is not valid where a more detailed local plan exists.

Every municipality has a *building code,* which includes regulations that are necessary for the realisation and preservation of a good living environment and for respecting cultural and natural values on the local level.

3.2 Hazard mitigation in spatial planning practice

Elements of available planning documents with relation to hazards and risks

The regional plan of Itä-Uusimaa does not have a risk-based approach, alhtough the two most relevant technological hazards of the region (nuclear power plant in Loviisa and industrial cluster and port in Porvoo) are recognised by drawing inner and outer exclusion areas around thme. Their purpose is to control land use in the close vicinity of these possibly dangerous areas. The inner exclusion area has a one kilometre radius, the outer exclusion area a five kilometre radius.

The regional plan of Itä-Uusimaa states that in the inner exclusion area of Hästholmen no permanent housing should be allowed and the construction of buildings is permitted only for the nuclear power plant's purposes. In the outer area the number of permanent residents is restricted to 200 and no such activities should be undertaken that include large masses of people or endanger the safe functioning of the power plant. In the inner exclusion area of Sköldvik no new housing should be built. In the outer area no new housing should be built without a specific purpose. Both Hästholmen and Sköldvik also have their own local detailed plans where the permitted building volume is defined according to the contents of the regional plan. In addition to these exclusion areas, a consultation ring of two kilometres has been drawn around the Sköldvik industrial cluster according to the Seveso II –directive.

Master and local detailed plans recognise some hazards that are not recognised in the regional plan level. One example is flooding, which is more relevant on local than on regional level in Itä-Uusimaa. The Land Use and Building Act states that building sites should be chosen in such a way that no risk of flooding or landslides occurs. In local detailed plans flood prevention is taken into account by setting a construction height for new areas. This height is specified in the building codes of separate municipalities.

Although the planning documents do not recognise all relevat hazards, hazard-specific guidelines or separate risk plans are made by environmental authorities, rescue departments, companies and other actors on all planning levels.

Relevant data sets available at regional level

Data sets concerning hazards and risks are scarce in the Itä-Uusimaa region. Spatial planners do not produce data about hazards, but the existing data is mostly available for them. The existing data are collected by several actors, the regional rescue department and environmental centre being the most important ones. The Regional environmental centre has e.g. data about floods and the possible risk sources of chemical accidents. Also the ground water areas that might be affected during a possible chemical accident are located on a map. Specific hazard maps are scarce, but flooding, the oil refinery and industrial cluster as well as the nuclear power plant are recognized in regional and local plans.

Nationally data are collected by specialized institutions, such as the Safety Technology Authority (TUKES) and the Radiation and Nuclear Safety Authority (STUK). Explicit data on the most probable sources of technological hazards is undoubtedly collected for the purposes of risk management inside the industrial areas.

Statistical data for measuring regional vulnerability (e.g. population density) is available inside the region, although it hasn't been widely used for the purposes of vulnerability. Nor is it combined with hazard data to create risk maps. However, population density is considered as a damage potential and thus vulnerability measure in the risk plans of the industrial cluster in Porvoo as well as the nuclear power plant in Loviisa. The regional rescue department also has risk analysis maps, where an area with a certain level of hazards and population is marked as risky area.

One reason for the lack of data sets concerning hazards in Itä-Uusimaa is the issue of scale. The whole region has a population of 90 000 and planning resources are accordingly small. Since the number of hazards is limited and their magnitude is in most cases small, there is necessarily no need for regional or national data. It is more likely that the regional council or municipalities will collect data on topical issues only when the information is needed and not beforehand.

4 Risk Review for Itä-Uusimaa

4.1 Application of the Delphi Method

The Delphi method was applied in the Itä-Uusimaa region in February 2004. The aim was to get an assessment of the importance of different hazards in the region. With the help of these results a regional risk profile and an exemplary aggregated risk map were drawn up.

4.2 Choice of hazards and vulnerability indicators

The relevant hazards for Itä-Uusimaa were chosen from the list defined by ESPON Hazards. Those hazards were left out, which were considered totally irrelevant for the region, e.g. volcanic eruptions. The list of hazards is presented with the results.

Two indicators, population density and GDP per capita, where chosen to represent regional vulnerability. These two indicators represent damage potential, whereas coping capacity indicators were not used in this evaluation. However, the experts had a chance to suggest other relevant indicators for their region.

4.3 Choice of experts

The most important thing for the successful functioning of the method is to find suitable and motivated experts. The expertgroup chosen for the Delphi test contained 4 experts from the following three organisations in the region of Itä-Uusimaa: Regional Council, Regional Environment Centre, City of Porvoo planning department.

The main qualification for these experts was that they have a good overview of Itä-Uusimaa and that they work in the field of environment and spatial planning. The fact that Itä-Uusimaa is such a small region affects both the number and variety of experts found in the region. There are no experts who deal with environmental and technological hazards directly, so general knowledge of the issue was considered sufficient.

It seems that the theme was somewhat difficult to grasp since the implementation process of the Delphi method took longer than expected. It also became clear, that the experts need to be especially motivated when using a method which requires a three-round-process. The most difficult thing for the experts was weighting regional indicators.

4.4 Weighting the hazards

The results were obtained through a three-round enquiry. The experts were asked to estimate (weight) the relevance of twelve hazards for the Itä-Uusimaa region. The idea was, that the overall hazard potential (=sum of different hazards) of a region is always 100%. In the second and third rounds the experts were shown the average results of the previous round in order to obtain the nearest thing to an unanimous opinion in the end.

The following table shows the average values obtained for each round, as well as the standard deviation and change in estimation. The average estimation value represents the average of all estimations submitted for each round. The deviation value shows the maximum departure of proposed values from the average, and also indicates how the estimates developed from round to round. The change in estimation value shows in which direction and how much the estimation of each hazard changed from the first to the final estimation.

Table 3: Weighting of hazards: average estimations and deviation from the average

	hazards	**average estimation Round 1**	**average estimation Round 2**	**final estimation Round 3**		**deviation Round 1**	**deviation Round 2**	**deviation Round 3**		**change estimation round 3 / round 1 (%) first estimation = 100**
Natural Hazards	Floods	4,3	3,5	**3,1**		4,3	1,7	1,0		73,5
	Droughts	5,8	4,3	**3,8**		4,9	3,0	3,0		65,2
	Storms	1,3	1,1	**0,9**		1,0	0,9	0,6		70,0
	Extreme precipitation	2,0	2,3	**2,0**		2,2	2,1	2,2		100,0
	Extreme temperatures	0,0	0,0	**0,0**		0,0	0,0	0,0		0,0
	Forest Fires	2,3	1,6	**1,5**		2,2	1,1	1,0		66,7
	Landslides	0,3	0,0	**0,0**		0,5	0,0	0,0		0,0
Technological hazards	Nuclear power plants	12,8	15,8	**13,5**		5,2	7,0	3,7		105,9
	Waste deposits	7,5	7,5	**9,8**		2,9	2,9	7,1		130,0
	Production plants	33,8	31,4	**31,5**		14,9	13,1	10,3		93,3
	Marine transport of hazardous goods	30,0	32,6	**34,0**		14,1	11,9	11		113,3
	Dams	0,3	0,0	**0,0**		0,5	0,0	0,0		0,0

The Itä-Uusimaa results show, first of all, that the experts changed their estimations when given the possibility to see the average estimations from the previous rounds. The fact that the experts' opinions got closer to each other can be seen in the total deviation score, which went down from 52,8 in the first round to 43,6 in the second and 39,9 in the third round.

The Itä-Uusimaa results show a clear contrast between the estimations for natural and technological hazards. In the case of natural hazards, not only are the average estimations low, but also the deviation score stays under 5 for each hazard. This indicates that the experts agree on the fact that natural hazards are not of high relevance in the Itä-Uusimaa region.

Tecnological hazards, on the contrary, receive high relevance scores (excluding dams). However, the experts don't seem to agree on the relative relevance of the different technological hazards. Especially production plants and marine transportation of hazardous goods get high estimations as well as high deviation scores, although the deviation scores do come down slowly from round 1 to round 3. Unexpectedly, the estimation for waste deposits goes up in the third round, as does the deviation score for this hazard. Waste deposits also score the highest change in estimation from round 1 to round 3.

4.5 Weighting vulnerability indicators

The Delphi method was used for an assessment of vulnerability in Itä-Uusimaa. In addition to the damage potential indicators, GDP per capita and population density, the experts were requested to list and estimate other feasible indicators for measuring vulnerability in the region. All of these indicators were then to be weighted so, that the overall vulnerability score for the region is 100%. Since none of the proposed indicators were directly feasible for the purposes of the Hazards project, only GDP/capita and population density were offered for estimation in the second and third rounds.

Already in the first round it became clear that the experts were not familiar with assessing the vulnerability of a region, nor was the concept of vulnerability clear to all of them. Most of the vulnerability indicators they proposed did not measure vulnerability at all. The results from the first round are not comparable with the results from the second and third rounds, and thus the results from the first round are not used here.

Table 4: weighting of vulnerability indicators: average estimations and deviation from the average

Indicators	**average estimation round 1**	**average estimation round 2**	**average estimation round 3**		**deviation round 1**	**deviation round 2**	**deviation round 3**		**change in estimation round 3 / round 2 (%) first estimation = 100**
Population density	-	77,5	77,5		-	20,6	20,6		100
GDP/person	-	22,5	22,5		-	20,6	20,6		100

The experts found population density substantially more relevant for measuring vulnerability in Itä-Uusimaa than GDP per capita. However, the deviation was high on both rounds, so the experts didn't quite agree on the weighting of these two factors. As a matter of fact, the individual estimations stayed the same on both rounds. Thus there was no change in the average estimation between the second and third rounds.

4.6 Risk profile of the Itä-Uusimaa Region

Table 5 shows the average final estimation from the Delphi test and hazard factors obtained from the potential hazard intensity. The intensity of different hazards in Itä-Uusimaa was measured by the Hazards project and can be found in the European-wide hazard maps. The hazard estimation and hazard factor were multiplied to obtain the individual score for each hazard. When the individual hazard scores are added up, an aggregated hazard potential for the Itä-Uusimaa region is obtained (44,6). According to the methodology developed in the project, this score is translated into a weigted hazard value, which for Itä-Uusimaa is 2 (scores from 35 to 50).

Table 5: aggregated hazard potential in the Itä-Uusimaa region.

hazard	**final estimation**	Hazarrd intensity in the region	Hazard factor	Individual hazard score
Floods	3,1	1	0,2	0,6
Droughts	3,8	1	0,2	0,8
Storms	0,9	3**	0,6	0,5
Extreme precipitation	2,0	1*	0,2	0,4
Extreme temperatures	0,0	1*	0,2	0
Forest Fires	1,5	2	0,4	0,6
Landslides	0,0	1	0,2	0
Nuclear power plants	13,5	5	1	13,5
Waste deposits	9,8	1*	0,2	2,0
Production plants	31,5	2***	0,4	12,6
Marine transport of hazardous goods	34,0	2****	0,4	13,6
Dams	0,0	1*	0,2	0
sum				**44,6**

* assumption lacking scientific data
** data of winter and tropical storms, storm surges and tsunami
*** data of chemical plants
**** data of Hazards from oil production, processing, storage and transportation, including major oil spills

In the table below, the vulnerability of Itä-Uusimaa is determined according to the methodology defined by the project. Following this methodology, GDP/capita in Itä-Uusimaa is defined as class III and population density as class II. The weighting of the two vulnerability indicators, GDP/capita (22,5%) and population density (77,5%) was obtained with the Delphi test. The overall vulnerability class for Itä-Uusimaa is obtained by weighting the two indicators accordingly. The high weighting of population density determines the overall vulnerability of Itä-Uusimaa as class II.

Table 6: Vulnerability matrix of the Itä-Uusimaa region (NUTS level 3)

	GDP per capita (%)			population density (%)			
NUTS3 level	**value (Euro)**	**% (EU 15 average = 100)**	**class**	**Value (persons/km^2)**	**% (EU 15 average = 100)**	**class**	**Vulnerability class**
Itä-Uusimaa	19.294	93,6*	III	30,6*	25,9	II	**II**
EU 15 (100%)	**20.613**	**100**		**118**	**100**		
*Copyright EUROSTAT							

From the obtained weighted hazard value (2) and vulnerability class (II) an aggregated risk matrix can be developed. In the case of Itä-Uusimaa only the whole region is depicted in the matrix, since Itä-Uusimaa itself is one NUTS3 level region (see table below). Itä-Uusimaa receives an aggregated risk value of 4.

Table 7: Risk matrix for the Itä-Uusimaa region (NUTS level 3).

	Degree of vulnerability				
Intensity of hazard	1	2	3	4	5
1	2	3	4	5	6
2	3	4 Itä-Uusimaa	5	6	7
3	4	5	6	7	8
4	5	6	7	8	9
5	6	7	8	9	

The aggregated risk map for the Itä-Uusimaa region is not very informative due to the fact that Itä-Uusimaa in itself is one NUTS3 region and thus no comparison between regions can be made. In theory it would be possible to use the ten NUTS5 regions in Itä-Uusimaa to obtain a more informative map, but in that case the Delphi method would have to be conducted separately in each municipality. What hinders this, is the lack of experts in a region, where the smallest municipality has a population of 1462.

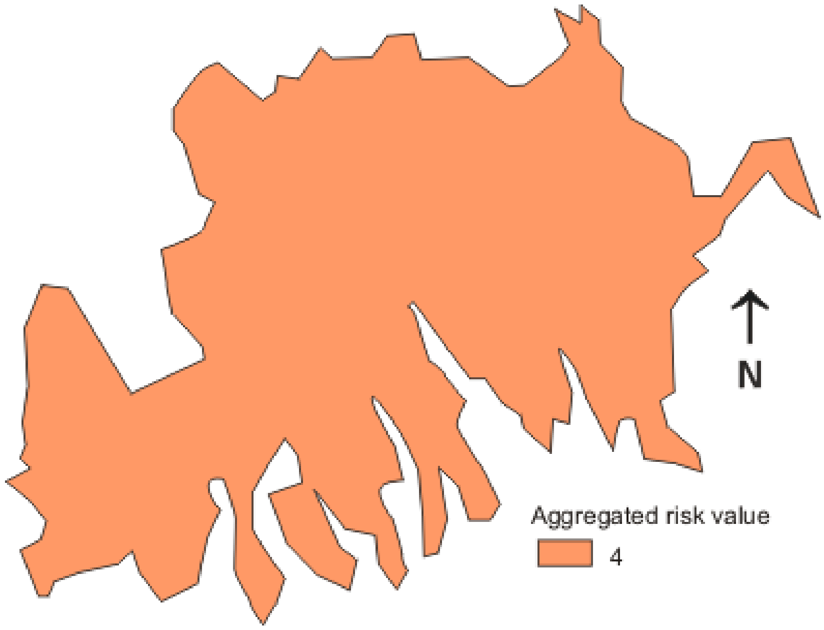

Figure 2: Aggregated risk map of Itä-Uusimaa.

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Annex IID The Ruhr District

1 Regional background

The Ruhr District is one of the biggest economic regions of Europe with 5.4 million inhabitants. It covers an area of 4.434 km² and it consists of 53 municipalities, which are partly independent from a district administration. The average population density is about 1.213 inhabitants/sq km. The Ruhr District is located between the slate mountains of Rhine in the south, the westphalian lowlands in the east and the plain of the Niederrhein in the west. The region is split in three governmental districts (Düsseldorf, Arnsberg and Münster).

The selection of the case study area, which consists of eight municipalities, depended on the following criteria:

Location inside the government district of Düsseldorf and of the Regional Association of Ruhr (RVR)

Location in the territory of the waterway of the river Rhine

A share of more than 15 % for housing and traffic area

Figure 1: The planning region in the conurbation of the Ruhr District (modified from RVR 2004)

The case study region region comprises the three city-counties of Duisburg, Mülheim and Oberhausen and five municipalities of the district Wesel (Dinslaken, Moers, Rheinberg, Voerde and Wesel). The following table shows their relevant socio-economic characteristics:

Table 1: Population, employment and size of districts in the planning region (LDS 2004)

Municipality	Population		Employment		Size		Pop. density	Empl. density	GDP 2001*
	number	%	number	%	km²	%	(inh./km²)		Mio Euro
Dinslaken	71 193	5,87	19 208	5,44	48	6,25	1 493	403	7 908
Duisburg	508 664	41,91	155 894	44,13	233	30,33	2 185	670	12 157
Moers	108 019	8,90	28 593	8,09	68	8,85	1 596	422	7 908
Mülheim (Ruhr)	172 171	14,18	56 684	16,05	91	11,85	1 887	621	4 446
Oberhausen	220 928	18,20	60 599	17,15	77	10,03	2 868	787	4 272
Rheinberg	31 853	2,62	5 992	1,70	75	9,78	424	80	7 908
Voerde	38 960	3,21	5 935	1,68	53	6,90	728	111	7 908
Wesel	61 996	5,11	20 358	5,76	123	16,01	506	166	7 908
total	**1 213 784**	**100**	**353 263**	**100**	**768**	**100**	**1 581**	**460**	**-**

*GDP only on the district level available (NUTS 4)

The region was strongly influenced in its development by economical features, especially by coal mining and steal industry. The coal was digged from the south to the north of the Ruhr District since the 19th century. Today the mining is still in the area of Rheinberg, Voerde, Dinslaken and in the north of Duisburg. Because of the big coal incidence and the steel industries the people build a dense railroad and road network. Some line of business (e. g. chemical industries, machine construction) settled down in the same region and used the advantages of the infrastructure. The inland port in Duisburg is the biggest one in Europe with a high total transport amount, located close to the sea port in Rotterdam.

In the last quarter of the 20th century the structural change of the region started. Almost all of the coal mines in the Ruhr District closed and the two remained (Lohberg in Dinslaken and Walsum in Duisburg) will follow in the next five years. In consequence, the dense railroad network seems to be more or lesse useless for future development.

After the high time of the production industries the third economic sector is getting more and more important. The old industrial areas are being reused as shopping malls and entertainment center (e.g. “CentrO Oberhausen”, “Scenery Park” in the north of Duisburg). In spite of these projects the unemployment grown up in the region as well as the population is decreasing. In consequence, the tax and purchasing power have been shrinking.

The countryside in the north of the region (along the Rhine) is partly close to nature but these areas are endangered in their existence, because of the mountain subsidence as a consequence of the coal mining, which has been moving north step by step. The southern part of the case study areas is characterised by industrial as well as residential areas. In opposite to the northern part the topography is more elevated (100 to 140 m above sea level). The sedimentation from the Rhine forms good soils like meadow soils, brown and black soils (Westermann, 1987, page 49)

2 Hazards and hazard mitigation in the region

Relevant hazards in this Case Study are:

Table 2: Relevant hazards

Natural hazards	**Technological hazards**
Floods	Production plants
Storms	Coal mining
Extreme precipitation	Waste deposits
Droughts	Pipes for oil, gas and other products
Forest Fires	Dams
Earthquakes	hazardous materials transportation
	Nuclear power plants and atom transportation

2.1 Natural hazards

The most important natural hazard in the case study area is flooding due to the dominant Rhine River, which passes the area from the south to the north. In this context, the lowland topography of the greater part of the case study area has to be stressed. Although the Rhine is bordered by a system of dams, in consequence most of the case study area is threatened by flooding in case of dam failures. The last big floods in this region happened in 1993 and 1995. After these occurrences a flood action plan has been developed on behalf of the "International Commission for the Protection of the Rhine". This plan incorporates a risk assessment and management; addressed to the responsible state actors within the participating countries (see ICPR, 1998, 2003).

The meteorological hazards storm, extreme precipitation and droughts happened irregular in the past but with a tendency to increase (especially storms and extreme precipitations). In the future the climate experts expect more extreme weather events in a year because of the climate change. The existence of these hazards can vary from region to region (Schönwiese, 2003). The hazard of tectonic caused Earthquakes is low in this region, but it exists, mainly caused by a long-distance effect of the active tectonic zone nearby Cologne and Aachen.

2.2 Technological hazards

The case study region is characterised by a high density of production plants, waste deposits and the transportation of dangerous goods (by truck, railway, ships and pipelines for oil, gas and other products.

The particular hazard of mountain subsidence in this region is caused by the coal mining. At the surface building or infrastructure could be damaged. Even more evident are the consequences of mountain subsidence for the environment. Especially the water circle is heavily affected. In some cases water change their direction or must be redirected to allow for continous flowing. Such a dangerous situation exists in the planning region near the settlement of "Stapp" nearby Dinslaken. The setting is located nearby the Rhine and shattered by the mountain subsidence. The settlement is protected by a dam with a high of ten meters. In case of a dam failure, the built up area would be overflowed between two to five meters deep. However, even in view of this risk the daggering of the coal in this area under the Rhine and under the dam will be maintained in the future. The municipality of Voerde is threatened by floods as a consequence of the coal mining up to 57 % of its territory and up to 67 % of its inhabitants (cf. Voerde, 2002).

2.3 Hazard mitigation in spatial planning practice

The regional planning has to be understood as most important planning level for mitigating natural and technological risks. The regional plan, elaborated in a scale of 1: 50.000, contains aims and principles for the spatial development which are partly connected with graphical designations. It has to be stressed, that its designations have been binding effects for the local land-use planning as well as for sectoral planning divisions. However, the actual regional plan of the district Düsseldorf (from 1999) refers only to one single hazard, floods:

Textual designations (GEP, 1999)

Preservation and recovery of flooding areas and their keeping free from other developments and uses; protection of buildings and dam relocations

Mining: Effects must be compatible with the aims of regional development planning

Graphical designations (GEP, 1999)

Explanation map 8: water management

Potential retention areas and polder locations

Dams along the Rhine

Explanation map 9: waste management

Waste burning plant

Waste disposal site, hazardous waste depot

Explanation map 10: mining

Mountain subsidence

Historical map: flooding areas in the year 1926

Polder areas

Flood protection plants

3 Exemplary Risk Review for the Case Study Region

3.1 Choice of experts

The selection of participants was a difficult and a time intensive job because of the lack of suitable experts. The experts have to be familiar with hazards and risks as well as with the planning region. 25 experts were contacted and at the end 10 experts attended the questioning. These 10 experts represented several institutions (state offices, universities, institutions of disaster control and private planning offices).

3.2 Choice of hazards and indicators

The selection of the hazards and vulnerability indicators was carried out parallel to the choice of the experts. Hazards and vulnerability indicators integrated in the case study, are listed with the analysis. The experts where offered 13 hazards selected for the region.

3.3 Application of the Delphi Method

The panel enquiry took place in three rounds. In the run-up to the questioning the experts were informed about the procedure. Before the second respective third round started, the experts had been informed about the average results of the round before. The purpose behind this procedure was the adaptation of the assessments of the experts.

3.4 Weighting the hazards

All hazards were assessed by the experts although some hazards do not really play a role in the planning region (e. g. nuclear power plants). The experts assessed floods (14,37 %), production plants (13,73 %) and hazardous materials transportation (12,67 %) as most important for the case study area. The hazards droughts (1 %), earthquakes (1,67 %), nuclear power plants and atom transportation (0,42 %) are hardly dangerous based on the opinion of the experts. Table 2 offers an overview about the different weightings of the experts:

Table 3: Weighting of hazards: average estimations and their change

Hazards		Average estimation			Change estimation Round 3 / Round 1 (%)
		Round 1	Round 2	Round 3	
Natural Hazards	Floods	15,94	15,10	**14,37**	**90,16**
	Storms	9,97	10,47	**10,74**	**107,66**
	Extreme precipitation	7,83	8,71	**9,17**	**117,07**
	Droughts	1,44	1,18	**1,00**	**69,65**
	Forest fires	5,14	4,93	**4,90**	**95,27**
	Earthquakes	1,81	1,69	**1,67**	**92,70**
Technological hazards	Production plants	12,56	13,51	**13,73**	**109,33**
	Coal mining	7,98	7,79	**7,37**	**92,29**
	Waste deposits	8,16	8,18	**8,42**	**103,20**
	Pipes for oil, gas and other products	9,24	9,18	**9,50**	**102,83**
	Dams	7,16	6,40	**6,03**	**84,24**
	hazardous materials transportation	11,89	12,20	**12,67**	**106,57**
	Nuclear power plants and transportation of nuclear material	0,87	0,65	**0,42**	**48,14**
	sum	**100,0**	**100,0**	**100,0**	

3.5 Weighting the vulnerability indicators

The used indicators are:

- Exposed persons (50%)
- GDP per capita (50%)

The indicator 'exposed persons' consists of the sub-indicators "population density" and "employment density". This takes into account that potentially exposed are on the one hand permanent residents and on the other hand commuters, daily visiting the area. (cf. Simoni, 1995). Data about the GDP per capita is only available at district level (Wesel, Duisburg, Oberhausen, Mülheim). It is not accounted for single municipalities in a district area (Dinslaken, Moers, Rheinberg, Voerde, Wesel). The indicator 'exposed persons' is calculated by use of the following formula:

Exposed persons = 0,7 * population density + 0,2 * employment density

These factors are based on the following assumptions (Simoni, 1995, p. 50):

factor 0,7

- around 45 % of the inhabitants stay during the working hours at their domicile
- outside the working hours 70 % of the inhabitants are at home
- the relation between working hours and not working hours is about 0,2 : 0,8

factor 0,2

- the division of the share of working hours to a year
- taken into account the certain absences of people during their regular working hours (about 20 %)

Table 4: Values of vulnerability indicators

municipality	**population**		**employment**		**Pop. density**	**Empl. density**	**Exposed persons**	**GDP 2001***
	number	%	number	%	(persons/km²)			Mio Euro
Dinslaken	71 193	5,87	19 208	5,44	1 493	403	1 126	7 908
Duisburg	508 664	41,91	155 894	44,13	2 185	670	1 663	12 157
Moers	108 019	8,90	28 593	8,09	1 596	422	1 201	7 908
Mülheim (Ruhr)	172 171	14,18	56 684	16,05	1 887	621	1 445	4 446
Oberhausen	220 928	18,20	60 599	17,15	2 868	787	2 165	4 272
Rheinberg	31 853	2,62	5 992	1,70	424	80	313	7 908
Voerde	38 960	3,21	5 935	1,68	728	111	532	7 908
Wesel	61 996	5,11	20 358	5,76	506	166	387	7 908
total	**1 213 784**	**100**	**353 263**	**100**	**1 581**	**460**	**1 199**	**-**

*GDP only available at district level (NUTS 4)

The values of these indicators (Exposed persons and GDP) are determined and are classified in table 5.

Table 5: Classification of the expose persons and the GDP

Class	**Exposed persons**	**GDP per capita**
I	< 250	< 2500
II	250 - 500	2500 - 5000
III	500 - 1000	5000 - 10000
IV	1000 - 2000	10000 - 20000
V	> 2000	> 20000

The next step was to determine vulnerability classes for the municipalities of the case study area (Table 5). The results of this process were remarkable for Oberhausen (class 5, exposed persons). Also the municipalities of Duisburg, Dinslaken, Mülheim (Ruhr) and Moers are characterised by a high level of exposed persons, which has great influence on the results of risk analysis.

Table 6: Determination of vulnerability classes

Municipality	Exposed persons	Exposition class	GDP	GDP class
Dinslaken	1126	4	7908	3
Duisburg	1663	4	12157	4
Moers	1201	4	7908	3
Mülheim	1445	4	4446	2
Oberhausen	2165	5	4272	2
Rheinberg	313	2	7908	3
Vorede	532	3	7908	3
Wesel	387	2	7908	3

In Table 7 the vulnerability matrix of the Ruhr district is presented.

Table 7: Vulnerability matrix Ruhr District

GDP	Exposed persons				
	I	II	III	IV	V
I					
II				**Mülheim**	**Oberhausen**
III		**Rheinberg Wesel**	**Voerde**	**Dinslaken Moers**	
IV				**Duisburg**	
V					

3.6 Risk profile of the western Ruhr District

Based on the individual hazard values, generated by using the Delphi method, the aggregated hazard intensity was calculated (Table 8).

Table 8: Aggregated hazard potential of the municipalities in the planning region

Hazard	Municipality							
	Dinslaken	Duisburg	Moers	Mülheim	Oberhausen	Rheinberg	Voerde	Wesel
Floods	3,35	8,56	7,19	2,08	0,94	18,54	11,54	15,30
Storms	5,91	5,49	9,19	8,78	9,48	8,43	8,26	9,37
Extreme precipitation	5,26	4,90	5,67	5,97	5,79	5,45	5,34	5,64
Droughts	0,19	0,18	0,21	0,23	0,17	0,21	0,21	0,21
Forest fires	0,94	0,55	1,00	1,27	1,15	0,87	1,03	1,04
Earthquakes	0,33	0,29	0,84	0,32	0,36	0,32	0,32	0,32
Production plants	2,37	13,69	9,61	6,67	13,66	4,17	1,74	4,79
Coal mining	7,00	1,31	2,60	0,73	0,97	7,06	7,13	0,42
Waste deposits	1,51	1,62	1,82	2,00	2,45	1,32	1,26	1,48
Pipes for oil, gas and other products	1,62	2,04	1,69	4,20	2,60	1,61	1,64	1,91
Dams	1,41	2,48	1,60	0,82	0,41	5,18	3,40	3,10
Hazardous material transportation	6,48	11,87	8,61	8,51	12,67	3,58	5,84	7,62
Nuclear power plants and transportation	0,08	0,07	0,09	0,09	0,09	0,08	0,08	0,09
Aggregated hazard potential	36,43	53,04	50,14	41,67	50,72	56,83	47,80	51,29

Subsequently the aggregated hazard potential is classified as shown in Table 9.

Table 9: Aggregated risk matrix (summary)

Municipality	**Aggregated hazard potential (class)**	**Vulnerability (class)**
Dinslaken	2	3
Duisburg	3	4
Moers	3	3
Mülheim (Ruhr)	2	3
Oberhausen	3	3
Rheinberg	3	2
Voerde	2	3
Wesel	3	2

The risk matrix shows a partially similar picture to the vulnerability matrix (Table 10). Concerning the risk value, the municipalities of the case study area were scored between five and seven (given the scale of 1 – 10). Duisburg, Moers and Oberhausen were identified as municipalities with the highest risk. The risk level of Mülheim (Ruhr) is unexpected taken into account its high population and employment densities. However, this area is less affected by hazards in comparison to other parts of the case study area. The low risk of Dinslaken, Rheinberg, Voerde and Wesel has to be seen in the light of the low population and employment densities in these rather rural areas.

Table 10: Aggregated risk matrix

Aggregated hazard potential (class)	**Vulnerability (class)**				
	I	***II***	***III***	***IV***	***V***
I	**2**	**3**	**4**	**5**	**6**
II	**3**	**4**	**5** Mülheim (Ruhr), Dinslaken, Rheinberg, Voerde, Wesel	**6**	**7**
III	**4**	**5**	**6** Moers, Oberhausen	**7** Duisburg	**8**
IV	**5**	**6**	**7**	**8**	**9**
V	**6**	**7**	**8**	**9**	**10**

3.7 Further considerations

The level of scale, represented by the discussed results of the Delphi method offer a first overview about the risk profile of the Ruhr district. However, as basis for concrete designations within spatial plans, a higher level of precision is needed. This refers to the hazard as well as to the vulnerability component. Aiming at non-structural mitigation measures like settlement restriktion, information about threaten areas on a detailed level are indispensable.

For this purpose, the spatial expansion of different hazards was taken into account. The spatial expansion has to be understood as the share of the area of a municipality, which can be influenced by an occuring hazard. The share of the area was calculated by using a GIS. By means of overlaying the single expansions of different hazards, an aggregated hazard map was created (Figure 2). The darker an area is shown, the .greater is the given hazard intensity ("Gefährdung")

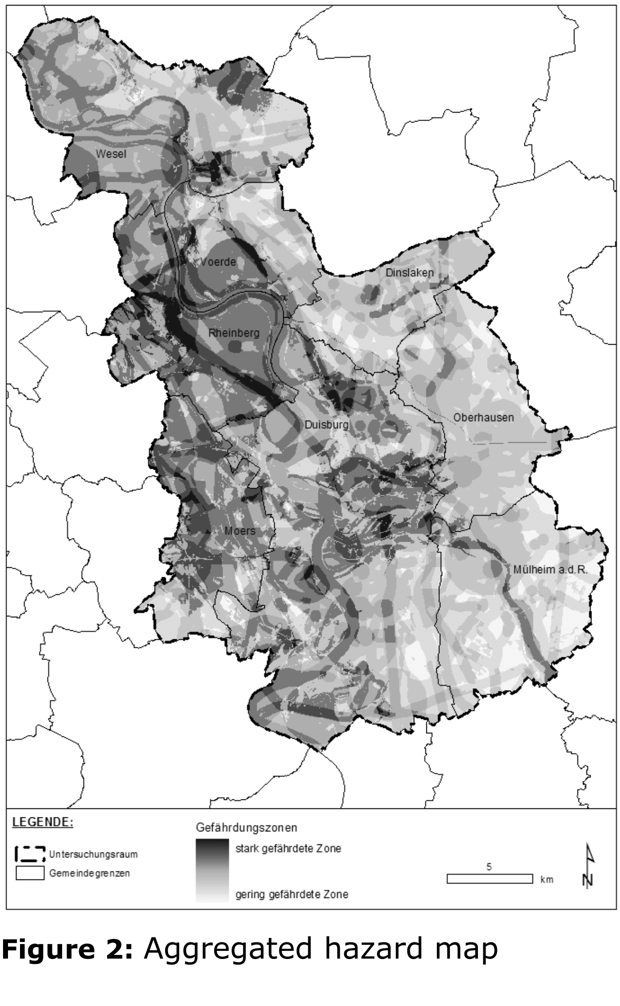

Figure 2: Aggregated hazard map

For decision making-making aiming at tolerating or altering risks, the given vulnerability has to be taken into account. In so doing a weighing-up seems to possible which considers carefully the appropriate level of protection in view of the different damage potentials (onsidering values such as residential areas, industrial facilities or transport infrastructure). On this basins concrete designations within a regional plan or a preparatory land-use plan could be made.

For that purpose, different levels of protection (called "Schutzwürdigkeit" on the key of the figure 3 shown below) needs have to be identified. The following four levels were taken into account:

- Low (gering): agricultural areas, other open spaces
- Moderate (mittel): industrial area
- High (hoch): residential areas
- special objects for protection (besonders schutzwürdige Objekte): hospitals, schools, kindergartens, old people's home

In addition, the different colors ("Vulnerabilitätsklasse") indicate the results of the vulnerability assessment, based on the Delphi method.

Figure 3 shows the results of the vulnerability assessment, based on Delphi method as well as the allocation of single protection goods:

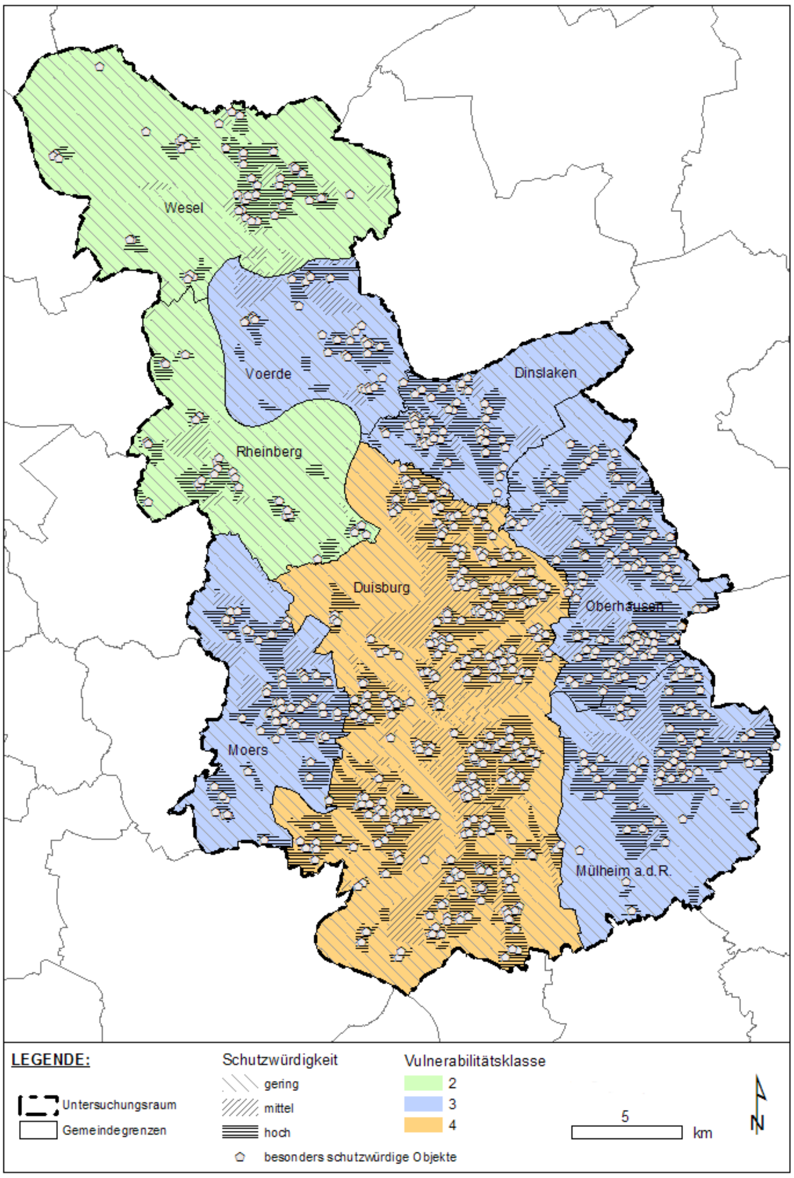

Figure 3: Vulnerability map

4 Conclusions

All in all it was shown, that the western part of the Ruhr district is affected by several hazards. By using the Delphi method, it becomes clear, that this region can be ranged in comparison to other regions as one with high risk, but not as a highly sensitive area. This result can be easily explained with a relatively high level of vulnerability on the one hand but only moderate hazard intensity on the other hand. However, within the case study area some significant and plausible differences between the several municipalities were identified.

Despite the obtained results, the Delphi method does not supply a precise enough data basis for a spatial planning response in terms of risk reduction.,First, more research is needed, especially for weighting the different hazards which may affect a certain area on a very small-scaled level. However, this currently faces the problem of data shortage. Second, the spatial scope, used for the Delphi method fits not in view of the detailed, small-scaled information which are needed on the local level.

For that purpose, this paper offers some first ideas for a more precise risk assessment. It is clearly visible, that the risk assessment, based on the analysis of the given hazard intensity as well as single protection goods leads to much more detailed results. This level of information is needed for decision-making regarding tolerating or alterings risks on the level of regional planning or problable preparatory land-use planning. The results, derived by using the Delhi method offers only a first indication which are nevertheless useful for an inter-regional comparison.

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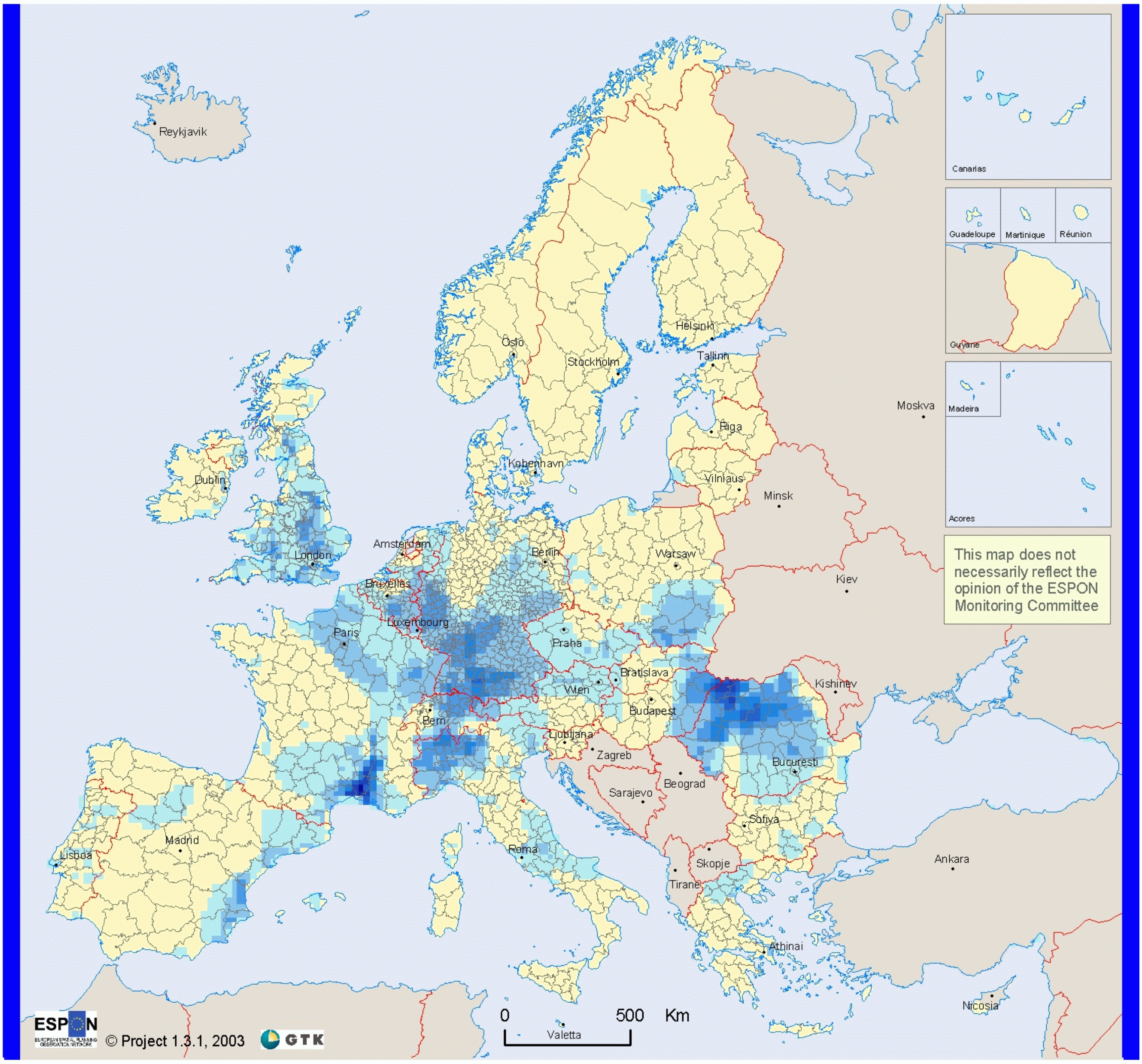
3 ANNEX III ADDITIONAL MAPS AND DATA

This annex presents some additional maps and data that were not included into the main report.

The table below shows the colour codes for the map production. This shall help the reader of the report to identify the colour schemes in case of different printer qualities.

Table 1: Colour codes (RGB codes) of the risk maps:

Legend of risk maps	Degree of vulnerability				
Intensity of hazard x	1	2	3	4	5
1	(255,255,204)	(255,255,153)	(255,204,0)	(255,153,255)	(204,236,255)
2	(255,255,0)	(255,153,102)	(204,102,255)	(51,204,255)	(153,255,51)
3	(255,153,0)	(204,0,255)	(102,102,255)	(51,204,51)	(255,80,80)
4	(153,0,204)	(0,90,193)	(102,153,0)	(255,0,102)	(153,51,0)
5	(30,60,92)	(0,128,0)	(255,0,0)	(128,0,0)	(0,0,0)



Number of large flood events

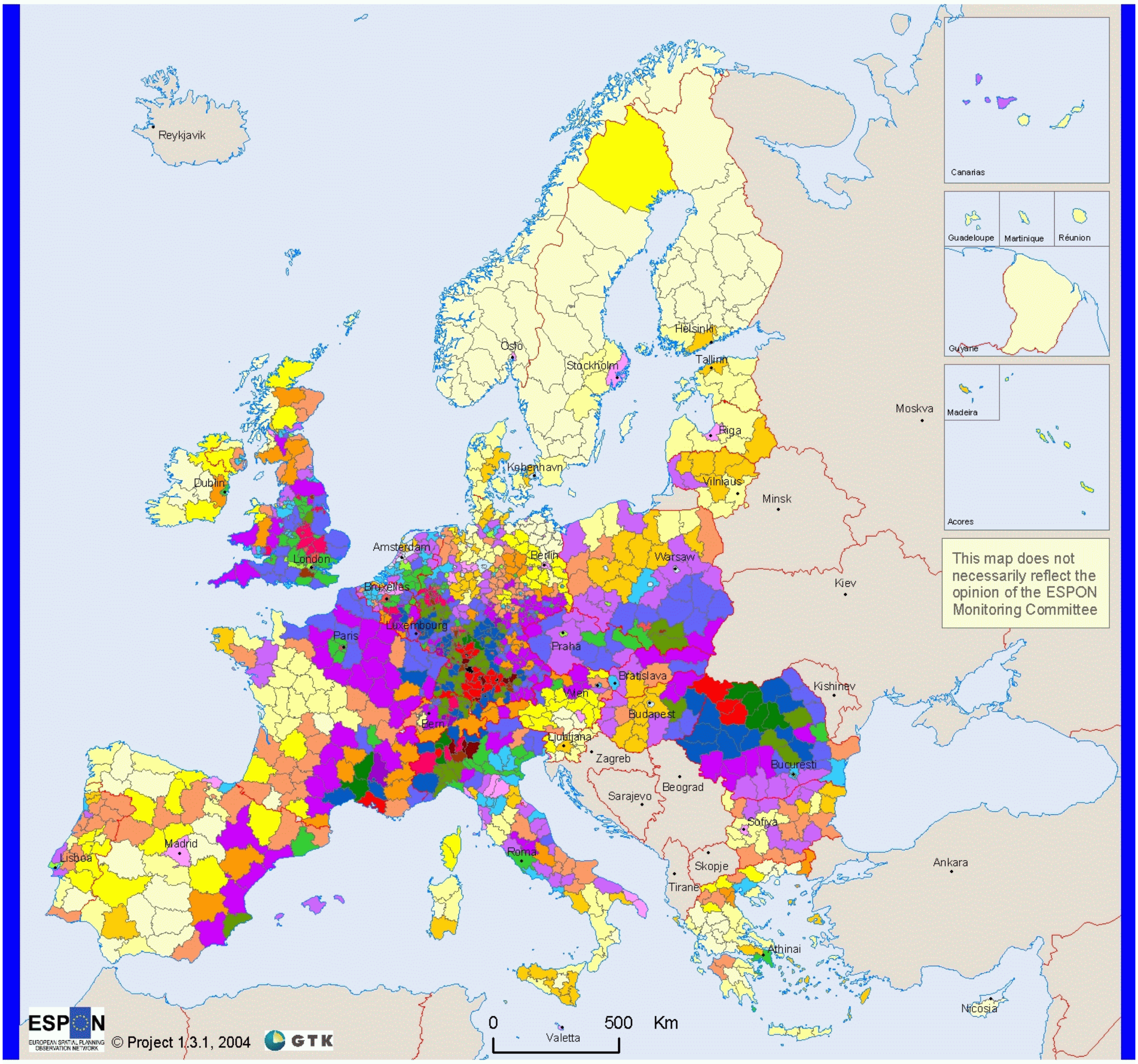
- 1
- 2
- 3
- 4
- 5
- 6
- 7
- 8
- ESPON space NUTS 3
- Non ESPON space

Origin of the data: © EuroGeographics Association for the administrative boundaries
Large flood areas © Dartmouth Flood Observatory
Flood areas © ESA - Earth observation- Earth online
Rhine Atlas 2001 IKRS-CIPR-ICBR

Source: ESPON Data Base

This map shows the large, discrete flood events in Europe during 1987-2002. However, repeated flooding in some regions is a complex phenomenon and this map is a compromise between aggregating and dividing such events. The flood events from the years 1989, 1990, 1991, 1995 (except Rhine) and 1996 have not been taken into account because of the lack of data. The information presented in this map is derived mainly from remote sensing source.

Map 1 Large river flood occurrence



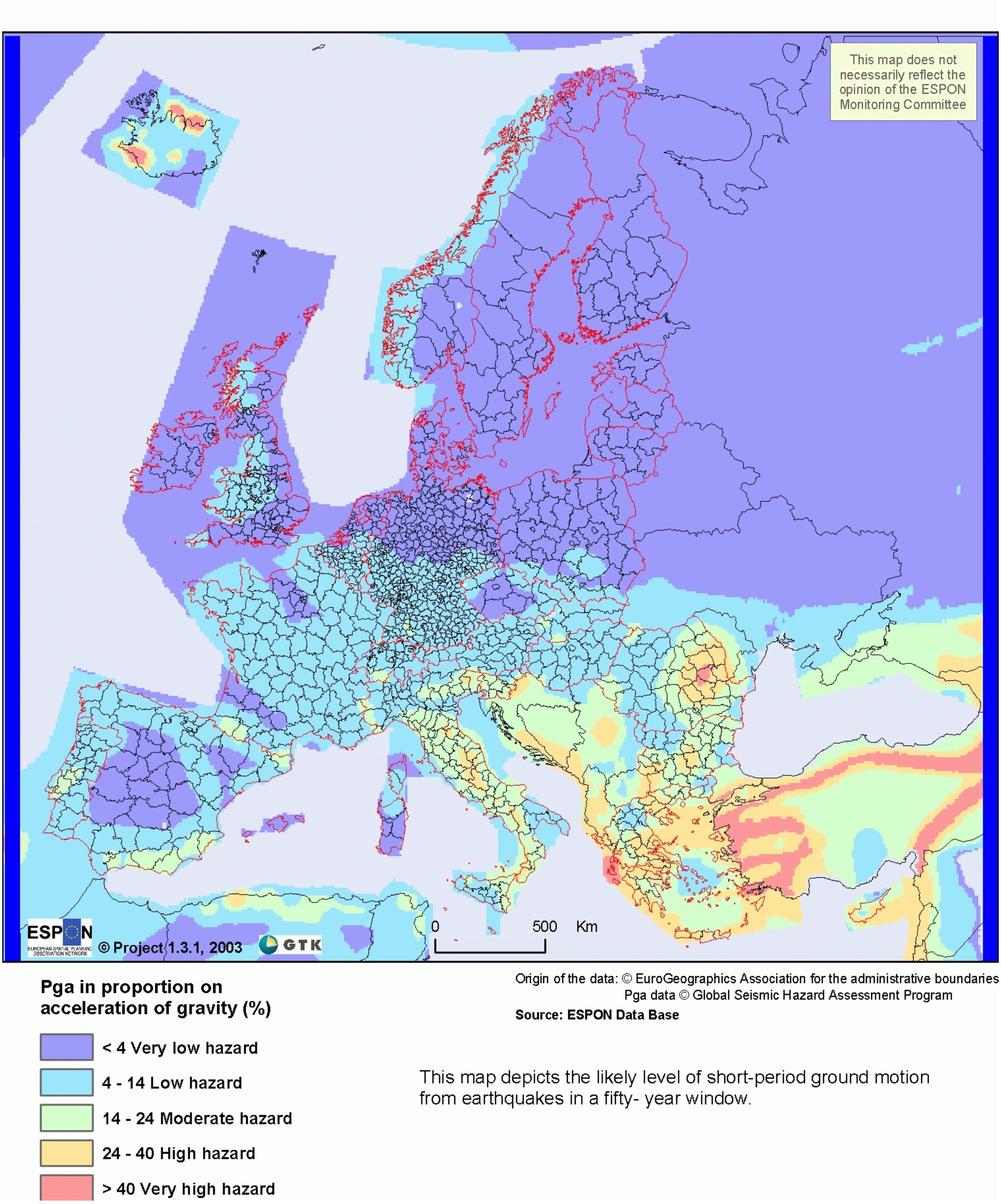
Origin of the data: © EuroGeographics Association for the administrative boundaries
Large flood areas © Dartmouth Flood Observatory
Flood areas © ESA - Earth observation- Earth online
Rhine Atlas 2001 IKRS-CIPR-ICBR
GDP 2000 Eurostat Newcronos Regio
Population density 1999 Eurostat Newcronos Regio
National GDP 2003 Eurostat
CLC90 EEA

Source: ESPON Data Base

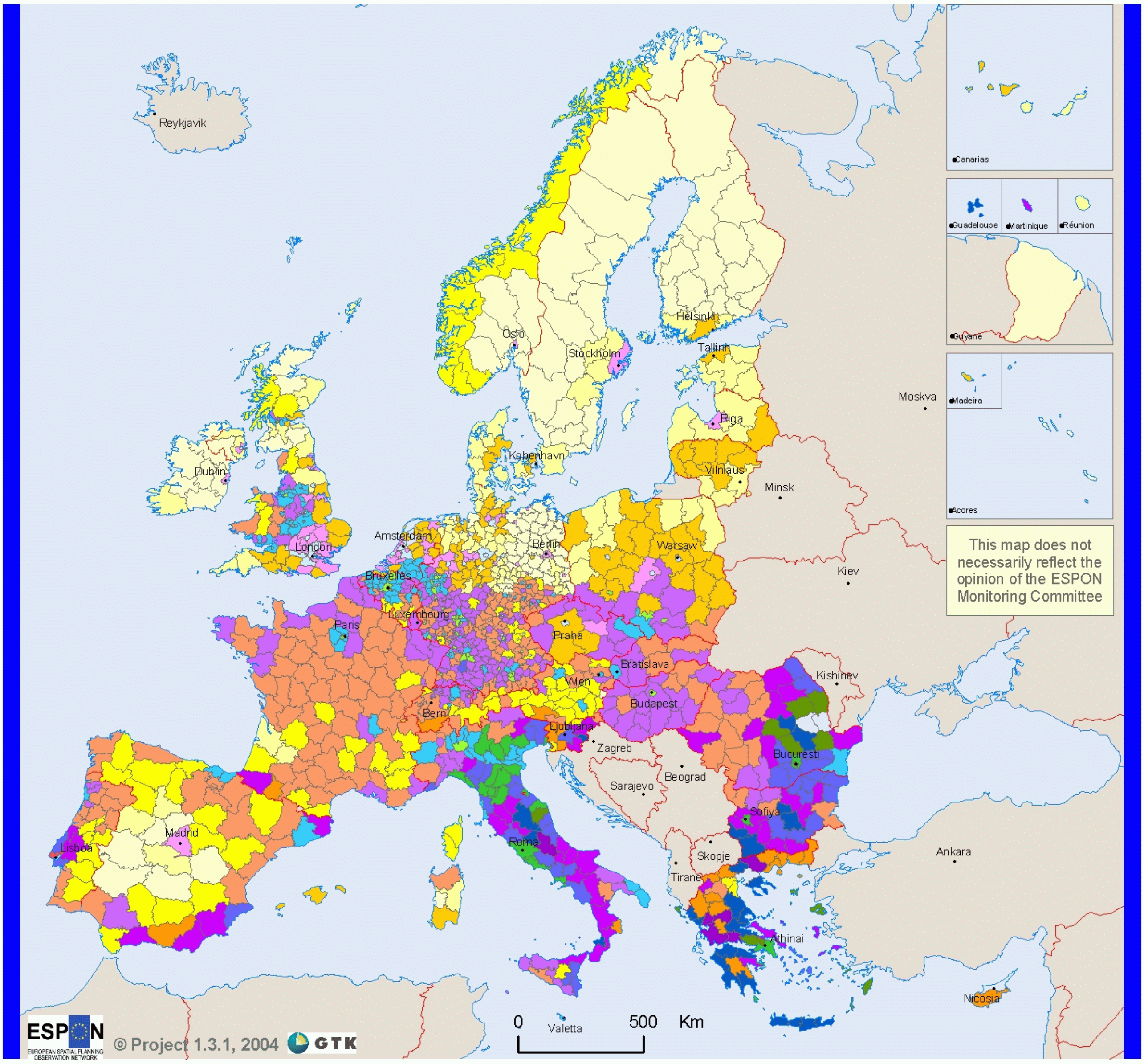
Typology of the regions

Legend of risk maps	Degree of vulnerability				
Intensity of river floods	1	2	3	4	5
1	2	3	4	5	6
2	3	4	5	6	7
3	4	5	6	7	8
4	5	6	7	8	9
5	6	7	8	9	10

Map 2 Large river flood reocurrence risk



Map3 Peak Ground acceleration (pga) as earthquake hazard



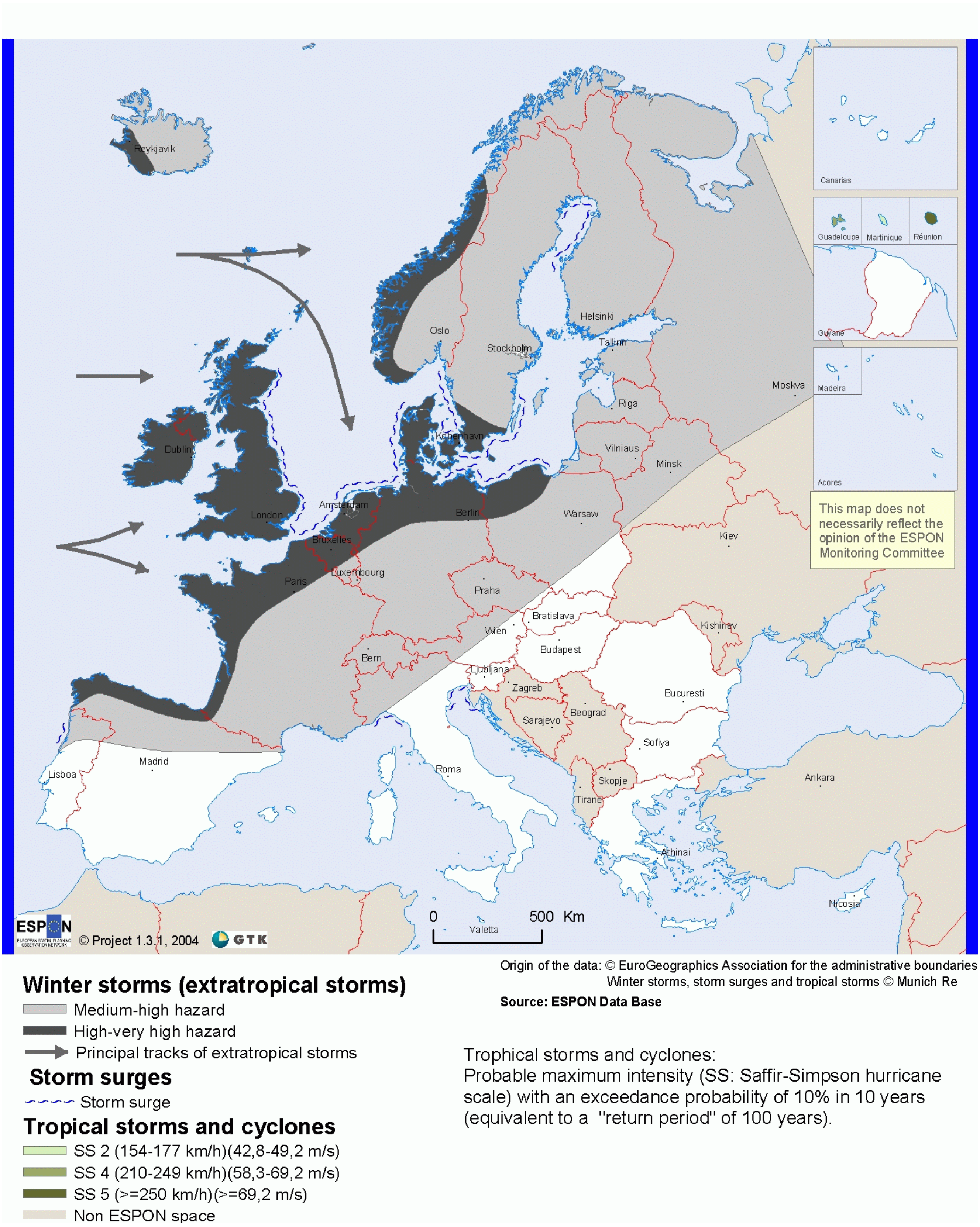
Origin of the data: © EuroGeographics Association for the administrative boundaries
Pga data © Global Seismic Hazard Assessment Program
GDP 2000 Eurostat Newcronos Regio
Population density 1999 Eurostat Newcronos Regio
National GDP 2003 Eurostat
CLC90 EEA

Source: ESPON Data Base

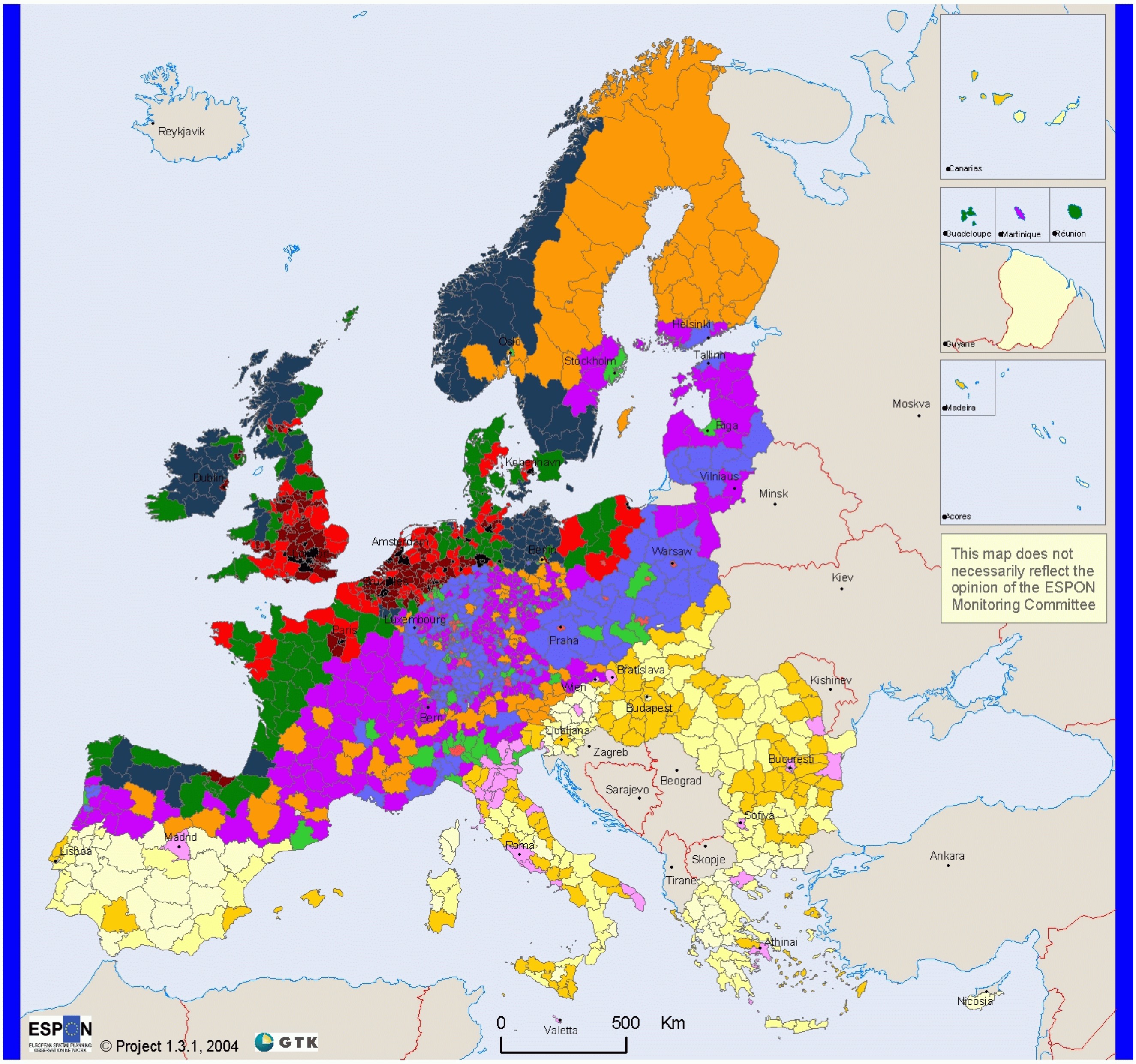
Typology of the regions

Intensity of earthquake hazard	Degree of vulnerability				
	1	2	3	4	5
1	2	3	4	5	6
2	3	4	5	6	7
3	4	5	6	7	8
4	5	6	7	8	9
5	6	7	8	9	10

Map 4 Earthquake risk



Map 5 Winter and tropical storms



Origin of the data: © EuroGeographics Association for the administrative boundaries
Winter and tropical storms © Munich Re
GDP 2000 Eurostat Newcronos Regio
Population density 1999 Eurostat Newcronos Regio
National GDP 2003 Eurostat
CLC90 EEA

Source: ESPON Data Base

Typology of regions

Intensity of storm hazard	Degree of vulnerability				
	1	2	3	4	5
1	2	3	4	5	6
3	4	5	6	7	8
5	6	7	8	9	10

Map 6 Winter and tropical storm risk

Table-1 Numbers of planes crashed during 1970 to 2004

Years	Types	Distance from the airport (km)				Total		
		0-5	5.01-15	15.01-30	> 30			
1970	take-off	15	1	2	2	20	38	**307**
1970	approach to land	5	3	0	0	8		
1970	Landing	9	1	0	0	10		
1971	take-off	13	1	0	0	14	32	
1971	approach to land	7	5	0	0	12		
1971	Landing	6	0	0	0	6		
1972	take-off	10	0	0	0	10	33	
1972	approach to land	10	8	1	0	19		
1972	Landing	3	1	0	0	4		
1973	take-off	11	2	0	0	13	36	
1973	approach to land	7	4	3	1	15		
1973	Landing	8	0	0	0	8		
1974	take-off	6	1	1	0	8	22	
1974	approach to land	7	3	0	0	10		
1974	Landing	4	0	0	0	4		
1975	take-off	7	0	0	0	7	28	
1975	approach to land	10	5	1	0	16		
1975	Landing	5	0	0	0	5		
1976	take-off	12	0	0	0	12	31	
1976	approach to land	8	2	0	0	10		
1976	Landing	9	0	0	0	9		
1977	take-off	7	2	0	0	9	27	
1977	approach to land	11	3	0	0	14		
1977	Landing	3	1	0	0	4		
1978	take-off	14	0	0	0	14	28	
1978	approach to land	8	0	0	0	8		
1978	Landing	5	1	0	0	6		
1979	take-off	11	1	0	1	13	32	
1979	approach to land	9	3	0	0	12		
1979	Landing	7	0	0	0	7		
1980	take-off	3	1	0	0	4	23	**242**
1980	approach to land	9	1	0	0	10		
1980	Landing	9	0	0	0	9		
1981	take-off	8	0	0	0	8	24	
1981	approach to land	7	3	1	0	11		
1981	Landing	3		1	1	5		
1982	take-off	10	1	0	0	11	30	
1982	approach to land	9	2	0	0	11		
1982	Landing	8	0	0	0	8		
1983	take-off	9	0	0	0	9	25	
1983	approach to land	8	2	0	0	10		
1983	Landing	6	0	0	0	6		
1984	take-off	5	1	0	0	6	17	
1984	approach to land	5	2	0	0	7		
1984	Landing	4	0	0	0	4		
1985	take-off	7	1	0	0	8	22	
1985	approach to land	5	3	1	1	10		
1985	Landing	4	0	0	0	4		
1986	take-off	9	0	0	0	9	21	
1986	approach to land	2	2	0	0	4		
1986	Landing	7	1	0	0	8		
1987	take-off	9	1	0	0	10	25	
1987	approach to land	4	4	0	0	8		

1987	Landing	6	1	0	0	7		
1988	take-off	4	1	0	0	5	25	
1988	approach to land	7	4	1	0	12		
1988	Landing	8	0	0	0	8		
1989	take-off	9	2	0	0	11	30	
1989	approach to land	8	3	0	0	11		
1989	Landing	8	0	0	0	8		
1990	take-off	5	2	2	0	9	23	**267**
1990	approach to land	6	1	0	0	7		
1990	Landing	7	0	0	0	7		
1991	take-off	7	3	0	0	10	28	
1991	approach to land	6	2	0	0	8		
1991	Landing	9	1	0	0	10		
1992	take-off	13	1	0	0	14	33	
1992	approach to land	4	6	1	0	11		
1992	Landing	7	1	0	0	8		
1993	take-off	10	0	0	0	10	24	
1993	approach to land	6	0	0	1	7		
1993	Landing	7	0	0	0	7		
1994	take-off	10	1	0	0	11	29	
1994	approach to land	6	3	0	0	9		
1994	Landing	9	0	0	0	9		
1995	take-off	13	1	0	0	14	31	
1995	approach to land	7	1	0	0	8		
1995	Landing	8	1	0	0	9		
1996	take-off	9	3	1	0	13	29	
1996	approach to land	6	3	1	0	10		
1996	Landing	5	1	0	0	6		
1997	take-off	6	2	0	0	8	28	
1997	approach to land	5	6	0	0	11		
1997	Landing	9	0	0	0	9		
1998	take-off	6	1	2	0	9	22	
1998	approach to land	8	2	0	0	10		
1998	Landing	3	0	0	0	3		
1999	take-off	6	2	0	0	8	20	
1999	approach to land	5	2	0	0	7		
1999	Landing	5	0	0	0	5		
2000	take-off	6	4	0	0	10	23	**97**
2000	approach to land	6	1	1	1	9		
2000	Landing	4	0	0	0	4		
2001	take-off	12	1	1	0	14	22	
2001	approach to land	3	1	0	0	4		
2001	Landing	4	0	0	0	4		
2002	take-off	8	0	1	1	10	21	
2002	approach to land	3	2	1	1	7		
2002	Landing	3	1	0	0	4		
2003	take-off	10	2	0	0	12	22	
2003	approach to land	4	1	1	1	7		
2003	Landing	3	0	0	0	3		
2004*	take-off	2	3	0	0	5	9	
2004*	approach to land	1	1	1	0	3		
2004*	Landing	1	0	0	0	1		
Total		**730**	**147**	**25**	**11**	**913**		
%		**80**	**16**	**3**	**1**	**100**		

2004* = As of June, 8

Table 2 total sums

Total	take-off	358
	approach to land	336,0
	Landing	219
		913

Table-3 Numbers of airplanes crashed per continent during 1970 to 2004

Years	North America	South America	Asian	Europe	Russia	Africa	Australia	Total
1970	10	4	9	9	2	4	0	38
1971	10	3	3	7	8	0	1	32
1972	6	4	4	12	4	3	0	33
1973	13	3	4	6	6	3	1	36
1974	10	2	4	4	1	1	0	22
1975	7	4	6	6	2	2	1	28
1976	11	5	5	3	4	3	0	31
1977	10	6	3	6	2	0	0	27
1978	14	4	7	2	1	0	0	28
1979	17	2	4	5	2	2	0	32
1980	7	3	9	2	1	1	0	23
1981	10	5	3	2	2	2	0	24
1982	11	5	7	3	3	1	0	30
1983	7	5	5	2	3	3	0	25
1984	7	4	2	1	2	1	0	17
1985	10	4	1	2	3	1	1	22
1986	7	2	2	1	4	3	2	21
1987	8	4	6	4	1	2	0	25
1988	3	3	5	7	4	3	0	25
1989	10	6	6	4	2	2	0	30
1990	4	8	7	1	1	2	0	23
1991	4	8	8	1	5	2	0	28
1992	7	4	9	3	6	4	0	33
1993	4	2	11	5	0	2	0	24
1994	8	7	3	3	5	2	1	29
1995	4	2	7	5	3	8	2	31
1996	6	6	7	5	3	2	0	29
1997	3	6	11	2	0	6	0	28
1998	3	8	9	0	1	1	0	22
1999	4	5	5	5	0	1	0	20
2000	5	3	5	3	1	6	0	23
2001	6	5	3	4	2	2	0	22
2002	3	5	4	2	2	5	0	21
2003	3	7	1	3	0	7	1	22
2004*	1	1	3	1	0	3	0	9
Total	253	155	188	131	86	90	10	913
%	28	17	21	14	9	10	1	100

References:

Aviation accident database (2005) http://www.planecrashinfo.com/database.htm, 17.06.2005

A-Z World Airports Online http://azworldairports.com/airports/index.htm

World Aeronautical Database: http://worldaerodata.com

World Airport Codes: http://www.world-airport-codes.com

4 ANNEX IV: LIST OF INDICATORS PROVIDED

Single hazard indicators on NUTS3:
Airports passenger traffic
Avalanche occurrence
Chemical plant density
Drought potential
Peak ground acceleration (earthquakes)
Extreme temperatures
Flood events 1987-2002
Forest fire hazard
Known volcanic eruptions
Landslide occurrence
Nuclear power plant distance
Oil transport
Storm surge potential
Tsunami occurrence
Winter and tropical storm hazard

Aggregated hazard indicators on NUTS3:
Aggregated technological hazard indicator
Aggregated natural hazard indicator
Aggregated hazard indicator (includes both technological and natural indicators)

Vulnerability indicators on NUTS3:
GDP per inhabitant year 2000 (Project 3.1)
Population density year 1999 (Project 3.1)
National GDP per inhabitant year 2003 (NUTS0 level data)
Fragmented natural areas (degree of natural vulnerability)
Integrated vulnerability of Europe

Risk indicators on NUTS3:
Aggregated technological risk indicator
Aggregated natural risk indicator
Aggregated risk indicator (includes both technological and natural indicators)

Climate change indicators on NUTS3:
Change of dry spell length between present day and 2071-2100
Change of precipitation between present day and 2071-2100
Change of dry spell length affecting forest fires
Change of dry spell length affecting droughts
Change of precipitation affecting floods

Hazard interaction indicators on NUTS3:
Winter storm – storm surge interaction
Winter storm – flood interaction
Drought – forest fire interaction

5 ANNEX V: INDICATION OF ESPON PERFORMANCE INDICATORS ACHIEVED

ESPON Hazards is a Priority 1 project

Table 1: Number of performance indicators achieved

Number of spatial indicators developed: in total covering the EU territory more than the EU territory	 32 32
Number of spatial indicators applied: in total covering the EU territory more than the EU territory	 2 2
Number of spatial concepts defined	2
Number of spatial typologies tested	2
Number of EU maps produced	33
Number of ESDP policy options addressed in that field	5

6 ANNEX VI: LIST OF MISSING DATA

In general it can be stated that all of the hazards and typologies developed in the ESPON 1.3.1 Hazards project are based on data sets that can be improved substantially. Many EU research programmes have developed excellent results so far but nearly non of these projects has a coverage over the entire EU 27+2 area. Therefore all presented maps should be seen as preliminary maps to gain an overview on the EU territory.

In ideal cases, it would have been possible to determine the hazard in each NUTS 3 region on a hazard probability in five classes. This was not possible according to substantial data gaps.

A coordinate problem: Many of the administrative boundaries by EuroGeographics Association did not fit together with another data layers e.g. CLC90 or ESRI products. The geometrical inconsistence were largest at the western and eastern ends of the ESPON area (approx. 5 km gap in west – east direction). This inconsistence might cause a minor error for all the indicators made by using some spatial analysis. This coordinate error is described more detailed by ETC-TE in TERRIS concept draft.

The following list provides an overview on required data sets for such an approach for each hazard:

Natural hazards	Additionally required data sets
Droughts	▪ In the drought potential indicator precipitation deficit information of the remote areas Guadeloupe, Martinique, Réunion and Guyane are missing ▪ In general differentiation into meteorological, hydrological and agricultural droughts, taking into account regional and local climatic factors and records
Earthquakes	-
Extreme temperature	▪ In the extreme temperature indicator information of all the remote areas are missing ▪ In general integration of more climate models and effects of extreme temperatures
Floods	▪ In the flood recurrence 1987-2002 indicator years 1989, 1990, 1991, 1995 (except Rhine) and 1996 are missing. ▪ In general estimation of probable flood prone areas for all large river
Forest Fires	▪ Forest types and available fuel. A combination with the results from forest fire forecasting experience would deliver very interesting results – once these are available
Landslides	▪ Landslide existence data from the remote areas Guadeloupe, Martinique, Réunion, Guyane, Madeira and Acores are still missing ▪ The land slide existence data has now only two classes (existence= yes or no) which does not tell much about the

	nature of the hazard ▪ In general integrated study on landslide probability and potential that would lead into a European landslide hazard classification
Snow Avalanches	▪ Integrated study on avalanche probability and potential that would lead into a European avalanche hazard classification
Storm Surges	▪ Munich Re data is very general telling mainly where storm surges exists e.g. The Gulf of Finland and The Gulf of Riga were missing ▪ Differentiation of potential storm surges and effects on European coastlines in 5 classes
Tsunamis	▪ Differentiation of European coastlines on Tsunami types (causers) and impact potential in 5 classes
Volcanic Eruptions	▪ Frequency of eruptions
Winter Storms	▪ Climate models on increase of extreme strom events
Technological hazards	
Air traffic hazards	-
Major accident hazards (e.g. chemical plants)	▪ EPER register does not include all indurstrial plans but only those activities which are listed in the EPER decision and only on EU15 level ▪ Data from the remote areas Guadeloupe, Martinique, Réunion, Guyane, Madeira and Acores were not found from any sources ▪ Data on all major accident potential as stored in the database
Nuclear Power Plants	▪ Differentiation on actual hazard potential, depending on available fuel in NPP's and saftey records/standards
Oil processing, etc	▪ Shipping lines with type and amount of oil shipped
Vulnerability indicators	
Fragmented natural areas	▪ This indicator is based on Corine land cover 1990 where data from Norway, Cyprus and remote areas are still missing
Climate change indicators	
Change of dry spell length between present day and 2071-2100	▪ In the climate change indicators information of all the remote areas are missing
Change of precipitation between present day and 2071-2100	▪ In the climate change indicators information of all the remote areas are missing

Further data needs on vulnerability:

Possible damage potential indicators

Damage potential indicators measure anything concrete that can be damaged by a hazard. The indicators measure the scale of possible damage.

- number of tourists/hotel beds: Tourists or people outside their well known environment are especially vulnerable, since they are generally unaware of the risks and don't necessarily understand the seriousness of hazardous situations. In addition, tourists don't necessarily know the local language and thus they are likely to miss important information. Tourist dwellings are often located in high-risk areas and might not meet the requirements of structural risk mitigation. (see e.g. White and Hass 1975). Further, tourism is an important source of income for many regions, and a catastrophe would have severe and long-term effects for regional economy.
- culturally significant sites: such sites are unique and important for the cultural and historical identity of people, e.g. sites on the UNESCO world heritage list.
- natural areas: Areas with special natural values (e.g. national parks or other significant natural areas) can be considered vulnerable because of their uniqueness and possible rarity of species. ESPON project 1.3.2 states (Final report Part 2 p. 102) that "the only spatially-specific and methodologically consistent units available for environmental reporting are land areas that are distinguished either by their protection or designation status or by their land cover type." Unfortunately there is no consistent data on protected areas for EU 27+2 NUTS3 level.

Possible coping capacity indicators

Coping capacity indicators measure those characteristics of a region that make people less able to understand the risk or recover from a hazard event. These coping capacity indicators measure either human properties or the existence of infrastructure. They measure how the community or region will be able to prepare and respond to a hazard and at the same time they point out social and place inequalities.

- education rate: measures people's ability to understand and gain information. The presumption is, that people with a low educational level do not find, seek or understand information concerning risks as well as others, and are therefore vulnerable. Project 3.1 has produced indicator Population by education, agegroups and sex 2000 on NUTS2 level. It was still unclear what the different classes actually represents.
- dependency ratio: measures the proportion of "strong" and "weak" population groups. A region with a high dependency ratio is especially vulnerable for two reasons. First, elderly people and young children are physically frail and thus vulnerable to hazards. Secondly, elderly people and children may not be able to help themselves but need help in the face of a hazard. Thus a region with a high dependency ratio is vulnerable, since with few able people, it is dependent on help from the outside. Project 1.1.4 has produced Dependency rates 1999, total population / population aged 20-64 years in Europe (NUTS 2).
- medical infrastructure: the level of medical infrastructure indicates how a region is able to respond to a hazard (e.g. number of hospital beds per 1000 inhabitants or number doctors per 1000 inhabitants)

- technical infrastructure: indicates how a region is able to respond to a hazard (e.g. number of fire brigades, fire men, helicopters etc.)
- share of budget spent on civil defence: indicates the level of mitigation of a region
- share of budget spent on research and development: indicates the level of mitigation of a region
- institutional preparedness: indicates the level of mitigation of a region
- risk perception: indicates how people perceive a risk and what their efforts have been to mitigate the effects of a hazard

7 ANNEX VII: LIST OF PUBLICATIONS AND CONFERENCES

The results were so for published or submitted under the following titles:

- Greiving, S.. Fleischauer, M., Olfert, A. (i.p.) The Delphi method as a solution to the weighting problem in multi hazard cases: The case study of the Dresden region.
- Philipp Schmidt-Thomé; Stefan Greiving; Kallio, Hilkka; Fleischhauer, Mark and Jaana Jarva: Natural Hazard and risk maps of floods and earthquakes for European regions, in: Special Issue of Quaternary International on "Dark Nature", **submitted 2004**. (Guest editors: S. Leroy (Suzanne.Leroy@brunel.ac.uk), H. Jousse (Helene.Jousse@univ-lyon1.fr) and M. Cremaschi (mauro.cremaschi@libero.it)
- Schmidt-Thomé, P.; Greiving, S.; Peltonen, L. and Jarva, J., 2003. Typologisation of Natural and Technological Hazards and Regions in Europe. Abstract. EU-MEDIN Forum on Disaster Research, 26.-27.5.2003, Thessaloniki, Greece.
- Schmidt-Thomé, P., Jarva, J. 2003. Typologisation of natural and technological hazards and regions in Europe. International Workshop “Geosciences or Urban Development and Environmental Planning”, Vilnius, September 13-18, 2003. Extended Abstracts. / Eds. J. Satkũnas, R. Kanopiené, COGEOENVIRONMENT, IUGS, Geological Survey of Lithuania, Vilnius University, Institute of Geology and Geography. pp. 85-86.
- Schmidt-Thomé, Philipp (2004): Typologisation of Natural and Technological Hazards and Regions in Europe, in: European Spatial Planning 70, Proceedings of the International CEMAT Conference on Natural Disasters and Sustainable Development: prevention of Floods.
- M.J. BATISTA; L. MARTINS; C. COSTA; A.M. RELVÃO; P., SCHMIDT-THOMÉ; S., GREIVING; M. FLEISCHHAUER; L. PELTONEN. Preliminary Results of A Risk Assessment Study for Uranium Contamination in Central Portugal. International Workshop on Environmental Contamination from Uranium Production Facilities and Remediation Measures. International Atomic Energy Agency (in press).

The results of the Espon Hazard project were presented at the following international conferences, workshops and seminars:

- May 26-27 2003: EU-MEDIN Forum on Disaster Research "The road to harmonisation", Thessaloniki, Greece, title: "Typologisation of Natural and Technological Hazards and Regions in Europe"
- June 28-30 2003: Conference of Ministers responsible for Regional Planning of the Member States of the Council of Europe – CEMAT-CoE "Natural Disasters and Sustainable Spatial Development: Prevention of Floods", Wroclaw, Poland, title of presentation: "Natural and Technological Hazards and risks in European Regions"
- September 13-18, 2003: The International Workshop "Geosciences for Urban Development and Environmental Planning", CoGeoEnvironment, Vilnius, title of presentation: "Developing Risk Maps on Natural and Technological Hazards in European Regions". Title of poster: "Preliminary hazard intensity and risk maps of selected natural hazards "
- February 11-13, 2004 - "Preliminary Results of a Risk Assessment Study for Uranium Contamination in Central Portugal",International Workshop on Environmental Contamination from Uranium Production Facilities and Remediation Measures. Instituto Tecnológico Nuclear Portugal,
- February 16-21, 2004 Workshop on the possibilities of applying a Decision Support Frame on sea level rise and other natural hazards to support spatial planning and regional development in South East Asia, Bangkok, Thailand, , including 3 day excursion
- August 20-28, 2004: International Geological Congress, Florence, Italy, title of presentation "Natural Hazard and Risk Maps for European Regions" on session "G03.12 Rapid and catastrophic geological changes and societal response"
- November 19-21, 2004: Coordinating Committee for Geoscientific programmes in East and South East Asia (CCOP), 41st annual session, Tsukuba, Japan, title of presentation: "Natural hazard and sea level rise risk assessment, examples from European research projects"
- January 31 – February 1, 2005: International Seminar on Tsunami "How Thailand and Neighbouring Countries will Become Ready for Tsunami" Bangkok, Thailand, title of presentation: "Policy development in risks and hazards"