Project 1.3.1
The spatial effects and management of natural and technological hazards in general and in relation to climate change

3rd Interim Report, March 2004

PART 1 / Summary

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PART I

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I INTRODUCTION

This Third Interim Report of the ESPON 2006 1.3.1 project "The spatial effects and management of natural and technological hazards in general and in relation to climate change" presents the progress made in the ongoing research of this project. The project is further on referred to in a shortened version as "ESPON Hazards project".

The Third Interim Report presents a deep going overview of the current work process. In the first instance, it therefore has to be seen as a progress report that shows interim results and further steps in the following core areas of the ESPON Hazards project:

- further development of the methodology,
- further map making process,
- application and review of methodology for inner-regional weighting of risks in case study areas,
- dealing with possible future highly sensitive areas according to development trends, including climate change scenarios,
- formulation of planning responses,
- and policy recommendations.

II INDICATOR AND HAZARD MAP DEVELOPMENT

Chapter 1 presents additional or modified indicators and maps, please see the ESPON Hazards 2nd Interim Report for a complete overview on the hazard indicators and maps developed so far. Not all indicators could be produced yet because there are still substantial data gaps. The ESPON Hazard project is dependent on publically available data, and, if the data is not freely accessible on the World Wide Web (www), on data requests. Many of the submitted data requests have not been answered and some indicators cannot be developed due to the poor quality of the data. The most important indicators that the project would still like to develop but are suffering from data gaps are presented in table 1 in Part II.

The drought hazard has a high priority in the EU Commission and the ESPON Hazards project was asked to develop a map on this issue. The topic of droughts is very complicated, because of the great variety of droughts and the large amount of factors that influence them. A drought map of Europe is basically impossible to develop because of the different climate zones, the varying geology and topography as well as the inhomogeneous data sets. Therefore the map 1 in Part II is a not a drought map but a map that shows reported negative deviations in the annual average precipitation and river runoff in Europe of the last 100 years. The map is presented to show the complexity of the drought problem, because precipitation and river runoff are major factor that influence droughts but other factors, such as the timing of precipitaion (amount per day/season), soils and landuse, etc play important roles too. For example, in comparison to southern Europe, Norway is far from being a dry country, but hence its energy is based nearly to 100% on hydropower even a small negative deviation in the annual precipitation is reported as a drought because some water reservoirs were not re-filled. The most striking aspect of the map 1 in Part II is that the areas with the largest deviation in precipitation are located in Eastern Europe, being the same areas that have suffered from the highest amount of floods in the observed time period from 1987-2002 (see also map 3 in Part II).

The flood event and intensity maps have been updated, meanwhile the flood risk map has been removed from the flood map set. Hence the observation period of floods covers, on a European scale and data avilable to the project, merely 15 years, it is feasible to show the flood intensity over the observed time period but it is not representative to derive an overall risk map. Currently the project is developing a new approach to model river floods in Europe and also possibilities to cooperate with other European research institutions to develop a flood prone area map of European Regions based on relief and climate models. If such a cooperation would be succesfull, the results will be presented in the final report.

The indicator on the oil hazard is based on oil terminals, refineries, storage and pipelines. Offshore oil riggs and major oil tanker accidents are shown in the overview map but are not taken into account in the hazard map. Both oil rigs and large tanker accidents can lead to major pollution of the maritime and coastal environment but it is impossible to forsee where the accidents occur and which areas will be affected. Even in the case of static oil riggs a possible pollution is always depending on the current meteorological situation during the accident. The inclusion of major shipping routes was not perceived as feasible either because one of the major recent oil tanker spills, the Prestige, did not happen during its cruise on a major shipping route since the wrecked ship was pulled out of a harbour area into the open sea before it broke apart. These kind of political decisions can happen again in the future, theoretically putting all European coastal areas at risk of a oil spill.

The indicator on storm surges was not developed into a hazard map yet because the additional information would be neglegtable on a single map. It is planned to include this hazard in an aggregated hazard map.

III FURTHER DEVELOPMENT OF THE METHODOLOGY

Before pointing at the strengths and weaknesses of the methodology, it would be useful to clarify some main characteristics of the applied methodology which have been subject of discussion.

By way of an addition of the hazard intensity class of a certain region and its vulnerability rate the risk level in this region will be examined. The outcome of this methodology is a **nine** risk classes matrix as a result of the addition process (1+1 to 5+5 respectively 2 to 10). Such a process is indispensable, because of the character of risk definitions as a mathematical function of economic vulnerability and hazard intensity.

One should understand the matrix diagonal from the corner lower down in the left to the upper corner above in the right as figured below:

Hazard Intensity	Degree of economic 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**

Figure 1. Nine risk classes matrix

III.1 Weighting problem

As already mentioned in the Second ESPON Hazards Interim Report, the problem of weighting the selected risks is still not solved, i.e. there is no way to scientifically determine an objective weighting of risks. The main reason is that the question of risk always is also a normative question which depends on certain social values that differ from society to society. Risk therefore can *not only* be discussed on a factual level. Further, the area of Europe is very large and heterogeneous which makes the setup of universally valid weighting factors for all risks an almost unsolvable task. These are the reasons why so far no attempt has been made in the ESPON Hazards project to weigh any of the indicators on European level (see argumentation in the 2nd ESPON Hazards Interim Report, Chapter 1.3.5, p. 75). All indicators are weighted equally which guarantees the highest degree of transparency on the way to develop a synthetic index of risk.

Despite all scientific objections, it is, also from a political point of view, of great interest to introduce a certain form of weighting of risks into the methodology. This may finally lead to the *development of an application tool* to individually change the weighting factors for the selected risks (see for this purpose chapter 2 in Part II: Application and review of methodology for inner-regional weighting of risks in case study areas).

III.2 Three dimensions of vulnerability

In the course of the ESPON Hazards project, the diversity and complexity of the term vulnerability has become clear and there is a need for further discussion and clarification of the term. Vulnerability is discussed from three different aspects (economic, ecological and social) and for the purposes of the ESPON Hazards project the three dimensions of vulnerability should be further on connected to the European scale with the help of maps.

There exists an array of different definitions for vulnerability (for an attempt to draw these together see Cutter 1996). In the ESPON Hazards project's glossary (2nd ESPON Hazards Interim report, p. 18) vulnerability is defined as the "degree of fragility of a person, a group, a community or an area towards defined hazards. [Vulnerability is] a set of conditions and processes resulting from physical, social, economical and environmental factors, which increase the susceptibility of a community to the impact of hazards. Vulnerability is determined by the potential of a community to react and withstand a disaster, e.g. its emergency facilities and disaster organisation structure (coping capacity)."

Vulnerability in the Hazards project → Economic dimension of vulnerability

In the 2nd ESPON Hazards Interim report of the Hazards project regional vulnerability in Europe is measured as the combination of GDP per capita and population density (equally weighted 50:50). With this combination it is possible to recognise the economic *damage potential* of a region, as well as the potential exposure of people. This definition of vulnerability is from now on called the economic dimension of vulnerability. Similarly, the term vulnerability index will be replaced by the term economic vulnerability index in the project.
The economic dimension of vulnerability offers an interesting approach to the issue of regional vulnerability, especially from the insurance company point-of-view, but it should not be used as the only determinant of a region's vulnerability.

In addition to the already existing maps on the economic dimension of vulnerability, sample maps that portray aspects, that the basic economic vulnerability index cannot be acknowledged, are currently developed. Possible sample maps include:

- Oil spills: the threat to different sectors of economy, e.g. tourism,
- Floods vs. land use: in what kind of areas does floods mostly occur?
- Droughts vs. agriculture

A new dimension for the hazards-project → Social dimension of vulnerability

The social dimension of vulnerability acknowledges the vulnerability of people, and the emphasis is on the *coping capacity* of different social groups.

There is no common agreement as to which variables should be used to measure social vulnerability, although socio-economic status, age, race and gender are among the most commonly used. For the purposes of the Hazards project, indicators measuring coping capacity were considered important, but also the damage potential aspect was incorporated into the social dimension in the form of population density. The amount of indicators was kept as small as possible. The following indicators were chosen:

- ***Population density:*** measures damage potential as in the amount of people in danger.
- ***National GDP/capita:*** The presumption is, that coping capacity is weak in poor countries and strong in rich countries.
- ***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..
- ***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 do, and are therefore more vulnerable.

The social vulnerability indicators, excluding population density, measure those characteristics of a region that make people less able to understand the risk or recover from a hazard event. They do not measure the scale of damage directly, but rather how a community or region will be able to prepare and respond to a hazard pointing out social and place inequalities. Possible further coping capacity related indicators like medical infrastructure, technical infrastructure and share of budgets spent on civil defense will be looked into.

Population density and national GDP will here be given the percentage share of 35 each. Dependency ratio and education rate will then both get the share of 15%. The reason for this weighting is, that dependency ratio and education rate haven't been used as vulnerability indicators often and it is important to test their feasibility first. This weighting can seem arbitrary, but no matter how the variables are weighted, the outcome will be a mere example on how social vulnerability could be measured. A first attempt to test the weighting of vulnerability indicators has been made by using the Delphi method in the case study areas (see Chapter 2 in Part II).

A new dimension for the Hazards project → Ecological dimension of vulnerability

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. According to Villa & McLeod (2002), there is neither general agreement on how best to define environmental properties, such as vulnerability, nor on how to calculate corresponding indicators. They point out, that even though environmental decision-making requires such quantification of environmental properties, it is not reasonable to base these decisions on measures that are too simplistic and often based solely on the most easily measurable indicators.

The ESPON Hazards project will not attempt to measure ecological vulnerability the same way as economic and social vulnerability are measured, due to problems in finding suitable indicators for measuring the degree of ecological vulnerability in all NUTS 3 regions and for all hazards. The fact that different hazards affect different natural areas (e.g. forest fires and oil transport) and appear in different scales (e.g. landslides and nuclear power plants) makes it impossible to find common indicators. It would also be difficult to consider ecological coping capacity or compare it between different regions. On a general level it can be said that robust environments are more resistant to hazards than fragile ones (e.g. marginal ecosystems in semi-desert areas), where even natural hazards alone (e.g. remaining dryness) can have a strong negative effect on the ecology of a region.

III.3 Further investigations – towards an integrated vulnerability map

The crucial question at this point is, whether it is possible to combine the different dimensions of vulnerability to create a comprehensive regional vulnerability. Having in mind the synthetic risk map as the most important and innovative approach of the Hazards project, an integrated vulnerability map on EU 27+2 level would be of great value. Such a synthetic approach is indispensable due to the project's spatially oriented perspective. Despite the fact, that there are still some methodological problems that have to be solved for the final report, the project 1.3.1 will aim at such an integrated vulnerability approach.

The core idea is the integration of the economic and social dimensions of vulnerability. This enables the inclusion of coping capacity into the project not only in a qualitative way (like suggested in the First Interim Report, p. 93), but also quantitatively. The ecological dimension will have to be excluded from the integration due to the unique way different hazards affect the environment.

As a result, the overall vulnerability would be composed as shown in the figure below. Both dimensions of vulnerability use population density as a core aspect, and the factors that determine either the social (coping capacity) or economic (damage potential) aspects of vulnerability are equally weighted.

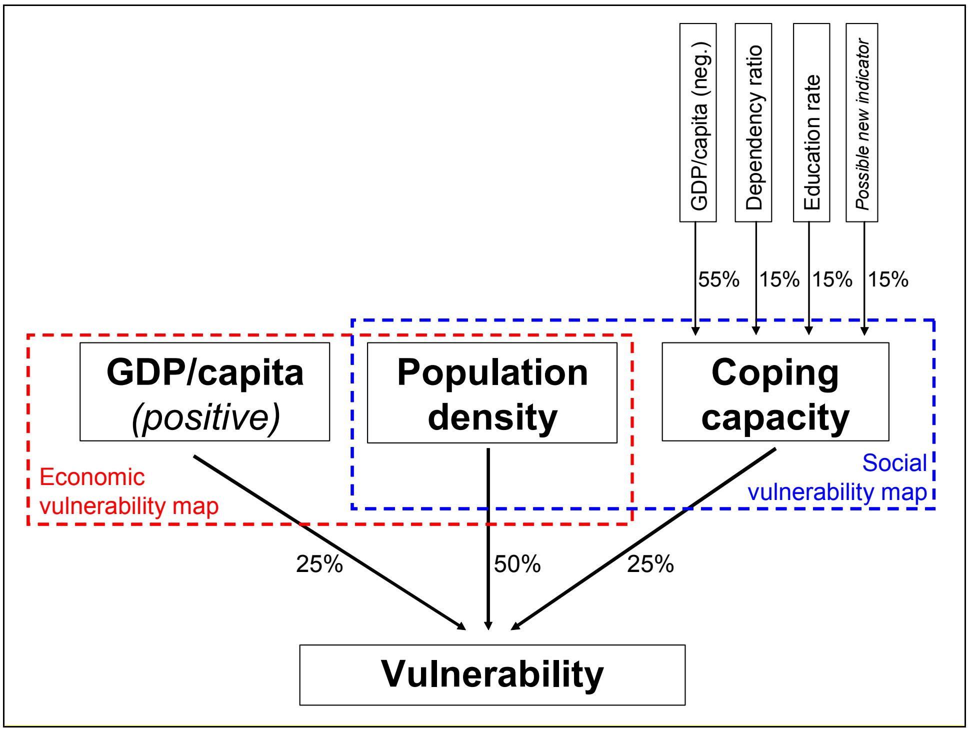

Figure 2. Towards an integrated vulnerability index. Source: ESPON Hazards 2004

III.4 Application and review of methodology for inner-regional weighting of risks in case study areas

The second ESPON Hazards Interim report presented a number of hazard maps detailing different degrees of hazard intensity and maps of potential risk presenting a combination of hazard intensity and vulnerability in European NUTS 3 level areas. Those maps gave an overview of risk in the European Community. However, the methodology backing the maps only allows a European wide view and does not contain sufficient information to facilitate risk bound approaches of spatial planning at different spatial levels.

It is thus inevitable to advance the methodology towards a tool allowing to form an information basis for planning activities at regional levels. The proposed approach in the first phase presented below considers discrete regions. The focus is based on the assessment of the inner-regional risk potential by a) drawing the regional risk profile and by b) elaborating aggregated risk maps for sub regional levels of the region of interest.

In this context the risk assessment methodology proposed in the second ESPON Hazards Interim report was used, i.e. risk is combination of hazard potential and vulnerability.

Vulnerability = Damage potential / Coping capacity
('/' meaning a decrease by which formula ever')

Risk = Hazard potential x Vulnerability
('Hazard potential' being determined by the combination of 'frequency' and 'magnitude')

Regarding the above mentioned weighting problem of the different hazard and vulnerability components, the so called “Delphi method” was specified for the project purposes. The original Delphi method objective was to "obtain the most reliable consensus of opinion of a group of experts ... by a series of intensive questionnaires interspersed with controlled opinion feedback" (Dalkey & Helmer 1959).

Risk analysis is currently an issue of uncertainty which still has to rely on subjective opinions. The Delphi-method offers an applicable tool to be introduced in the process of risk assessment in the case study regions to prove its appropriateness for the issue. Chapter 2 in Part II presents three full Delphi method applications in case study regions of the ESPON Hazards project.

The goal of the Delphi application is to draw an exemplary risk profile for each case study region. For this reason the importance of hazards and vulnerability indicators are weighted by the use of the Delphi method. The application of the tool takes place in the following steps:

1. Choice of experts
2. Preparation of the tool (hazards and indicators)
3. Application of the tool with the experts
4. Summary and description of results
5. Transformation of results into regional maps

From the case study regions a more or less homogeneous group with relation to spatial planning and risks is chosen. It is self evident that the lack of ideal experts is on the one hand also compromising the results of risk assessment. One output from the regional risk assessment is the production of regional risk maps as a basis for regional as well as local sectoral and comprehensive planning. For each case study area all hazards can be considered for the aggregation, important is the response each hazard received by the expert group.

In a second step detailed risk maps for each case study region are approached. Therefore the obtained hazard value is combined with the vulnerability (respectively damage potential). Finally, based on the ESPON Hazards risk matrix (see 2nd ESPON Hazards Interim report), maps of the available degree of explicitness are drawn.

III.5 Results from the case study applications

The application of the proposed methodology in three case study areas has shown that it is possible to obtain descriptive results that can form a good basis for spatial planning. The tool offers the possibility to assess the current risk profile of a region.

Each of the three case study regions Dresden, Itä-Uusimaa and the Central region of Portugal owns a medium aggregated risk. The main reason for this key result is, that every region owns on the one hand a few hazards with a high intensity and on the other hand a low threat regarding other hazards. While Dresden (Floods, storms) and Portugal (forest fires, floods) are in the first instance threatened by natural hazards, the hazard profile in Itä-Uusimaa concentrates on technological hazards (productions plants, marine transport and nuclear power plants).

Difficulties remained through the application of the Delphi method and the hazard aggregation tool due to lack of impartial and scientifically backed data on expected hazard intensities. Limiting was also that proposed vulnerability indicators could partly not be operationalised due to lack of background data.

Although applied, the so far proposed indicator system made up by only one social and one economical indicator leaving out ecological indicators and coping capacity needs further development. In several occasions experts had difficulties in following the presented approach to vulnerability. It is also worthwhile considering to refine the set of indicators for use on finer spatial levels than NUTS 3.

During the application it became apparent that the information derived from the Delphi method and the application of the aggregation tool is good for quick overview on rather abstract levels of spatial planning.

IV PLANNING RESPONSE: FOCUS ON THE PLANNING PROCESS

The general difference between planning responses and policy recommendations in the ESPON Hazards project is as follows:

- *Planning responses* are all measures, instruments and methodologies that are applied by "planners" respectively the administration or executive level Therefore, the addressees of the planning response suggestions are planning authorities on different spatial levels. Another distinction is that suggestions for planning responses aim at possible improvements and further developments inside the given institutional and legal framework.
- The addressee of the projects' *policy recommendations* is the European Union / European Commission, respectively the political or legislative level. Nevertheless, policy recommendations that are formulated by the European Commission can address any lower (national, regional or local) level. The implementation of these recommendations needs, in contrast to planning responses, changes in the present institutional and legal framework.

The question, if planning measures could be an area of policy recommendations was discussed earlier (see 2nd ESPON Hazards Interim Report, p. 154 ff.). The ongoing work in the project showed that this procedure would not be manageable hence it is impossible to assess all relevant measures because too many specific aspects have to be taken into account for 14 hazards in 27 countries on 5 spatial levels. Moreover, it is a fact that often very well designed measures do not have any effect at all because of the existence of typical planning problems (e.g. fit, interplay and scale).

Especially the problem of interplay (see 2nd ESPON Hazards Interim Report, p. 152 ff.) is a crucial factor for mitigating spatial risks: Most institutions interact with other similar institutions both horizontally and vertically. Horizontal interactions occur at the same level of social organisation. Vertical interplay is a result of cross-scale interactions or links involving institutions located at different levels of social organisation. Interplay between or among institutions may take the form of functional interdependencies or arise as a consequence of politics of institutional design and management (Young 2002, p. 19 ff.). The problem of interplay shows that the process area plays an important role for a successful planning response towards hazards. In the following, risk management will be understood as the systematic application of management policies, procedures and practices to the task of identifying, analysing, assessing, treating and monitoring risk (see glossary for a broader definition of this term).

For the integration of risk management into the spatial planning process there is a need to identify the elements of an ideal risk management process. The ideal risk management process as a part of the spatial planning process can be described by the following elements:

1. *Scientific basis:* Are appropriate data and assessment methods available (e.g. hazard maps, risk maps) for developing a scientifically correct foundation for the decision making process?
2. *Political decisions:* To which extent is the scientific basis considered when political decisions are made? What are the reasons for neglecting information about hazards and risks? How and to what degree had the results of the assessment of risks been taken into account in decision-making about specific plans or programs?
3. *Implementation process:* Once a decision about a measure has been made, how to insure will it be implemented in reality? What are the possible obstacles?

The following figure illustrates the mentioned interrelationships between an ideal planning process and risk management.

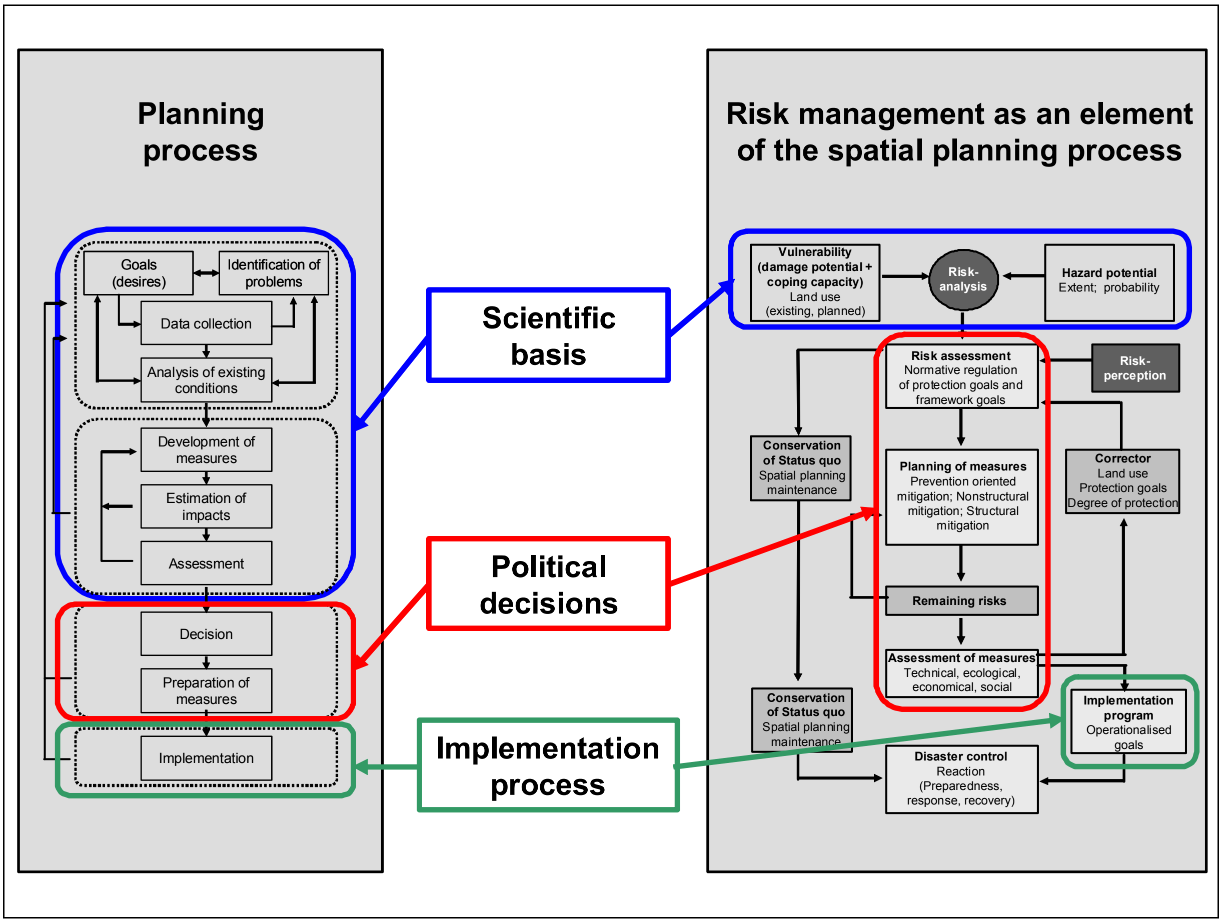

Figure 3: Comparison of ideal planning processes along the criteria of the scientific basis, political decisions and the implementation process. Source: ESPON Hazards 2003.

The steps of the ideal risk management concept set the criteria for a "checklist" to assess risk related spatial planning in four selected case study regions in Germany, Portugal, Finland and Switzerland. The results of this analysis have proven the hypothesis that there is no systematic and spatial oriented approach of analysing, evaluating and mitigating spatial risks in the selected case studies – neither on local nor on regional level. This deficit in planning practise is not only valid for the case studies but also for Europe in general highlighting the importance of the development and implementation of risk management into the spatial planning process.

IV.1 Regional and land-use planning level of planning guidelines

In terms of institutional vulnerability and coping capacity, the role of spatial planning is a central concern for the ESPON Hazards project. Planning can be seen as a crucial factor in reducing losses from disasters. The setting up of guidelines for a spatial planning response to technical and natural hazards focuses on the regional as well as the local level. Therefore, the appropriate level of space related risk planning has to be addressed by planners and planning instruments.

For natural and technological hazards an important level is the *regional level* because the local level is too small in scale for appropriate risk reduction planning. The main reasons for this are the existence of individual local interests of the municipalities as responsible actors for land-use planning and the usual over-local scope of the hazard including consequences. The main task for regional planning and/or regionalised structural funds as responsible actors should be the setting of a framework for local mitigation activities. Having in mind the described "ideal risk management process" the regional level has to take the responsibility for setting the protection goals (and objectives) in cooperation with all relevant actors. This includes the municipalities, sectoral planning divisions and private stakeholders.

In the light of the above mentioned process, the *local level* should be responsible for the selection of appropriate measures and their implementation which aim to fulfil the fixed goals, because of its 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.).

Due to this shared responsibility, an appropriate monitoring system on the basis of suitable indicators has to be carried out. The regional authority, which takes the responsibility for the setting of the protection goals, should be responsible for this monitoring in order to assess the success of the arranged measures regarding the relevant protection goals.

IV.2 Towards a handbook for mitigating natural and technological risks: elements of a framework for spatial risk mitigation

The following suggestions are derived from the study of existing literature (systematic approaches, best practice examples). The following considerations aim towards setting up a handbook for mitigating natural and technological risks on the regional and local level.

The ESPON Hazards project suggests that every European region and municipality should be aware of possible risks due to natural and technological hazards to mitigate the risks. The Third Interim Report presents a framework of a risk mitigation planning guide that shows the main elements of a spatial risk mitigation or risk management, respectively, and can be applied on the regional or local level. In general, a spatial risk mitigation planning guide has the following purposes:

- minimize the impacts of the effects of hazards on people and (built) environment,
- review the hazards of the respective area (region, municipality),
- establish goals and objectives,
- review a range of possible approaches to reduce risk,
- identify the highest priority mitigation strategies and policies,
- identify potential future actions to implement those measures that appear to be effective and appropriate for the area,
- provide a background document (on the regional level) for local action.

The section about planning guidelines is still open for further investigations. The following aspects have to be elaborated more in detail for the final report:

- *Handbook for Mitigating Natural and Technological Risks:* Towards the Final Report we suggest to further develop the first findings for a handbook for risk mitigation which take into account different categories and typologies of regional planning and regional authorities in Europe. The final output would be different combined modules of risk mitigation elements in a handbook that can be applied in different Member States of the European Union.
- *Ideal planning process:* The steps of the ideal risk management process have only been basically sketched so far. A more detailed description is desirable, too.

V FIRST POLICY RECOMMENDATIONS

Policy recommendations go beyond the improvement of the work within already existing administrative structures or the already existing planning system that were the main aspect of the previous section on planning responses. The following summary focuses on those policy recommendations that are of spatial relevance and that extend the present set of strategies, concepts or instruments.

I: EU-level

1. Need for better inclusion of risks related to natural and technological hazards in EU policies. This calls for better integration of environmental and regional policy measures at all spatial scales. Risk management should be made an integral and explicit part of EU cohesion policy.
2. Stress *vulnerability reduction* as a key strategy in policy and planning. There should be more emphasis on prevention and vulnerability reduction through spatial planning, based on the “precautionary principle” and “redundancy”, i.e. developing robust policies that cover multiple hazards. Such measures are more cost-effective than risk reduction of single risks based on exact scientific predictions.
3. Deliberate use of Stuctural 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); 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.
4. Establish a European Emergency Management Agency (EEMA) for coordinating European risk management efforts. The EEMA should, among other functions, coordinate emerging EU initiatives in the field of risk management and guarantee the coherence between EU policies.
5. Implement the recommendations of the 6th Environmental Action Programme in broadening the scope of the SEVESO II Directive.
6. Ensure fluent co-operation between different ongoing initiatives in the field of hazard and risk management, including legislative and financial instruments.

II: Meso-level (national, Interreg)

7. 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.
8. Create governance networks to address risk management in regions with special environmental characteristics and related challenges. Instruments such as the river basin management plans of the Water Framework Directive (2000/60/EC) for risk management purposes, should be used.
9. 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.

10. Transnational Interreg areas with common ecological denominators should be used as ‘breeding and testing’ grounds for meso-level risk management programmes.
11. Make financial aid in disaster events conditional upon the compliance to national guidelines of risk management.

III: Regional level

12. 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 make use of the *space-type concept* as outlined in (chapter 4.2.).
13. In order to support regional mitigation plans, adopt measures in the new Thematic Strategy on the Urban Environment (COM (2004)60 final).
14. Enhance horizontal co-operation between regions and urban areas (e.g. through networks such as Interreg initiatives, EUROCITIES, URBACT etc.) in the fields risk management and civil protection.
15. Enhance public awareness of hazards and public participation in risk reduction efforts.

IV: Local/Community level

16. 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:
    a. Multi-hazard approach, including “domino” effects
    b. Integration of the relevant vulnerability components
    c. Facing all elements from prevention oriented mitigation to preparedness, response, recovery (see DPSIR chain, 2nd Interim Report p. 150).
    d. Public participation; integration of private stakeholders in risk assessment, decision making, choice of measures and implementation
17. 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.).

To sum up, 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. Yet another necessary task at the local and regional levels is to integrate different hazards into one management scheme, taking into account their interrelated nature.

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. However, natural and technological hazards do not simply fall in the category of “environmental protection”.

Rather, they are hybrid phenomena involving complex socio-ecological processes and bring together 'distant relatives' such as nature protection and civil protection. Furthermore, hazards expand the perspective of environmental policy into the areas of security policy through the notion of environmental security.

Further work on Policy recommendations

The section about policy recommendations is still open for further investigations. The following aspects have to be discussed or deepened for the final report:

- *Space-type-concept:* The suggestions concerning the space-type-concept have to be described in more detail in order to prove their relevance for achieving a successful spatial risk mitigation.

- *Arrangement of objectives:* This recommendation has to be tested in a case-study area for its applicability.

- *Completion of risk mitigation suggestions:* The proposed ideal planning process and the "Handbook for Risk Mitigation" may be described in more detail if these suggestions will be approved by the commission.

- *Contextualise the case-based spatial planning response with national policies and regulations:* What are key national regulations and policies which either help or hinder the realisation of an ideal planning process?

- The Interreg offices could be addressed with a very brief questionnaire about projects that relate to risk reduction.

- Beyond the Interreg initiatives, it would be interesting to study other possible forms of meso-regional cooperation in common risk issues, existing outside of the project-bound world.

- Hazard and vulnerability patterns in Europe will be further analysed after the 3rd ESPON Hazards Interim report.

- *Description of European Emergency Management Agency (EEMA):* The organization and duties of a European Emergency Management Agency can be described in more detail.

- The *CAP* should be reviewed from a risk management perspective.

- Cooperation with other ongoing efforts of hazard mapping (check on the process initiated by DG Environment/ Civil protection).

- Interviews at the EC Commission (DG Regio, DG Environment and DG Agriculture).

- The question should be asked whether the present interest (and resources) on climate change as a driving force behind natural hazards are exaggerated compared to other driving forces influencing European vulnerability?

- Financial instruments such as public-private partnerships in risk reduction and different insurance instruments should be discussed

- Monitoring (not only risks but vulnerabilities, social and economic trends) and research activities: Where should the focus be? What does Europe need to know more?

- Arrangement of policy recommendations by order of priority.

EUROPEAN SPATIAL PLANNING OBSERVATION NETWORK

Project 1.3.1
The spatial effects and management of natural and technological hazards in general and in relation to climate change

3rd Interim Report, March 2004

PART 2

Prepared by the following consortium:

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PART II

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1 INDICATOR AND METHODOLOGY DEVELOPMENT

1.1 Further map making and data research

This chapter complements the chapter 1.4 of the 2nd ESPON Hazards interim report in which a lot of preliminary maps of selected hazards were presented. These preliminary maps are still actual and can be described as core elements of the ESPON Hazards project's work. As an important part of the ongoing work, the 3rd ESPON Hazards interim report presents furthermore some completely new maps (landslides and droughts) and in addition, some maps that have been updated since the last report (floods and oil spills). Finally, future possible hazard indicators that have not yet been developed as well as their data sources are presented. Only the new and updated maps are presented in this report (see chapters 1.1.1 - 1.1.4 and annex 4). Please see the 2nd ESPON Hazards interim report for the maps produced earlier in the project.

Table 1. Possible future hazard indicators and data sources

Hazard	Drought	Technological hazards	Forest fires
Indicator	The monthly standardized precipitation indices (SPIs) Number of extreme drought events in Europe during 1901-1999 Mean duration of extreme drought events in Europe during 1901-1999	Production plants	Location of outbreak Total area burnt Forest fire risk areas in Europe
Source	Lloyd-Hughes, B. & Saunders, M.A. 2002. A drought climatology for Europe. International Journal of Climatology 22, 1571-1592. Department of Space and Climate Physics, University College London	SPIRS data base Joint Research Center	DG AGRI
Type of data	0.5^{o} grid	Statistics	Statistics

1.1.1 Droughts

Hazard characterisation

Dryness and the more serious drought are conditions encountered in a regional climate system when supply of water that is available for plants and humans cannot satisfy the demand adequately. In addition to precipitation and evaporation, such factors as temperature, wind, type of soil and its capacity to store water, depth and availability of groundwater as well as vegetation growth influence drought. (Munich Re, 2000)

Drought is a natural hazard, which is not restricted to the Mediterranean region; large areas of Europe have been affected by droughts during the 20th century. Drought can be defined in terms of meteorological, hydrological, agricultural and socio-economic conditions. There are many drought indices and classification systems for drought problems. For the ESPON project an optimal drought indicator should have harmonized data with large coverage and sufficient resolution for NUTS 2 level maps.

So far there is no universally accepted definition of drought. There are several categories and definitions for droughts that are frequently used (Tate and Gustard, 2000). The definition of drought as an effect of the lack of precipitation, for instance depends on the average precipitation of an area. Climates that are characterized by low temperatures and high precipitation, e.g. in northern Europe, experience droughts at precipitation rates that are still considered as humid in Mediterranean areas. A drought is normally not a single event but an accumulation of several factors that are harmful by themselves and catastrophic in their combination:

- Climatological drought (deficit in precipitation)
- Agro meteorological drought (deficit in soil water)
- River flow drought (deficit in river discharge)
- Groundwater drought (deficit in groundwater recharge)
- Operational drought (conflict of water shortage and water management problems
- Heat waves (exceptionally high temperatures that lead to unusually strong evaporation)

Droughts do normally not occur in a single short event but are an accumulated effect of a combination of the factors mentioned above. Meanwhile failing groundwater recharge in a certain period or a heat wave do not necessarily have a long lasting effects on the ecosystem, an accumulation of many events over several years lead to drought events that 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, for example in sandstones, can cope easier with a dry year, simply because they store much more water.

Table 2. Risk typologisation based on the drought hazard

Criteria	**Values**
Probability of occurrence *P*	High
Certainty of assessment of *P*	Medium
Extent of damage *E*	High
Certainty of assessment of *E*	High
Ubiquity	Over regional
Persistency	Relatively short removal period
Irreversibility	Low
Delay effect	Low
Mobilization potential	Medium political relevance

Risk management

Drought is extremely difficult to predict and it is usually not recognizable until it is already well advanced. Drought may result in further phenomena such as subsidence (particularly some types of clay can shrink tremendously and collapsing can occur when these types of soil are stressed e.g. by building), desertification (the ability of the ground and the flora is damaged so badly due to prolonged drought that their ability to recover is impaired or destroyed) and forest fires (Munich Re, 2000). One reason for increased crop damages during droughts nowadays is also the fact that water-demanding plants are cultivated in dry areas where they do not grow naturally, e.g. in southern Europe. Increasing droughts in the last decades can often also be, at least partially, explained with inappropriate land use and water management.

Droughts and long dry periods Europe have also led to serious power failures Europe and in the consequence to great economic losses in the industrial sector and the tourism. Another effect were shipping problems on rivers and lakes all over Europe. Most drought assessments concentrate on the effect on the vegetation and estimate economical losses of agricultural production. In Europe the drought risk should also take the effects on the producing industry and the service sector into account. Most of the European countries' agricultural GDP share is well below 5%, in most of the countries it is below 3%. Therefore in Europe impacts caused on the industry and service sector are more harmful to the economy of a society than agricultural losses. The long term effect on groundwater and surface water levels have a strong impact on the power production, e.g. nuclear power plants have to be shut down 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 difficult in a country like Norway that is mainly depending on hydropower. Droughts usually have long-term impacts as the water reservoirs, both surface and subsurface, need several raining periods in order to restore. A dreadful combination is a drought in combination with 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.

To avoid the problems that dryness and drought can cause, the use of water should be sparingly even at those times when it is in abundant supply. This means that reservoirs should always be kept as full as possible, aquifers should not be lowered unnecessarily, and evaporation should be reduced as far as possible, e.g. planting crops that are suitable for the local climate (Munich Re, 2000).

Possible indicators

A recent British publication by Lloyd-Hughes and Saunders (2002) introduces a promising future indicator for droughts. Lloyd-Hughes and Saunders present a high spatial resolution, multi-temporal climatology for the incidence of the 20th century drought. The monthly standardized precipitation indices (SPIs) are calculated on a 0.5^{o} grid. The models provide the time series of drought strength, the number, the mean duration, and the maximum duration of droughts of a given intensity, and the trend in drought incidence. In this approach the longest mean extreme drought durations were found in Italy, northwest France, Finland and northwest Russia. The problem with these calculations is that the evaporation is not taken into account, therefore countries that have an equally low precipitation as Finland but a far higher evaporation (e.g. Portugal) are not suffering from longer drought periods. Nevertheless the further development of this approach should be followed.

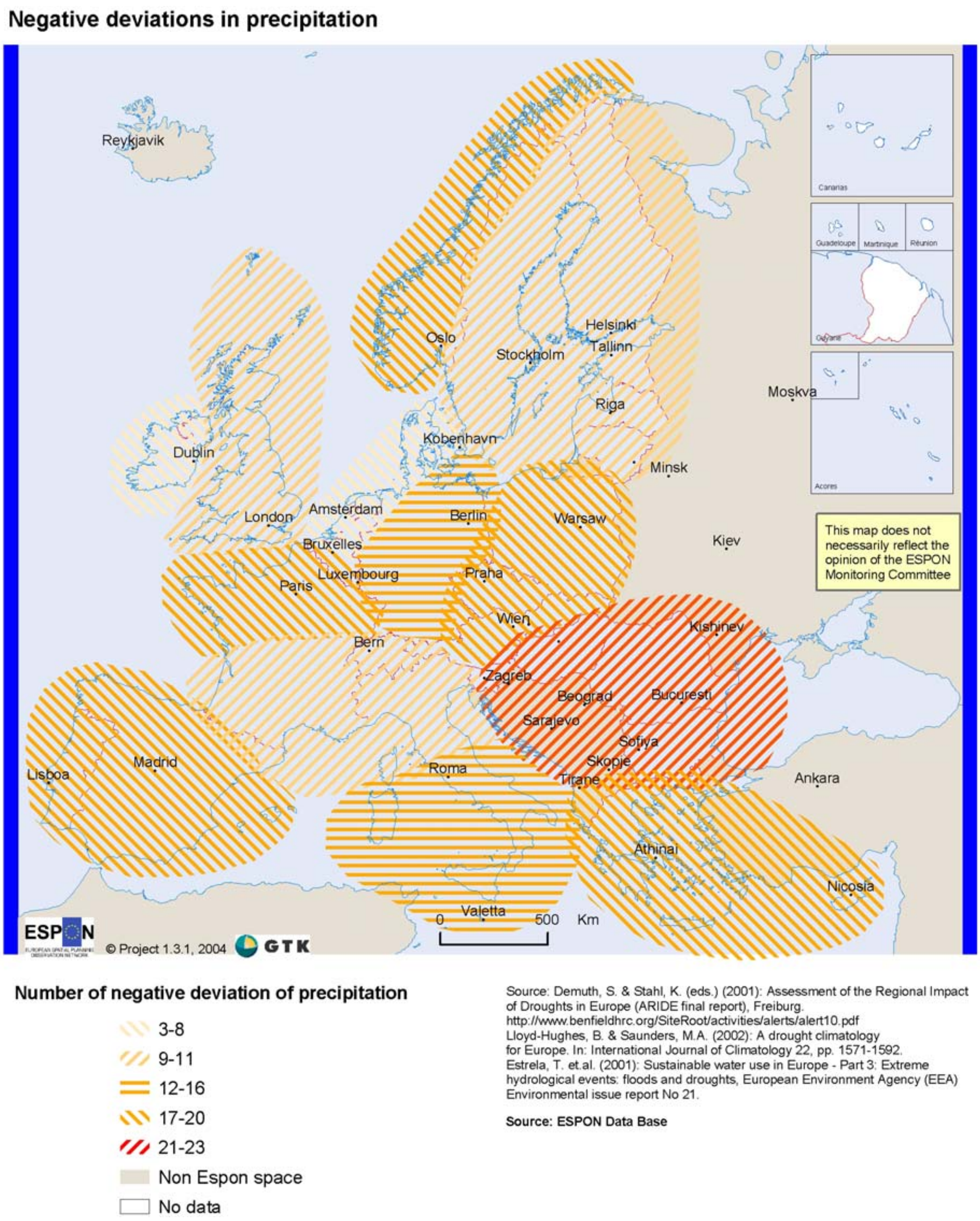
Long-term drought predictions based on climate modelling are not yet in the position to make reliable forecasts. In the United States exist some drought monitoring systems (e.g. http://www.cpc.ncep.noaa.gov/) but they are mainly short term.

The ESPON Hazards project has not yet developed a drought indicator because of the lack of data. The map presented in this chapter gives a mere overview upon negative precipitation and runoff deviations over in the 20th century. In indicator on drought should take all the economical and ecological aspects of droughts into account if a risk map on, e.g. NUTS III level should be developed. These economical and ecological aspects of droughts, their various effects on, e.g. water storage capacities and the consequent development of water availability and water prices, etc. cannot be estimated in the course of this project for the European territory. These assessments should be carried out on a regional (river catchment) level.

Map

Because of the difficulties in drought prediction, it was not possible to develop a drought hazard map. It was possible to develop a map that shows the negative deviations in precipitation and river runoff in catchment areas that is based on events observed during the last 100 years in Europe. The records were collected from Demuth and Stahl (2001) and several other sources. The most severe recorded events of the last 100 years of Europe were not assigned to NUTS levels because of the insecurity of the data sources. Historical recordings give an interesting overview on past events but are usually not suitable for hazard and risk mapping. Therefore the map 1 should be seen as an overview map on precipitation and runoff deficiencies recorded in Europe.

Even though the map has deficiencies due to data accuracy, it shows two very interesting points in the discussion of droughts: Norway has problems with water deficiency because the country's economy is based on hydropower. Even though 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. The second interesting point is that those Eastern European countries that have experienced the highest amount of floods during the last 15 years (see map1) have also experienced the highest problems with lacking precipitation and river runoff in the last century.



Map 1. Negative deviation in precipitation in Europe in the 20th century

1.1.2 Large river flood hazard maps in European Regions

Flood Hazard

Floods are defined as 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 along rivers but also further away from them. 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 Re 2000).

River flood mapping in general

River flood and flood prone area modelling/mapping is possible, although undoubtedly complex, because the numerous variables can cause a high degree of uncertainty. Fundamentally, a river flood attempts to evaluate some, if not all, of the following factors:

How deep – possible inundation depths
How Often – frequency of inundation at varying depths
Extent – The geographic extent of flooding at varying depths

The most important part of flood hazard identification is 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 enough digital elevation data, discharge data and number of cross-sections located throughout the watershed (Guy Carpenter 2002, Lear J. *et al*.).

In Europe this complex kind of data is available only from certain study areas. One approach to global scale flood maps are presented in the UNDP global report "Reducing disaster risk". These maps show frequency and physical exposure for floods based on the EM-DAT database. A geo-reference of each recorded flood was produced and the watershed related to each flood event was identified. The watersheds were split to follow country borders. The biggest problem in this method is that the use of watersheds affected by floods to delimit hazard exaggerates the extent of flood-prone areas.

Large river flood events recurrence map in Europe

The methodology of creating a first aggregated flood map of Europe relies on the frequency of floods in the time span of 1987-2002, the regional flood hazard (for this 15 year period) being displayed on NUTS 3 level (administrative boundaries). 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. Flood prone areas are not feasible in this methodology because they cannot be displayed on European NUTS 3 level maps. In addition, current flood prone are calculations (10 year, 50 year, 100 year floods, etc.) might have to be recalculated because the main results of most recent climate change studies reveal that the *frequency* of extreme climate events (including floods) is increasing, meanwhile the *magnitude* of these events is not necessarily changing (see 1st ESPON Hazards Interim Report, chapter 4.5, and 2nd ESPON Hazards Interim Report, chapter II.3 and 1.2.1.1). Based on these climate change scenarios, the international scientific community is starting to perceive that the probability approach for flood prone area mapping used so far is to be revised and flood prone areas are presumably to be re-estimated.

Most of the background data for the presented flood and flood hazard maps are taken from the "Global Active Archive of large Flood Events", maintained by the Dartmouth Flood Observatory. The Rhine floods 1993-1994 data have has been taken from Rhine Atlas 2001, the Oder/Germany 1997, Tuscany/Italy 1992 and River Guadian 1997 have their source in ESA's Earth observation Earth online.

The Global Active Archive of large Flood Events since 1985 facilitates research into the causes of extreme flood events to provide international warning of such floods, and improve widespread access to satellite-based measurements and mapping. Many floods have been imaged by satellite or airborne sensors and translated by Dartmouth Flood Observatory staff into maps of inundation extents. However, repeated flooding in some regions is a complex phenomenon and this map is a compromise between aggregating and dividing such events. Unfortunately the Global Active Archive of large Flood Events by Dartmouth Flood Observatory doesn't cover completely the time period 1985-2002. The flood events archive is under supplement work and the aim is to add the data from missing years until the end of year 2003.

The inundation extents data by Dartmouth Flood Observatory have been digitised without particular scale of mapping, which leads to a situation where the accuracy of the map is difficult to define. In general, these maps are addressed to be used in a global scale assessment and should therefore not be utilized for precise local analysis. Because of the accuracy problem, the digitised flood areas have been changed by project 1.3.1 to a relatively coarse raster size (25km x 25km) to avoid detailed interpretation. Representing this data on NUTS 3 level is therefore mainly useful as a generalized overview. For regional applications, regional and local experts should be contacted.

From flood data converted to the raster format it is possible to derive the *flood hazard map*, as based on the frequency of flood events in European regions on NUTS 3 level. In this "Flood hazard intensity" map the average value of the large flood events has been calculated for each NUTS 3 area. The intensity results are not dependent of the size of the flooded area but only the number of flood events occurred. The flood hazard intensity has been classified on the basis of these average values using the time interval 1987-2002 in the following manner (flash floods are not possible to estimate in the frame of this project, therefore flash floods can appear in all flood intensities below):

Flood intensity	Average value of flooding events on NUTS 3 area
1 Very low hazard	0
2 Low hazard	1
3 Moderate hazard	>1 - <=2
4 High hazard	>2 - <=3
5 Very high hazard	>3

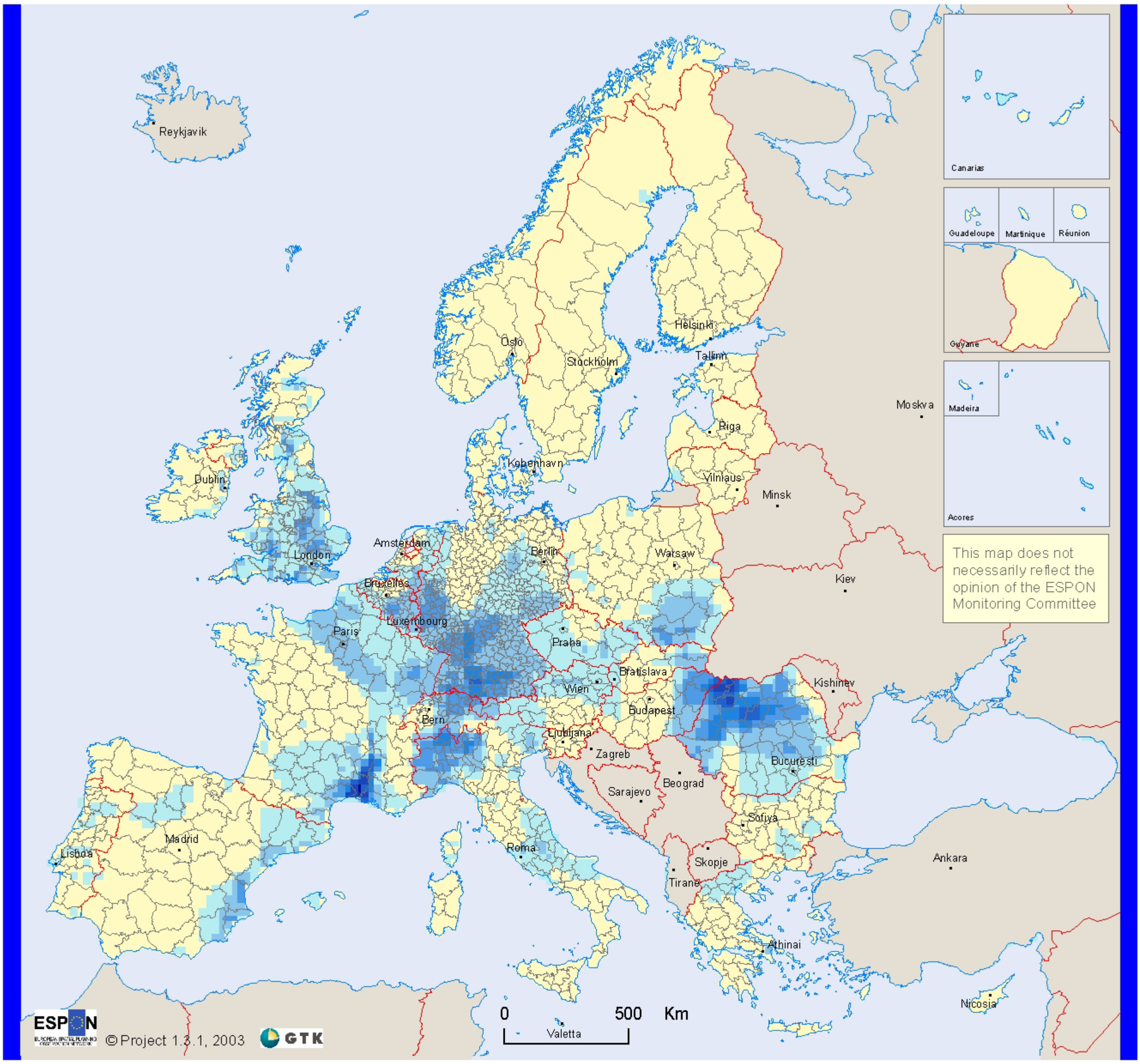
This classification is synthetic and points out the frequency of large flooding events in Europe, meanwhile the magnitude of single flood events is not taken into consideration.

Based on maps 2 and 3 the highest amount of large flood events during these periods is concentrated in North-Western Romania, South-Eastern France, Central and Southern Germany and in the east of England. As explained above, the source data was obtained through satellite images and the mapped areas may not coincide to 100% with areas that have actually experienced floods. Nevertheless, the presented maps are currently the most comprehensive flood maps of Europe based on publicly available data.

The risk map shown in the 2nd ESPON Hazards interim report has been disregarded in this report. This is because the flood data is only showing flood events recurrence during such a short time period (1987-2002) and thus no frequency or magnitude for future risk areas can be estimated.

Currently the project is developing a new method on how to present large river flood prone areas in European regions by river catchment area modelling. Additionally the ESPON Hazards project is seeking possibilities to cooperate with other European research institutions to develop a flood prone area map of European Regions based on relief and climate models. If such a cooperation would be succesfull, the results will be presented in the final report.

Large river flood events recurrence 1987-2002 in Europe



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

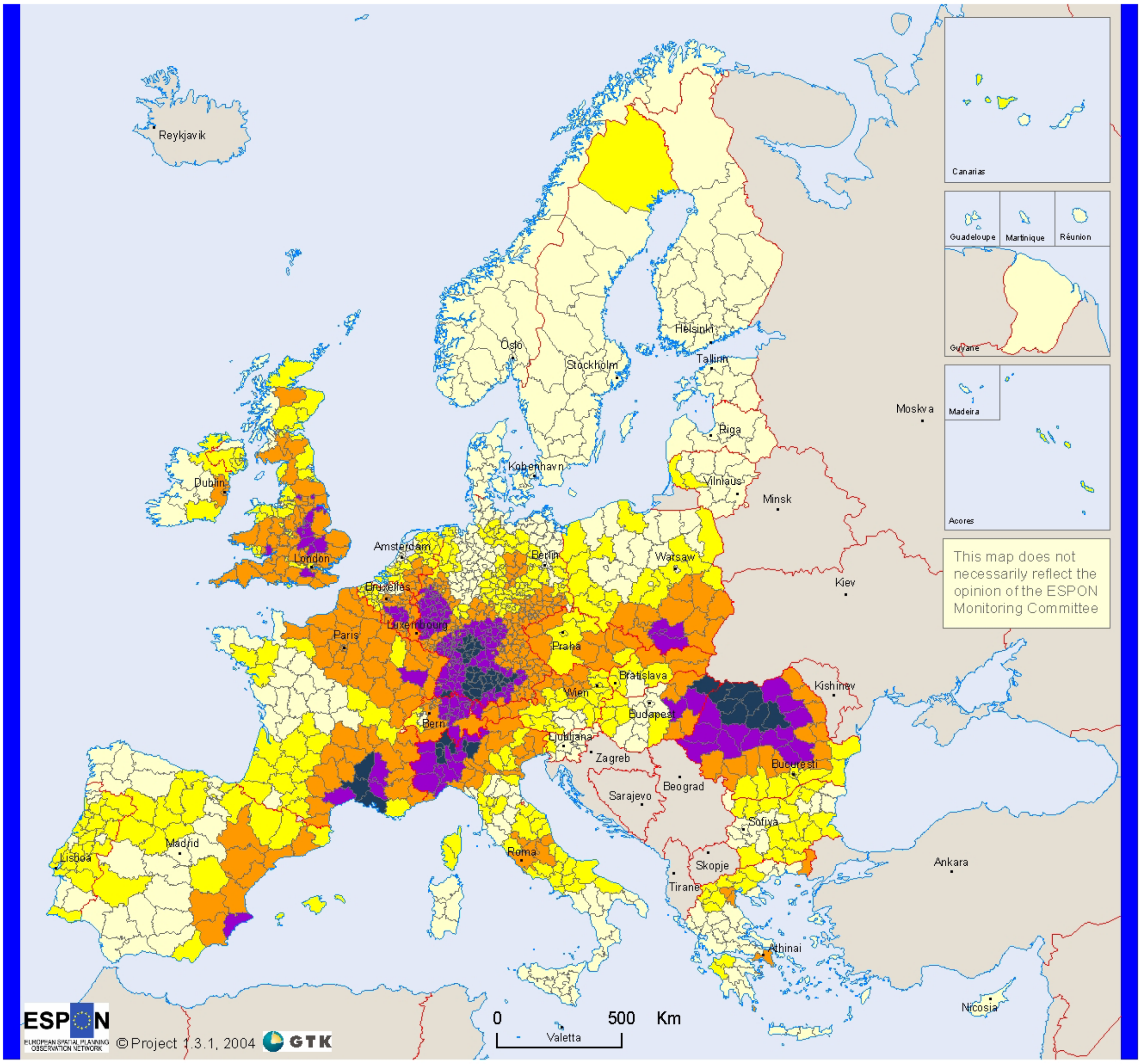
Number of large flood events

- 1
- 2
- 3
- 4
- 5
- 6
- 7
- 8
- ESPON space NUTS 3
- Non ESPON space

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 2. Large river floods in Europe 1987-2002

Large river flood events recurrence in Europe (NUTS 3)



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 shows the hazard recurrence based on average number of large flood events on NUTS 3 level during 1987-2002. Each NUTS3 region has been given an average of the large flood event that fall inside it. To the first class "Very low hazard intensity" only the regions without large flood events are included.

Flood intensity
Average value of flooding events on NUTS 3 area
Very low hazard 0
Low hazard 1
Moderate hazard >1 - <=2
High hazard >2 - <=3
Very high hazard >3

Map 3. Large river flood events recurrence in NUTS 3.

1.1.3 Landslides

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 an over steepened slope is the primary reason for landslide, there are other contributing factors (U.S. Geological Survey, 2002):

- erosion by rivers, glaciers, or ocean waves create oversteepened slopes
- rock and soil slopes are weakened through saturation by snowmelt or heavy rains
- earthquakes create stresses that make weak slopes fail
- earthquakes of magnitude 4.0 and greater have been known to trigger landslides
- volcanic eruptions produce loose ash deposits, heavy rain, and debris flows
- excess weight from accumulation of rain or snow, stockpiling of rock or ore, from waste piles, or from man-made structures may stress weak slopes to failure and other structures

With landslides it is most difficult or even impossible to assess return periods or probabilities of occurrence. Hazard maps, therefore, are usually based on depth of the sliding surface and the activity of the process only.

- $<$2 m shallow sliding
- 2 m – 10 m medium sliding
- $>$10 m deep running sliding

Shallow landslides do not figure among the most dangerous natural hazards. However, they may well become a threat to single buildings and, particularly, to traffic lines. Shallow slides may be stabilised by ordinary retaining walls (concrete, gabions, timber) in combination with bio-engineering methods. Deep running landslides is sometimes quite difficult or even impossible to stabilise.

Different types of geology, morphology, climate and land use make it nearly impossible to develop maps on overregional scale. Also, it is not feasible to develop landslide maps that are mainly based on the topography, as slope steepness is an important but not the only factor for landslides. Nevertheless, in order to obtain a major overview on the situation in Europe, the ESPON Hazards project attempts to develop a map on slope steepness on a coarse grid size for the ESPON area. With this map it is possible to obtain a first overview on the areas in Europe that experience landslides due to topographical reasons. For detailed assessments, local and regional experts should always be contacted.

The relation between slope and landslides is complex. The topography of Europe was calculated on a 1km grid cell size. Slope, in one-degree increments, is the maximum rate of change for the central 1km cell within each 3x3 subgrid of cells. The studied field researches do not express the exact relation between slope and landsliding, but some guidelines have been documented (Pike R. J. *et al*. 2001, Boll A. 2002, Bhandari R. K. *et al*.1996). Non-debris-flow landsliding in the study areas increases with terrain slope, but only up to a maximum value, commonly 15° to 35°, depending on mode of failure and the underlying lithology. Mass-movements as rock falls, topples and shallow landslides occur in the steeper areas between 28° and 45°. Debris-flow source areas have their peak at about 30° mean slope. Besides hydrological, geological and geotechnical parameters, vegetation is a decisive factor for occurrence of shallow landslides (figure 1).

In the SPESP final report one slope instability hazard indicator has been evaluated. In that paper slope instability gets the **value 0.5** if the percentage of an area with slopes steeper than 4° is 0-10% and **value 1** if the percentage of an area with slopes steeper than 4° is > 10%.

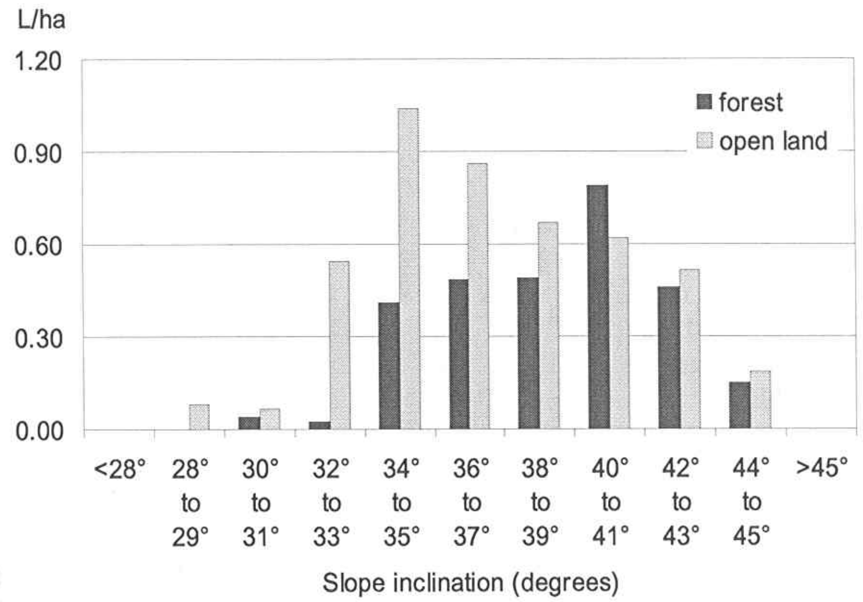


Figure 1. Landslides per ha (L/ha) in relation to slope inclination (Boll 2002).

Slope steepness map

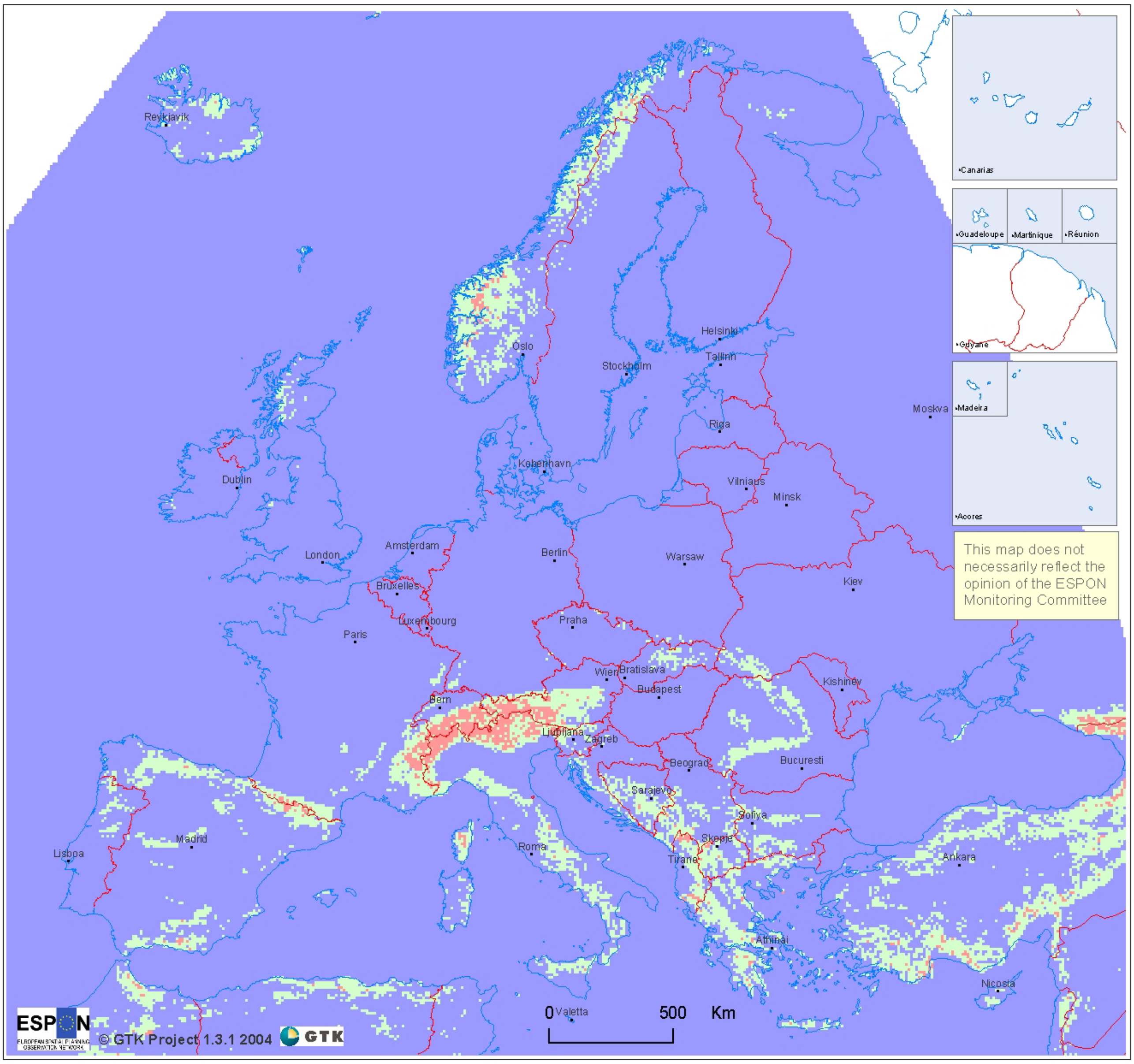
The slope steepness map (see map 4) is computed from USGS 1km digital elevation model and it is classified in three categories:

0°- 4°
4°- 15°
>15°

For the final report the slope raster map will be classified in NUTS 3 level by steepness and area values, similar to the SPESP report.

Although the physical cause of many landslides cannot be removed, geologic investigations, good engineering practices, and effective enforcement of appropriate land-use management regulations can reduce landslide hazards.

Slope steepness in Europe



Slope steepness (degrees)

- 0 - 5
- 5 - 12
- >12

Origin of the data: © EuroGeographics Association for the administrative boundaries
Digital terrain model © USGS
Source: ESPON Data Base

For the calculation of slopes the DTM of mesh 1km of the USGS has been used. Remote areas can be presented in the forthcoming hazard map based on NUTS 3 classification.

Map 4. Slope steepness in Europe

1.1.4 Hazards from maritime oil transport onshore oil storage and pipelines

Sources of the maritime oil pollution hazard

The driving forces for hazards from oil transport and storage are not only lying in the current demand for oil but also in future increasing demands. The current hazard of oil spills from maritime transport and pipelines is continuously increasing because world's industry and economy is still mainly depending on oil. In 2003, the world oil demand was expected to grow by about 1.2 million barrels per day. Worldwide the oil demand is projected to reach almost 119 million barrels per day by 2025, which would require an increase of world production of more than 42 million barrels per day over current capacity. The worldwide smallest increase is projected for Western Europe, currently it lies at 0.4 percent per year, from 14 million barrels per day in 2001 to 15.3 million barrel per day in 2025, with little or no increase in the United Kingdom, Germany, France, and Italy. Oil demand in Eastern Europe is projected to grow by 2.5 % per year, to 2.5 million barrels per day in 2025, resulting in an increase of 29 % of total energy consumption.

According to the International Energy Outlook 2003 (IEO2003), the decline in the North Sea production of crude oil is slowing down over the next decades; currently the production is of currently ca. 6 million barrels per day down to approx. 4.5 million barrels per day. With a moderate decline in the North Sea production, Western Europe is expected to import increasing amounts from Persian Gulf producers and from OPEC member nations in both northern and western Africa.

Due to limited data resources this chapter shows the hazard of maritime oil transport in general terms and displays terrestrial oil transport in pipelines and terrestrial oil handling and storage. Dangers along maritime shipping routes, river, rail and road transport are not taken into account hence they can happen virtually everywhere in the European territory. Eventhough oil spills are percepted to be confined to navigation corridors and cause significant damage on local beaches, fish and bird populations along close shores, the Prestige accident that happened in November 2002 occurred off its original shipping route. The half-wrecked ship was pulled out of a harbor area out into the open sea by Spanish authorities were it finally broke into pieces and caused the devastating oil spill along Portuguese, Spanish and French coastal areas. Hence this kind of political decisions can lead to further catastrophes in the future it is not feasible to develop hazardous oil spill zones along the main shipping routes.

Table 3. Risk typologisation based on the oil transport hazard

Criteria	**Values**
Probability of occurrence *P*	High
Certainty of assessment of *P*	Low
Extent of damage *E*	Low-High
Certainty of assessment of *E*	Medium to high
Ubiquity	Local to overregional
Persistency	High removal period
Irreversibility	Medium to high
Delay effect	Medium to high
Mobilization potential	Medium to high political relevance

Oil pollution and contamination

The two main sources of oil pollution in the marine environment are from maritime transport, as well as refineries and offshore installations. Oil enters the marine environment from a number of sources. The hazards from oil transport do not only originate from large oil spills but is a current threat caused by smaller accidents and dispersion of oil into the environment. The total quantity of dispersed oil discharged into the maritime area (resulting from discharges of production and displacement water, and from accidental spillage) was 9 420 tones in 2000 and 9 317 tones in 2001. An accidental spill in 2000 partly explains the increase between 1999 and 2000. The decrease in 2001 hides the fact that total quantity of dispersed oil discharged by production and displacement water increased slightly over these years. The overall picture of oil pollution is highly fragmentary and reliable aggregated data sets showing general trends are not available. Offshore activities and refineries are an important source of oil pollution for the North Sea, but are of far less significance for the Baltic and Mediterranean Seas where offshore activity is much lower. The volume of oil transported by ships in the Baltic Sea will increase and is estimated to reach twice its 1995 level between 2005 and 2010, increasing the probability of spills. Oil spills from aerial surveillance in the French and Italian Mediterranean areas exceed 200 occurrences per year. However, the data are available only at national level and not commonly reported under the Barcelona Convention. There is no other reporting for the Mediterranean Sea, where there are about 40 oil-related sites (pipeline terminals, refineries, offshore platforms, etc.). Much of the Black Sea is severely polluted with oil, especially near ports and river mouths, probably because of heavy boat traffic in the Black Sea; oil pollution along shipping lanes is especially heavy and is suggested to be caused by de-ballasting and bilge discharges.

Data since 1987, currently under revision, suggest that discharges from offshore activities and refineries add up to about 30 % to the total from tanker oil spills of greater than 7 tones. Oil spills in marine areas can cause surface contamination and smothering of marine biota. In addition, chemical components of the oil can have acute toxic effects and long-term cumulative impacts. Marine life may also be affected by clean-up operations, either directly or through physical damage to marine and coastal habitats. Natural recovery is possible but the time required depends on the size of the spill or discharge. In the case of large accidental spills, expensive clean-up operations and programs to save marine sea birds and sea life are required. The impacts of accidental spills can be catastrophic on coastal zones that are often sites designated for their high ecological quality. Spills can also have severe repercussions for tourism, mariculture and fisheries in affected areas.

Large spills occurred off Portugal in 1989, Italy in 1991, the UK and Spain in 1992, the UK in 1993, Portugal in 1994, the UK in 1996, and the Prestige oil spill off the coast of Spain in 2002. Pollution by oil spills worldwide has been reduced by 60 % since the 1970s. In the EU, major accidental oil spills (>20 000 tonnes) still occur at irregular intervals. Oil spills from shipping – illegal discharges or from accidents - are an important source of pollution in sea areas. Worldwide estimates of oil pollution of sea areas show that transport contributed 22 % to total spills in 1973 (1.3 million tonnes out of 5.9 million tonnes) and 34 % in 1981 (1.1 million tonnes out of 3.2 million tonnes). Between 1973 and 1981, the quantities spilled during accidents were always below those spilled during operations. The latest estimate was made in 1989: transport-related oil spills in that year (0.387 million tonnes) were only a third of the 1973 estimate. Aerial surveillance of oil spills is conducted over the North Sea, Baltic

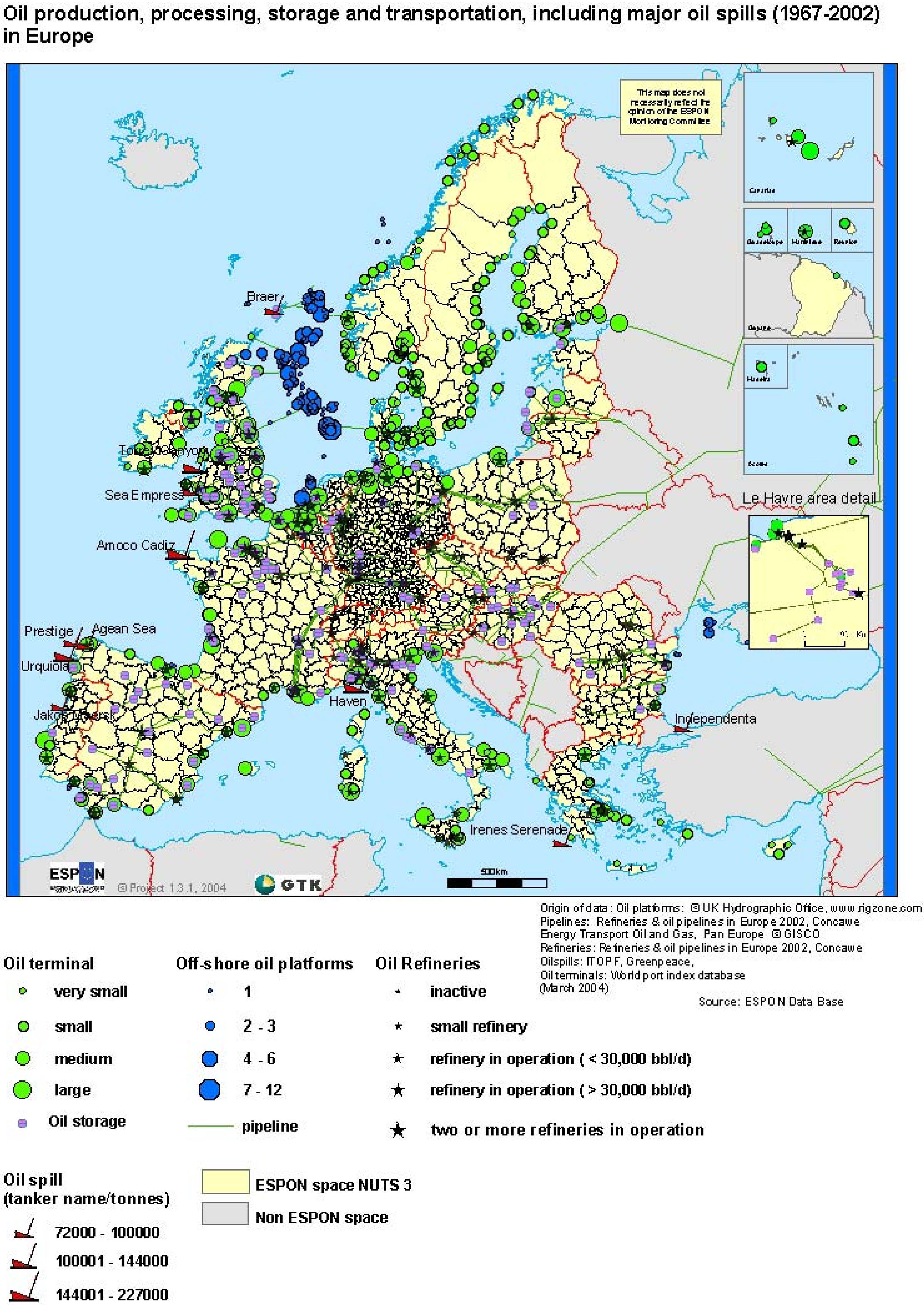
Sea and Mediterranean (International Maritime Organisation (IMO) "special areas") in order to prevent and detect illegal discharge of oil from ships and platforms (EEA 2004).

The oil transport and storage hazards map

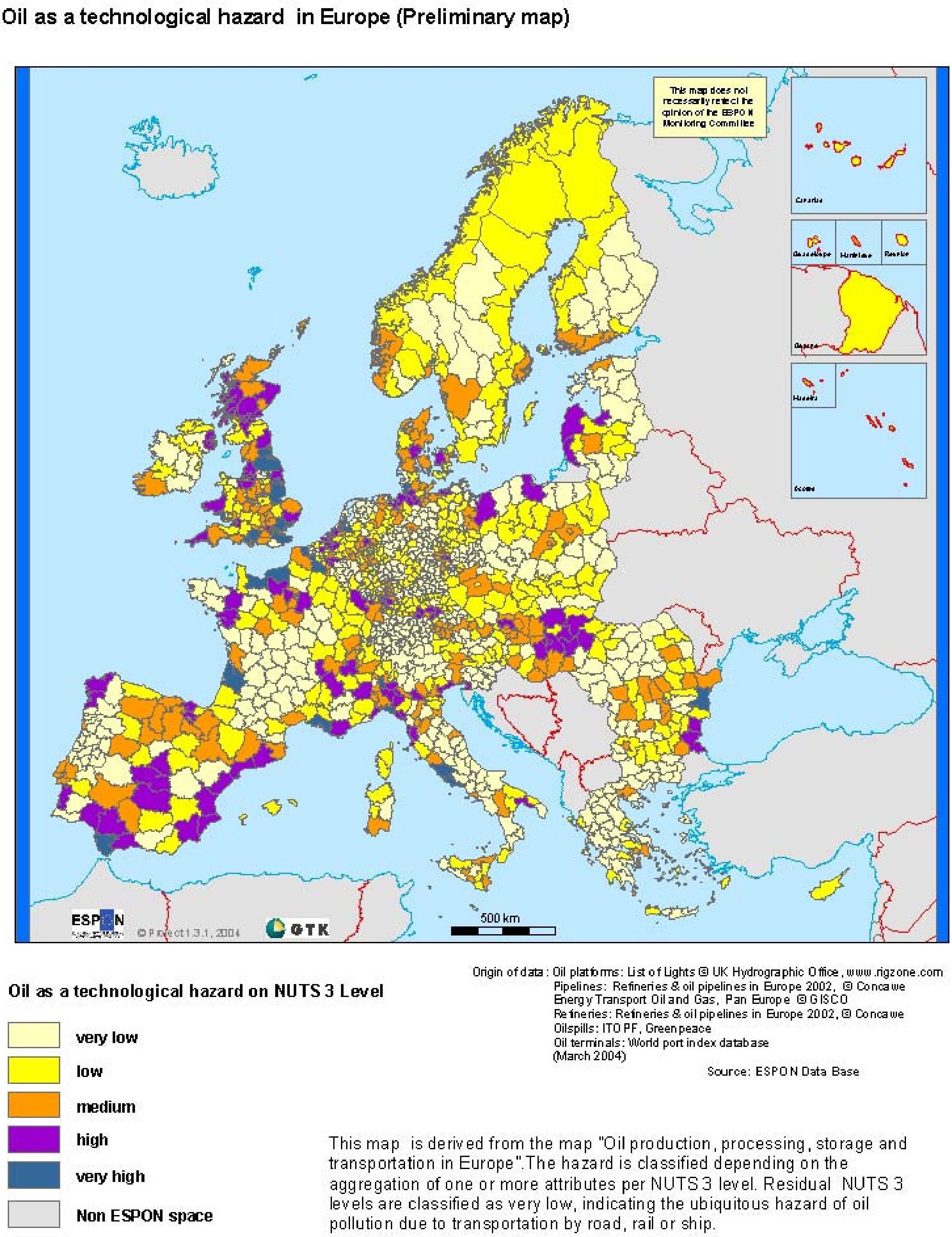
The overview map on oil production, processing, storage and transportation displays the main European maritime oil terminals, refineries, storage tanks and pipelines, offshore oil platforms and major oil spills caused by tankers. The hazard map on oil transportation, storage and processing is produced on NUTS levels, and therefore oil platforms and shipping routes are no eligible source of information. The risk of terrestrial oil pollution by other means of transportation (e.g. road) than pipelines cannot be displayed because it is ubiquitous among the dense European infrastructure (see spatial filter for hazards, 1st ESPON Hazards Interim Report). These NUTS 3 levels are therefore classified with a very low hazard. The main maritime transport routes can be estimated by the size of the oil terminals.

The hazard map assumes that the larger an oil terminal is, the higher is the hazard, due to the higher amount transported oil. The same principle accounts for refineries and pipelines. The hazard map categorizes the oil terminals and refineries into classes according to their size. Data on the size of oil storage and pipelines was not available, therefore the oil storage and the pipelines are counted as "class 1".The classification in the oil transport and storage map differs between attributes because lacking information, therefore the other attributes (oil terminals and oil refineries) have to be count also as “class 1” for the hazard map. The resulting hazard on NUTS 3 level is then determined by the aggregation of one or more attributes per NUTS3 level with the following classification:

Very low: NUTS 3 levels without any installations, but with a ubiquitous hazard of oil pollution due to transport
Low: NUTS3 level with at least one attribute
Medium: NUTS3 level with two attributes
High: NUTS3 level with three attributes
Very high: NUTS3 level with four attributes



Map 5. The overview map on oil production, processing, storage and transportation in Europe



Map 6. Preliminary map on oil as a technological hazard in Europe

1.1.5 Further data search

One of the best example of competent data precision and coverage is the earthquake indicator based on the data produced by Global Seismic Hazard Assessment Project (2nd ESPON Hazards Interim Report, p. 90). The project was launched in 1992 and ended in 1998 producing a global homogeneous indicator on the earthquake hazard that is easy to download from the website. On the other hand, for example, the flood hazard map is more complicated because the main flood data source (Dartmouth Flood Observatory) is still under reconstruction and does not yet cover the entire time period 1985-2002. The main data gaps were already described in detail in each single hazard map chapter.

Moreover, it is important to keep in mind that the results generated on NUTS 3 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. The data from different datasets can still be improved both in terms of precision and completeness. The ESPON Hazards project has sent data requests to all the below mentioned sources but has, so far, not received any answers:

Table 4. Possibel future hazard indicators and data sources

Natural and technological hazards	Hazard indicators	Economic vulnerability	Social vulnerability	Ecological vulnerability
Natural hazards				
Floods	Large river flood event recurrence (2IR 3IR) The share of rivers in NUTS 3 level area (4IR) Highest 7-day precipitation (3IR)			Flooding on the contaminated lands, e.g. chemical plants
Droughts	Negative deviation of precipitation (3IR) Average dry spell length (precipitation <0,5 mm) (3IR)	Areas economical dependent on agriculture, except wineyards (4IR) Areas energy production is dependent on hydropower (Project 2.1.4) (4IR) Nuclear power plants' cooling system (4IR)		
Forest fires	Number of forest fires Burnt area Forest areas (4IR)	GDP/capita (4IR)	Dependency ratio (4IR)	
Winter storms	Approximate probability of having winter storms 2IR) Changes in annual wind speed (3IR)	GDP/capita (2IR)	Dependency ratio (4IR)	
Landslides/ avalanches	Slope steepness (3IR) Geological map Peak ground acceleration (2IR)	GDP/capita (4IR)		

	Heavy precipitation (>10 mm) (3IR) Extreme precipitation (>25 mm) (3IR) Highest 7-day precipitation (3IR)			
Earthquakes	Peak ground acceleration (2IR) Earthquake casualties (4IR)	GDP/capita (2IR)	Dependency ratio (4IR)	
Volcanic eruptions	Known volcanic eruptions (2IR) Volcanic activity (4IR)	GDP/capita (2IR)	Dependency ratio (4IR)	
Extreme precipitation (heavy rainfall, hail)	Highest 7-day precipitation (3IR) Heavy precipitation (>10 mm) (3IR) Extreme precipitation (>25 mm) (3IR)			
Extreme temperatures (heat waves, cold waves)	Number of warm days (Tmax >25°) (3IR) Number of tropical nights (Tmin > 20°) (3IR) Number of freezing days (Tmax <0°) (3IR) Number of frost nights (Tmin <0°) (3IR)			
Technological Hazards				
Hazards from nuclear power plants	Location of nuclear power plants (2IR) The distance from nuclear power plants (2IR)	GDP/capita (3IR)		
Hazards from production plants with hazardous production processes or substances	Location of chemical plants			
Hazards from hazardous waste deposits / storage of nuclear waste	Location of hazardous waste deposits Location of nuclear waste storages			
Hazards from the marine transport of hazardous goods	Location of oil terminals, refineries, storages (3IR) Location of oil rigs (3IR) Location of pipelines (3IR)	Risk of oil spills on coastal areas economical dependent on tourism (4IR)		Risk of oil spills on coastal areas' nature protection and valuable nature areas (4IR)
Hazards from large dams	Location of large dams			

Black = Developed
Blue = In preparation / planned
Red = No feasible data resources available to the project at the moment stage
White/empty box = Not feasible
(#IR) = Number of ESPON Hazards interim report

1.2 Three dimensions of vulnerability

In the course of the ESPON Hazards project, the diversity and complexity of the term vulnerability has revealed that there is a need for further discussion and clarification of the term. In this chapter, vulnerability is discussed from three different aspects and two new dimensions of vulnerability are introduced. The idea of acknowledging different dimensions of vulnerability is not new, and a similar trisection of vulnerability (economic, ecological and social) has been used e.g. for considering the vulnerability to hazards of the Small Island Developing States (SIDS 2003). For the purposes of the Hazards project the three dimensions of vulnerability are connected to the European scale with the help of maps. At the end of this chapter a suggestion for an integrated vulnerability map is presented.

Approaching regional vulnerability

There exists an array of different definitions for vulnerability (for an attempt to draw these together see Cutter 1996). In the Hazards project's glossary (2nd ESPON Hazards Interim Report, p. 18) vulnerability is defined as the "degree of fragility of a person, a group, a community or an area towards defined hazards. [Vulnerability is] a set of conditions and processes resulting from physical, social, economical and environmental factors, which increase the susceptibility of a community to the impact of hazards. Vulnerability is determined by the potential of a community to react and withstand a disaster, e.g. its emergency facilities and disaster organisation structure (coping capacity)."

According to Cutter (1996:530), disagreements on how to define vulnerability are often related to the origins of vulnerability. While vulnerability is broadly defined as "potential for loss", it is not clear what type of loss and whose loss we are describing. Cutter distinguishes first of all *individual* vulnerability, which describes the personal or individual potential for loss. *Social* vulnerability includes the potential of social groups, classes or society at large for losses from hazard events. In the case of *biophysical* vulnerability, the potential for loss is derived from the interaction of society with biophysical conditions. This affects the resilience of the environment to respond to a hazard or disaster, as well as the adaptation of society to changing conditions.

Cutter (1996:530) distinguishes three distinct themes in vulnerability studies in the hazard literature: vulnerability as risk/hazard exposure, vulnerability as social response and vulnerability of places. Vulnerability of places combines physical risk and social response within a specific area.

Cutter (1996, 2003) has introduced a place-based model of vulnerability in order to pin together the diverse elements that contribute to the overall vulnerability of places (see figure 2). Here, hazard potential is created by a combination of risk and mitigation. It is filtered through the geographic context and the social fabric of society and either moderated or enhanced by them. In this model, biophysical and social vulnerability together form the overall vulnerability of a region. Cutter's social vulnerability includes the susceptibility of social groups, classes or society at large to potential losses, whereas biophysical vulnerability includes the resilience of the environment as explained above.

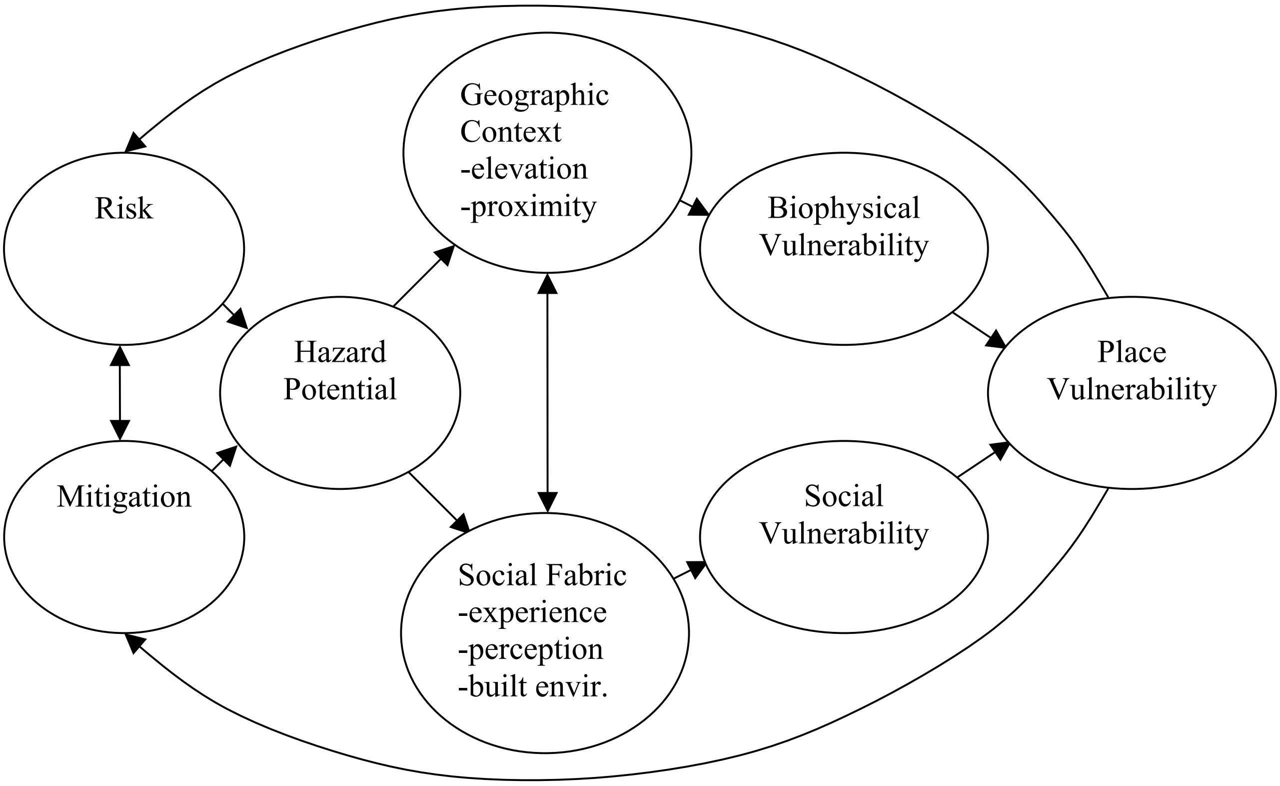


Figure 2. The Hazards-of-place model of vulnerability (Cutter et al. 2003).

Cutter's model is interesting for the Hazards project, although her definitions of risk and hazard potential differ from the definitions that have been used in this project. According to Cutter (1996:536):

- Risk is "the likelihood of occurrence (or probability) of the hazard". This definition corresponds with what the project defines as hazard potential (= a hazard closer described by magnitude and frequency).
- Hazard potential= "Risks combine with mitigation (efforts to reduce risks such as planning, prior experience) to create an overall hazard potential". This corresponds to some extent with the Hazard project's definition of risk: "A combination of the probability or frequency of occurrence of a defined hazard and the magnitude of the consequences of the occurrence" (see Glossary, First ESPON Hazards Interim Report).

In a current report of the UNDP Bureau for Crisis Prevention and Recovery (UNDP 2004:11), human vulnerability is defined as "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". The report introduces a Disaster Risk Index (DRI), which enables the measurement and comparison of physical exposure to hazard, vulnerability and risk between countries. Here, physical exposure refers to the number of people located in hazardous areas (risk of death) (UNDP 2004:31). Contrary to the Hazards project, population density is not seen as an indicator of vulnerability, but as a condition for a disaster risk to exist. Vulnerability is used to explain why, with a given level of exposure, people are more or less at risk. In the DRI, vulnerability refers to the different variables that make people less able to absorb the impact and recover from a hazard event. These also include variables that increase the severity or frequency of a hazard. The definition of vulnerability in the DRI is thus far more extensive than the commonly used "potential for loss".

Vulnerability in the Hazards project → *Economic dimension of vulnerability*

In the 2nd ESPON Hazards Interim Report regional vulnerability in Europe is measured as the combination of GDP per capita and population density (equally weighted 50:50). With this combination it is possible to recognise the economic *damage potential* of a region, as well as the potential exposure of people. This definition of vulnerability is from now on called the economic dimension of vulnerability. Similarly, the term vulnerability index will be replaced by the term economic vulnerability index in the project.

Since the economic dimension has received the main attention in the project so far and the current risk maps represent this dimension, the values this dimension represents must be made clear. The economic dimension of vulnerability represents the risk to production, distribution and consumption, as well as to human lives. 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. Cross (2001), on the other hand, argues that people in small cities and rural communities are more vulnerable than people in megacities because of weaker preparedness. The economic dimension fails to acknowledge this preparedness or coping capacity as one determinant of a region's vulnerability.

The economic dimension of vulnerability offers an interesting approach to the issue of regional vulnerability, especially from the insurance company point-of-view, but it should not be used as the only determinant of a region's vulnerability.

Maps

In addition to the already existing maps on the economic dimension of vulnerability, sample maps that portray aspects that the basic economic vulnerability index cannot acknowledge will be made. Possible sample maps include:

- *Oil spills: the threat to different sectors of economy, e.g. tourism.* Here the percentage amount of tourism of the GDP of a certain coastal region would allow to see 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. Such a map would also enable the integration of tourism into the project. Oil spills are also a relevant risk to fishing industry. Eurostat Regio database contains "compensation of employees at NUTS 2" indicator divided in 23 different NACE branches. The Oil-tourism-fishery map could be done by choosing branches like fishing, hotels and restaurants per millions of euro and show them together with fishing areas and oil transport routes. Another tourism related indicators could be the following (Eurostat Regio):
    - t06_2r Arrivals of non-residents - NUTS 2 - annual data

- t07_2r Nights spent by non-residents - NUTS 2 - annual data
- t_3r Number of establishments, bedrooms and beds - NUTS 3 - annual data

- *Floods vs. land use: in what kind of areas do floods mostly occur?* It would be interesting to see where floods most easily occur in respect to land use type. However, it is not possible to make such a map on the European scale. The mapping scale difference between *number of large flood events* map (ca. 1:10 million) and Corine land cover (250m x 250m) is too large. Therefore simple method (superimposing two data sets) would lead to great misunderstandings. The method would work better in case study areas with more precise flood prone area data.

- *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. The vineyards should be excluded because droughts do not harm them. The data is available on NUTS 2 level.

A new dimension for the hazards-project → *Social dimension of vulnerability*

The social dimension of vulnerability acknowledges the vulnerability of people, and the emphasis is on the *coping capacity* of different social groups. Blaikie *et al.* (1994:9-10) argue, that the most vulnerable groups of people are those, who find it hardest to reconstruct their livelihood after a disaster (see also UNDP 2004). Blaikie *et al.* further emphasize social forms of disaster explanation, and 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 (environmental justice). Tobin & Montz (1997:32) stress the importance of coping capacity in defining the vulnerability of regions, and according to them vulnerability represents a combination of risk and response.

Cannon *et al.* (2003) see social vulnerability as a complex set of characteristics that include a person's initial well being, 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". In the Hazards-of-place model of vulnerability, Cutter *et al.* see social vulnerability as a combination of social inequalities and place inequalities. *Social inequalities* are "those social factors that influence or shape the susceptibility of various groups to harm and that also govern their ability to respond". *Place inequalities* are "those characteristics of communities and the built environment, such as the level of urbanization, growth rates, and economic vitality, that contribute to the social vulnerability of places".

The social aspects of vulnerability have largely been ignored in vulnerability research mainly due to difficulties in quantifying them. However, the social science community has widely acknowledged some major factors that influence social vulnerability:

- Lack of access to resources (including information)
- Limited access to political power and representation
- Social capital (including social networks)

- Beliefs and customs
- Building stock and age
- Frail and physically limited individuals
- Type and density of infrastructure and lifelines (Cutter *et al*. 2003).

There is no common agreement as to which variables should be used to measure social vulnerability, although socio-economic status, age, race and gender are among the most commonly used. Cutter *et al.* (2003) have constructed a Social Vulnerability Index (SoVI) to measure social vulnerability to environmental hazards in the United States. With the help of factor analysis Cutter *et al.* reduced the data of as many as 42 variables to form 11 factors, which explained about 76 percent of the variance of social vulnerability among the U.S. counties. For the purposes of the Hazards project, indicators measuring coping capacity were considered important, but also the damage potential aspect was incorporated into the social dimension in the form of population density. The amount of indicators was kept as small as possible. The following indicators were chosen:

- *Population density:* Measures damage potential as in the amount of people in danger.
- *National GDP/capita:* The presumption is, that coping capacity is weak in poor countries and strong in rich countries. It is further presumed that there are no marked differences in coping capacity inside a country.
- *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. Statistics Finland defines dependency ratio as the sum of unemployed people and the people outside workforce divided by the number of employed people. ESPON project 1.1.4 defines dependency ratio as total population in relation to the population in the ages 20-64, where the dependent population groups are the young age groups (0-19) and the older age groups (65+). The 1.1.4 definition seems to suite our purposes better, although it would make even more sense to measure the share of population in the ages 15-64 for measuring dependency ratio.
- *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. Education rate here will measure the percentage share of people who have received a particular level of education. Data availability is still unclear, although Project 1.1.4 considers educational level as an indicator of causal and effect processes and will assess and elaborate it further.

The social vulnerability indicators, excluding population density, measure those characteristics of a region that make people less able to understand the risk or recover from a hazard event. They do not measure the scale of damage directly, but rather how the community or region will be able to prepare and respond to a hazard. These indicators point out social and place inequalities. Possible further coping capacity related indicators like medical infrastructure, technical infrastructure and share of budgets spent on civil defense will be looked into.

How should the chosen indicators be weighted? Population density and national GDP will here be given the percentage share of 35 each. Dependency ratio and education rate will then both get the share of 15%. The reason for this weighting is, that dependency ratio and education rate haven't been used as vulnerability indicators often and it is important to test their feasibility first. This weighting can seem arbitrary, but no matter how the variables are weighted, the outcome will be a mere example on how social vulnerability could be measured, just as in the case of economic vulnerability. In the future it would perhaps be possible to consider these indicators and their weighting more thoroughly by asking specialists for opinions in the case study areas. A first attempt to test the weighting of vulnerability indicators has been made by using the Delphi method in the case study areas (see Chapter 2).

Maps

The chosen indicators will be used in making maps that depict social vulnerability in EU 27+2 similarly to the economic vulnerability index. It is somewhat problematic to measure social vulnerability with the same three indicators for all hazards. Even if it is agreed upon that less well-off population groups are more vulnerable in the face of most hazards, it would be unsound to say that e.g. in a nuclear accident the poor people/regions suffer the most. Perhaps they have fewer options and resources to deal with the catastrophe after it has occurred, but in the face of such a hazard everybody is endangered likewise. UNDP (2004:32) 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. It needs to be discussed, whether social vulnerability maps can be made for every hazard.

A new dimension for the Hazards project → *Ecological dimension of vulnerability*

Ecosystem or environmental vulnerability and/or fragility are terms often used along with the term ecological vulnerability. 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).

According to Villa & McLeod (2002), there is no general agreement on how best to define environmental properties, such as vulnerability, or on how to calculate corresponding indicators. They point out, that even though environmental decision-making requires such quantification of environmental properties, it is not reasonable to base these decisions on measures that are too simplistic and often based solely on the most easily measurable indicators.

The Hazards project will not attempt to measure ecological vulnerability the same way economic and social vulnerability are measured, due to problems in finding suitable indicators for measuring the degree of ecological vulnerability in all NUTS 3 regions for all hazards. The fact that different hazards affect limited natural areas (e.g. forest fires and oil transport) and work in different scales (e.g. landslides and nuclear power plants) makes it impossible to find such indicators. It would also be difficult to consider ecological coping capacity or compare it between different regions. On a general level it can be said that robust environments are more resistant to hazards than fragile ones (e.g. marginal ecosystems in semi-desert areas), where even natural hazards alone (e.g. remaining dryness) can have a strong negative effect on the ecology of a region.

Maps

Due to the above-discussed methodological difficulties, no complete set of risk maps will be made for the ecological dimension of vulnerability. Nevertheless, individual sample maps will be made. First it needs to be considered how different hazards affect the environment. Kaly *et al.* (2002) define risk to the natural environment as "any events or processes that can cause damage". Although both natural and human events and processes can cause damage to the environment, Kaly et al. point out that natural hazards are mostly not included in discussions of environmental vulnerability. The reason for this is that natural events are considered normal, unless they are somehow caused or altered by humans. However, human actions can have a significant effect on natural hazards by inducing or altering them. On such occasions the environment often doesn't have the necessary methods to cope with the consequences. The following table lists the hazards selected for this project, and includes an evaluation of their possible damage to the environment and the anthropogenic effect in inducing them.

Table 5. The selected hazards and the evaluation of their possible damage to the environment and the anthropogenic effect in inducing them

Hazard	Damage to the environment	Anthropogenic effect in inducing the hazard	Relevance for the ecological dimension
Floods	Floods can threaten the environment if e.g. a chemical plant is damaged and pollutant spread over large areas.	The felling of trees can induce flooding. Soil sealing changes the normal hydrological cycle and can induce flooding.	+
Winter storms	Trees can fall down.	No known effects	-
Earthquakes	Local effects	No known effects	-
Volcanic eruptions	Local effects to the flora and fauna, global effects to the atmosphere (e.g. Krakatau, Pinatubo)	No known effects	-
Forest fires	Large areas of forests and vegetation can be burned.	Can be lit by humans.	+/-
Landslides	Local effects	Human activity, such as the felling of trees, construction works, blasting and traffic can induce landslides.	-
Drought	Vegetation can suffer in large areas.	Human activity such as selection of crops, deforestation and soil degradation can affect droughts.	+/-
Nuclear power plants	Flora and fauna can suffer in large areas	Generated by humans	(+) -
Oil transport	Threatens the coastlines and soils as well as rivers, lakes and the maritime ecosystem.	Generated by humans	+

The table above shows an estimation of the relevance of each hazard for the ecological dimension. The purpose is to assess which hazards would be most relevant and interesting as sample maps. The emphasis is on hazards, that have clear, large-scale impacts on the environment. Landslides are not considered relevant for the ecological dimension since they have only local effects. Nuclear power plants are not considered relevant here since they damage all life in their vicinity, not just the environment.

The sample maps will depict the impact chosen hazards can have on the environment. The maps will also make clear, that different hazards threaten different natural areas in Europe. Possible sample maps include:

- *Coastal 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. A risk map of oil spills to national parks and other enlisted natural areas is being developed.[1] Data: Corine land cover data, project 1.3.2. national parks etc.
- *Forest fires in forest areas*: data on forest areas in Corine-data, data on forest fires that have taken place is available only in Southern Europe, Germany an Finland. Large settlements could be made visible on the map.
- *Floods in respect to chemical plants*: The SPIRS database owned and maintained by JRC with information on major hazardous industrial establishments in Europe is not available for the Hazards project. The data requests have been ignored.

Further investigations – towards an integrated vulnerability map

The crucial question at this point is, whether it is possible to combine the different dimensions to create a comprehensive regional vulnerability. Having in mind the synthetic risk map as the most important and innovative approach of the Hazards project, an integrated vulnerability map on EU 27+2 level would be of great value. Such a synthetic approach is indispensable due to the project's spatially oriented perspective. Despite the fact, that there are still some methodological problems, which have to be solved for the final report, the project 1.3.1 will aim at such an integrated vulnerability approach.

The core idea is the integration of the economic and social dimensions of vulnerability. This enables the inclusion of coping capacity into the project not only in a qualitative way (like suggested in the First ESPON Hazards Interim Report, p. 93), but also quantitatively. The ecological dimension will have to be excluded from the integration due to the unique way different hazards affect the environment. Here follows a suggestion on how to create an overall vulnerability factor/indicator.

As both economic and social vulnerability use population density as a main indicator, it would make sense to use it as the core indicator of the overall vulnerability. It should be weighted by 50% (the corresponding vulnerability map already exists: population density in the EU 27+2 in five classes).

Concerning economic vulnerability, regional GDP/capita would be still an appropriate indicator. It would be counted by 25% (the corresponding map already exists: GDP per capita in the EU 27+2 in five classes). Population density and regional GDP/capita would together form the "economic part of the vulnerability map" (damage potential).

Concerning social vulnerability, the chosen three coping capacity relevant indicators (see chapter on social vulnerability) will be combined to create a joint coping capacity factor for the social vulnerability part (together 25% of the combined vulnerability, see figure below). The weighting of these indicators is not as simple as in the case of economic vulnerability. National GDP/capita (negative) would need to be weighted equally to population density as in the social vulnerability index, but here it is not possible without excluding the other coping

[1] Such a map may be considered inadequate, since it takes only those natural areas into account, which have been politically approved of as "enlisted natural areas". (The ESPON 1.3.2 project on natural heritage has an interest in broadening the definition of European Natural Heritage beyond the existing nature conservation areas.) From a practical operational point of view this may be the only feasible solution, however.

capacity indicators. Hence, national GDP/capita will be given the percentage share of 55, dependency ratio and education rate will both get a share of 15 and the remaining 15% will be left open for a possible new indicator. Together with population density, the coping capacity indicators will form the "social part of the vulnerability map".

As a result, the overall vulnerability would be composed as shown in the figure below. Both dimensions of vulnerability use population density as a core aspect, and the factors that determine either the social (coping capacity) or economic (damage potential) aspect of vulnerability are equally weighted.

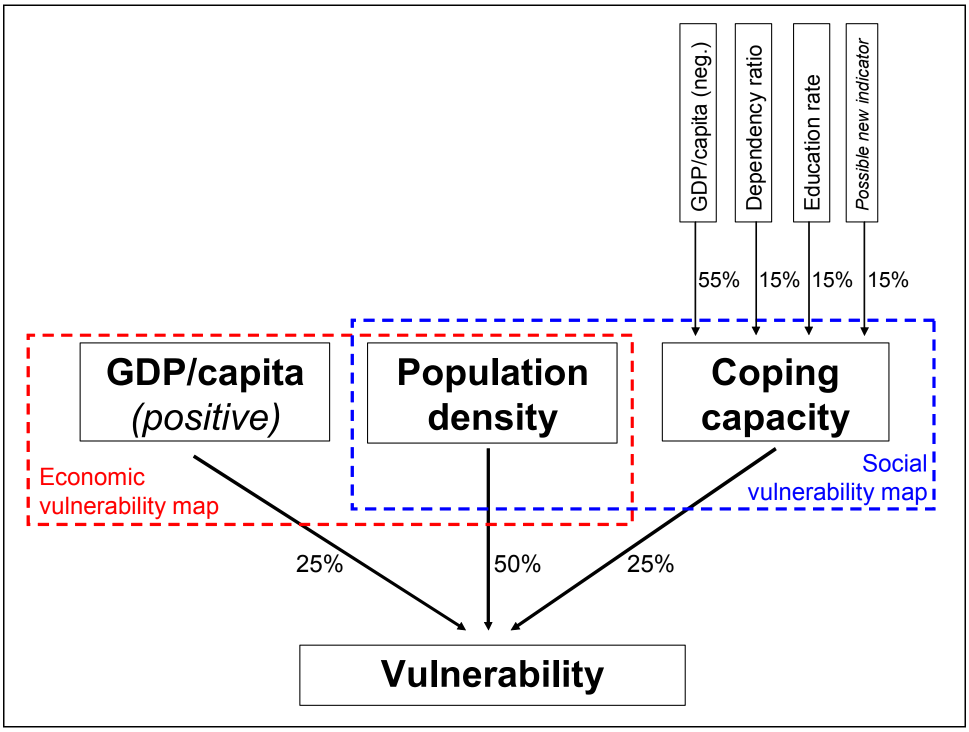


Figure 3. Towards an integrated vulnerability index. (ESPON Hazards 2004)

1.3 Strengths and weaknesses of the methodology

Main characteristics of the methodology

Before pointing at the strengths and weaknesses of the methodology, it would be useful to clarify some main characteristics of the applied methodology which have been subject of discussion.

By way of an addition of the hazard intensity class of a certain region and its vulnerability rate the risk level in this region will be examined. The outcome of this methodology is a **nine** risk classes matrix as a result of the addition process (1+1 to 5+5 respectively 2 to 10). Such a process is indispensable, because of the character of risk definitions as a mathematical function of economic vulnerability and hazard intensity.

One should understand the matrix diagonal from the corner lower down in the left to the upper corner above in the right as figured below:

Hazard Intensity	Degree of economic 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**

Figure 4. Matrix of nine risk classes.

Further, one should understand the ostensible 25 classes, respectively shades of the 9 basic colours, as an intermediate, explanatory step for the indication whether the risk is rather based on the hazard intensity or the vulnerability of an area.

The present risk map should integrate two contradictory efforts:

1. Figuring in a visible way the differences in risks between the NUTS 3 regions
2. Indicating whether the risk is rather based on the hazard intensity or the vulnerability of an area

As a result of the present discussion about the practicability of the used methodology, one could see, that these efforts are really incompatibly, of course in one aggregated map. In the consequence, the following way in dealing with the given methodological efforts will be proposed:

1. The present risk map, which focuses on the origins of the risk to indicate whether the risk is rather based on the hazard intensity or the vulnerability of an area.

2. A risk map with the nine risk classes, which concentrates on the given differences in spatial relevant risks. This map will be used as basis for the coming synthetic risk map and will be integrated into the coming reports.

Strengths

Synthetic risk approach

The approach that has been chosen in the ESPON Hazards project gives the opportunity to view all kinds of different risks and to generate a synthetic risk map for the selected natural and technological risks for the whole area of Europe. There is no comparable and plausible approach that has tried a synthetic approach like this one for such a large area and over such a variety of different risks so far. This synthetic risk approach was only possible by fulfilling two main prerequisites:

1. *Use of historical data* instead of trying to combine probability assessments because the latter depend on different specialised disciplines. Thus they are hardly comparable to each other and can not be synthesised.
2. *Use of a relative scale* instead of absolute values for probabilities or – as used in the project – for historical catastrophic events. This is important due to the fact that hazard potentials, damage potentials and their data are heterogeneous to a very high level and that it is impossible to compare and combine such data on an absolute scale/level.

Weaknesses

Weighting problem

As already mentioned in the Second ESPON Hazards Interim Report, the problem of weighting the selected risks is still not solved. Or, to be more precise, there is no way to scientifically determine an objective weighting of risks. The main reason is that the question of risk always is also a normative question which depends on certain social values that differ from society to society. Risk therefore can *not only* be discussed on a factual level. Further, the area of Europe is very large and heterogeneous which makes the setup of universally valid weighting factors for all risks an almost unsolvable task. These are the reasons why – in the first step – no attempt has been made in the ESPON Hazards project to weigh any of the indicators (see argumentation in the Second ESPON Hazards Interim Report, Chapter 1.3.5, p. 75). All indicators are weighted equally which guarantees the highest degree of transparency on the way to develop a synthetic index of risk.

Nevertheless, despite all scientific objections, it is – from a political point of view – of great interest to introduce a certain form of weighting of risks into the methodology. This may finally lead to the *development of an application tool* to individually change the weighting factors for the selected risks. This will have three main advantages:

1. From a *European viewpoint* it can be illustrative to see how the total risk changes in dependency of different weighing factors for the selected risks. This “playing with the data” can illustrate how the methodology works and it can simulate the normative

aspect of risks because the weighting of risks is nothing other than the methodological translation of "real life" risk perceptions.

2. From a *national or regional viewpoint* the weighting of risks offers the possibility to fade out those risks that are of no relevance in that certain country or region (like volcanoes in Finland). This leads to a more realistic picture of the total risk within one region.
3. From an *overall political viewpoint*, an application tool can also simulate on the one hand differences in the risk perception between societies and regions and on the other hand changes in risk perceptions within time (for example, the risk from nuclear power plants may be either regarded much higher or much lower in the future which will consequently lead to a higher or lower total regional risk).

Both, the difficulties in weighting the hazard as well as the advantages of weighting them are obvious. So it seems to be fruitful for the ESPON Hazards Project to find a solution to this dilemma. One solution could be to normatively determine weighting factors which are derived from a combination of existing data of past catastrophes and data about probability assessments of possible catastrophes (for the "Natural hazard index for megacities", Munich Re suggests to weigh the two components "average annual losses" [AAL] and "probable maximum loss" [PML] by a share of 80:20, which of course, also is a normative decision – and also has the problem of determining probable maximum losses for very infrequent catastrophes; see Munich Re 2003, p. 32 ff.).

Another possible solution is the application of the *Delphi method* for determining weighting factors for risks. This method asks experts which hazard has, according to their point of view, a higher or lower relevance in a concerned area. The basic idea behind this method is the creation of a maximum level of agreement between the experts. The method works as follows:

1. In a first questioning, all experts will be asked for their opinion. They have to allocate special percentages for each hazard up to a sum of 100%.
2. The second questioning will inform all experts about the different estimations of all other participants. Normally, those experts, whose opinions differ more or less from the meaning of the majority, change their estimation.
3. The same process as mentioned before will be repeated once more. Afterwards, hopefully a higher level of agreement in weighting the different hazards will be reached.

This method has been applied in the case study areas (see chapter 2) because they are, in contrast to the whole area of Europe, more or less homogeneous (homogeneity is a prerequisite for the application of the Delphi method). The regional application implies that only those natural and technological hazards are taken into consideration that really exist in the studied region. Non-relevant hazards had to be left out because they falsify the process of the method. "Delphi" helps to find out (a) significant differences between the weighting factors of risks in different regions and (b) offers an adequate decision support tool.

At a later stage, this method could be applied to weight hazards in the entire European territory (although large differences of hazard occurrences in Europe will not make this an easy task). The goal would be to ask experts all over Europe which hazard has, according to their expert opinions, a higher or lower relevance in a European perspective.

2 APPLICATION AND REVIEW OF WEIGHTING OF RISKS IN CASE STUDY AREAS

2.1 Background

The second ESPON Hazards Interim report presented a number of hazard maps detailing different degrees of hazard intensity and maps of potential risk presenting a combination of hazard intensity and vulnerability in European NUTS 3 level areas. Those maps gave an overview of risk in the studied European territory. However, the methodology backing the maps only allows a European wide view and does not contain sufficient information to facilitate risk bound approaches of spatial planning at different spatial levels.

It is thus inevitable to advance the methodology towards a tool allowing to form an information basis for planning activities at regional levels. The proposed approach in the first phase presented below considers discrete regions. The focus is laid on the assessment of the inner-regional risk potential by a) drawing the regional risk profile and by b) elaborating aggregated risk maps for sub regional levels of the region of interest.

In this approach a more or less impartial risk analysis is combined with subjective weighting factors of expert groups to advance the result in terms of risk assessment. There are two reasons to do it this way: First, the subjective component of risk perception is considered, which is an important component of risk assessment (Greiving 2002). Second, the aggregation of risks allows the inner-regional comparison of sub regions in terms of the total risk potential to more easily determine focal points of strategic planning.

In the following weighted risk scores shall be used to draw a 'closer to reality' picture within the regions. Weighting factors, determined by experts groups using the Delphi method, will be combined with data from the risk analysis. The risk factors are 'population density' and 'DGP per capita' (also individually weighted) at sub regional level in the case study areas. This approach will not resolve the problem of comparativeness of obtained data between the regions as the weighting factors are only valid within the region itself but not in relation to other regions.

The approach has the assumption that any region has its individual 100 % hazard potential. This hazard potential is formed by a totality of all hazards relevant for the area. Depending on the frequency of reoccurrence, the expected hazard intensity and public perception, each hazard has a share in the total 100% hazard potential. By combining the weighted hazard potentials with vulnerability indicators at sub regional level the aggregated risk of sub regions is determined. It is important to emphasise once more that this approach is applicable only for inner-regional purposes that are relevant for spatial planning. The results obtained for different case study regions can not be compared on a European level.

2.2 Methods

Determination of vulnerability and risk

The first ESPON Hazards Interim Report proposed a simplified methodology for the determination of vulnerability, and based on this the risk of regions. Following this vulnerability is the combination of damage potential and coping capacity. Risk is then the combination of hazard potential and vulnerability.

Vulnerability = Damage potential / Coping capacity
('/' meaning a decrease by which formula ever')

Risk = Hazard potential x Vulnerability
('Hazard potential' being determined by the combination of 'frequency' and 'magnitude')

In the present risk analysis (the second ESPON Hazards Interim Report) the factor 'coping capacity' has been let out so far due to methodological difficulties. Also the third ESPON Hazards Interim Report (ESPON Hazards 2004) uses 'Damage potential' only in its vulnerability assessment. Though this may distort the comparability between the regions of the European Union it allows a first methodological test providing a first general view on the situation within the regions.

Table 6. Indicators for Hazard potential and Vulnerability (1st ESPON Hazards Interim Report)

Hazard indicators (weight 50:50)
Frequency Magnitude

Vulnerability indicators (weight 50:50)
GDP per capita Population density

As far as GDP per capita and population density are concerned reference values from the European Union play an important role for the classification.

Table 7. European reference values for the indicators GDP per capita and population density

Degree of vulnerability (damage potential)	**GDP per capita**		**Population density**	
	classes** (EU-average = 100)	**value**	**classes**** (EU-average = 100)	**value**
I	< 50	< 10307	< 25	< 30
II	50 - 75	10307 - 15460	25 - 100	30 - 118
III	75 - 125	15460 - 25766	100 - 200	118 - 236
IV	125 - 175	25766 - 36073	200 - 500	236 - 590
V	> 175	> 36073	> 500	> 590
EU 15 (100%)*	**20.613**		**118**	

*European Commission 2000
**Classes as proposed in the 2nd ESPON Hazards Interim Report

2.3 Weighting the risk – the Delphi method

The method was developed in the middle of the 20th century as a tool enabling forecasts about uncertain issues. The Delphi method may be characterised as a method for structuring a group communication process so that the process is effective in allowing a group of individuals, as a whole, to deal with a complex problem (Linestone & Turoff 2002). The original objective was to "obtain the most reliable consensus of opinion of a group of experts ... by a series of intensive questionnaires interspersed with controlled opinion feedback" (Dalkey & Helmer 1959).

As a tool designed to provide expert-opinion on uncertain issues the Delphi method has also found its way into the area of "classical" management science and operations research where there is a growing recognition of the need to incorporate subjective information (e.g. risk analysis) with relation to complex problems facing society (Linestone & Turoff 2002).

Risk analysis at the moment is an issue of uncertainty which still has to rely on subjective opinions. The Delphi-method offers an applicable tool to be introduced in the process of risk assessment in the case study regions to prove its appropriateness for the issue. In the following three full applications in case study regions of the ESPON 1.3.1 project are presented.

2.4 Application in case study areas

The goal of the Delphi application is to draw an exemplary risk profile for each case study region by weighting hazards as well as vulnerability indicators. The method has been adopted for its application in case study areas presented in the second ESPON Hazards Interim Report except for the region Andalucia. Annex 1 presents additionally a Swiss case study. The case study regions represent different administrative levels with NUTS 3 as reference level of detailing.

The application of the tool takes place in the following steps:

1. Choice of experts
2. Preparation of the tool (hazards and indicators)
3. Application of the tool with the experts
4. Summary and description of results
5. Transformation of results into regional maps

From the case study regions a more or less homogeneous group with relation to spatial planning and risks is chosen. This step is the most complicated since experts for spatial planning and risk assessment are rather rare and it has been tried to obtain a group of experts being as close as possible to both topics. It is self understanding that the lack of ideal experts is on the one hand also compromising the results of risk assessment. On the other hand, however, this is exactly the reason why 'Delphi' was chosen. Several consultations of the expert group will allow to come as close as possible to the believed situation. The identical tool has been applied by each case study partner.

One output from the regional risk assessment is the production of regional risk maps as a basis for regional and local sectoral and comprehensive planning. For each case study area all hazards are considered for the aggregation.

Transformation of results

In a <u>first step</u> a *weighted hazard estimation* is realised by the combination of obtained Delphi results and the expected hazard intensity on NUTS 3 level. However not for every hazard scientifically based information about the expected intensity is available (some have been introduced in the second ESPON Hazards Interim Report). The missing values have to be estimated relative to the existing data with experts help. The formula for the combination of Delphi results with hazard intensity is:

Hazard potential

=

Delphi result for each hazard x hazard factor

The hazard factor is the multiplier formed from the hazard intensity classes as described in Table 8.

Table 8. 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

As a result the aggregated hazard scores are added to obtain the aggregated hazard class for the region. The expected outcome (sum of all hazards potentials) will deliver 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. The received value can then be classified according the 5 classes scale of ESPON Hazards.

Table 9. Classification of the aggregated hazard

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

In a <u>second step</u> detailed risk maps for each case study region are approached and the obtained hazard value is combined with the vulnerability (respectively damage potential). Vulnerability indicators, population density and GDP per capita are also individually weighted in the scope of the Delphi application. The obtained weighting factors are used in the calculation of the final vulnerability class.

To achieve more detailed views for spatial planning purposes, available data on vulnerability shall be applied lower NUTS levels, whereby NUTS 5 level should be the perspective for further risk assessment in regional planning.

2.5 Application reports

2.5.1 Planning region Oberes Elbtal / Osterzgebirge (Dresden Region)

Hazards and indicators

Despite the fact, that the Dresden Region is predominately affected by some hazards mentioned in Delphi methodological tool, the experts were asked to state their opinion in regard to all the relevant hazards considered within this project. The results are presented in the section below. In addition, experts were asked to use the economic vulnerability indicators on GDP per capita and population density (see chapter 1.2) and also to suggest new one's relevant for the case study area, including possible weighting factors.

Experts

The expert group chosen for the Delphi test contained seven experts from five different institutions:

- State Ministry of Environment and Agriculture
- State Authority for Environment and Geology
- Regional Council
- Regional Planning Office
- The Institute of Ecological and Regional Development

A framework condition for the choice was that no systematic risk assessment is currently being conducted in spatial planning at neither administrative level. As a result also regional planning does not contain systematic risk assessment. It thus was challenging to find experts that have a good overview over the case study area and are (or have until recently been) working in the area of spatial planning and/or hazards. It is true that there is no perfect participant being expert for the case study area, spatial planning and risk assessment all at once. However, we believe that a good combination could be found to produce as good results as possible by the use of the Delphi method.

Results

Results were obtained from an anonymous enquiry in three rounds. Against the expectation all hazards received at least a very low estimation of relevance. The reason for this may be seen in the relevance of distant events that may impact the area of the case study region. It became apparent that most importance is attached to natural hazards (in total 79 %) with floods (25 %), Extreme precipitation (15 %) and Storms (13 %) on the top of the estimation (see Table 10). Technological hazards in total received only 21 % with dams (6 %) and industrial production plants (6 %) on top.

Table 10. Weighting of hazards: average estimations and deviation from the average in the Dresden region

Hazards		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 1 (%) first estimation = 100	coefficient of variation (%) Round 1	coefficient of variation (%) Round 2	coefficient of variation (%) Round 3
Natural Hazards	Volcanic eruptions	0,3	0,2	0,2	0,4	0,2	0,2	**65,0**	163,0	141,4	139,6
	Floods	24,4	24,9	24,8	15,1	13,1	12,1	**101,5**	62,1	52,5	49,0
	Landslides/Avalanches	3,9	2,6	2,8	3,8	1,7	1,5	**72,0**	97,6	64,0	52,6
	Earthquakes	0,4	0,3	0,4	0,4	0,3	0,3	**83,1**	100,3	122,2	82,4
	Droughts	9,6	9,1	9,1	3,6	2,5	2,4	**95,1**	38,0	27,8	26,3
	Forest Fires	8,6	9,0	9,2	3,4	2,8	2,4	**106,6**	39,1	30,8	26,1
	Storms	12,9	13,6	13,1	4,6	4,1	3,6	**102,2**	35,7	30,3	27,4
	Extreme precipitation	14,6	14,9	15,0	4,1	2,7	2,0	**103,0**	28,1	18,1	13,3
	Extreme temperatures	4,0	4,0	4,0	1,2	1,4	1,4	**100,0**	30,6	35,4	35,4
Technological hazards	Nuclear power plants	1,7	2,0	2,1	1,6	1,4	1,3	**124,0**	99,0	70,7	62,1
	Production plants	5,8	5,7	5,6	4,1	3,5	2,9	**96,6**	70,5	62,1	51,4
	Waste deposits	4,1	3,9	4,1	3,0	2,6	2,4	**100,0**	72,3	66,6	57,2
	Marine transport	3,8	3,4	3,5	1,8	1,5	1,1	**92,6**	48,0	45,4	32,3
	Dams	6,0	6,5	6,1	5,1	3,1	3,3	**102,8**	85,2	48,7	53,1
	Sum	**100,0**	**100,0**	**100,0**	**52,4**	**41,1**	**36,9**		**969,4**	**816,1**	**708,2**

The development of average estimations through the three rounds shows that experts have used the scope of "Delphi" for adjustment of the previous estimations to a certain extent. In most cases the final estimations remained close to the previous (Table 11, column 'Change in estimation') though deviation of responses from the average reduced considerably (columns 'deviation'). The total deviation score decreased from 52,4 in the first round to 36,9 in the final round also indicating that experts have used the offered average scores from the former rounds for adaptation of the own estimation. Also the deviation from all discrete estimation has decreased from round to round (except for the hazard 'dams'). The provided average scores from the previous round has not led to a levelling of the opinion of the experts, which may be indicating the active cooperation of all experts throughout the enquiry. Measured by the change in estimation from Round 1 to round 3 the largest relative change experienced the estimations for the hazards 'Volcanic eruptions' (65 % of previous estimation) and 'Landslides/Avalanches' (72 % of previous estimation) as well as 'Earthquakes' and 'Nuclear power plants'. These hazards are at the same time the four (absolute) lowest 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 by up to 6,6 % (Forest fires) only. To measure variation of responses regardless of the absolute average value of responses the 'coefficient of variation' has been used (see accordant columns). This measures value is reliant on average estimations as well as the standard deviation figure and thus also shows a clear "coordination effect" throughout the rounds.

Table 11. Weighting of vulnerability indicators: average estimations and deviation from the average in the Dresden region

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 1 (%) first estimation = 100		coefficient of variation (%) Round 1	coefficient of variation (%) Round 2	coefficient of variation (%) Round 3
Population density	54	55	55		7	6	5		**102**		12	11	9
GDP/capita	46	45	45		7	6	5		**98**		15	13	11
Sum	**100**	**100**	**100**		**13**	**12**	**10**				**27**	**24**	**20**

The Delphi method was also used to weight the vulnerability indicators 'population density' and 'GDP per capita'. The weighting by the experts awarded population density with 55 %, and 45 % GDP per capita) differed only slightly from the so far introduced the figure proposed by ESPON Hazards (Table 10). These different weighting factors are considered for determination of the vulnerability score (Table 11).

Risk Profile of the Dresden region

Hazard estimation

For the purpose of hazard estimation the weighting results from Delphi is combined with potential hazard intensities. Weighting factors for each hazard and hazard factors obtained from the potential hazard intensity are multiplied to obtain the individual potential for each hazard.

Through adding the individual hazard potentials the aggregated hazard potential of the Dresden region is obtained: **38,6** (Table 12).

Table 12. Aggregated hazard potential in the Dresden region.

Hazard		**Average estimation by Delphi**	**Hazard 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 presented in the 2nd ESPON Hazards Interim Report
** Comparative assumption lacking scientific data

Table 13 shows the determination of vulnerability according to the methodology defined in the first ESPON Hazards Interim Report for Dresden region. In this table coping capacity is not yet considered. The table considers the weighting factors obtained as well with the Delphi method. The result is a weighted vulnerability class for each NUTS 3 level region within the case study area.

Table 13. Vulnerability matrix of Districts (NUTS 3 level) in the Dresden region

NUTS 3 level Districts (No NUTS 5 areas)**	Population density			GDP per capita			Vulnerability class Pop. Dens / GDP = 55 / 45
	Value** (pers./km²)	% (EU 15 average = 100)	class	value*	% (EU 15 average = 100)	class	
Dresden Stadt (1)	1.455	1.233	V	23.145	112	III	**IV**
Meißen (17)	242	205	IV	16.149	78	III	**IV**
Riesa-Großenhain (23)	149	126	III	14.991	73	II	**III**
Sächsische Schweiz (26)	166	141	III	13.025	63	II	**III**
Weißeritzkreis (20)	164	139	III	12.012	58	II	**III**
EU 15 (100%)* **	**118**	**100**		**20.613**	**100**		

* Statistical Reports 2000, except for ***
** Source: planning region website http://www.rpv-elbtalosterz.de, except for ***
*** European Commission 2000

From the obtained aggregated hazard potential and vulnerability class (damage potential) the following aggregated risk matrix can be developed:

Table 14. Risk matrix for the planning region Oberes Elbtal / Osterzgebirge (NUTS 3 level)

Aggr. hazard potential	Degree of vulnerability (coping capacity not considered)				
	1	**2**	**3**	**4**	**5**
1	2	3	4	5	6
2	3	**4** - Riesa-Großenhain [DED27] - Sächsische Schweiz [DED29] - Weißeritztalkreis [DED2A]	**5** - Meißen [DED25]	**6** - Dresden [DED21]	7
3	4	5	6	7	8
4	5	6	7	8	9
5	6	7	8	9	10

Following the risk matrix the five NUTS 3 level regions of the case study area are distributed in two risk classes (figure 5). Dresden and Meißen are attributed class 6 (hazard potential /

vulnerability = II / IV). The regions Riesa-Großenhain, Sächsische Schweiz and Weißeritztalkreis are attributed class 5 (hazard / vulnerability = II / III).

Figure 5. Aggregated risk map of the Dresden region (NUTS 3 level)

Application report

The most complicated part of the enquiry was the choice of experts. As there is no "perfect expert" for this issue a combination of knowledge was searched with the goal to obtain an as homogeneous as possible group. The majority of participating experts were interested in the issue and the approach. The chosen method was highly welcomed by active participation and additional ideas shared. These ideas will form a basis for further collaboration / coordination with those experts with the aim of further advancement of the methodology. It was also found that homogeneity of participating experts was an important prerequisite for the success of the application. It furthermore appears to be of highest importance to ensure that all experts have more or less the same level of knowledge about the issues concerned. Basically this is the reason why the process of expert choice may be the most critical point in the application of the Delphi method. The effect of different choice of experts will be analysed in a second edition of the Method application to be realised end of March 2004.

It proved to be very helpful to contact the participating experts personally in advance and after sending information material. Because of the characteristics of Delphi it was important to give the experts a concise introduction into the method of work to ensure every body has the same understanding of the method. During the enquiry several experts proposed to include also further hazards and parameters for the assessment of vulnerability. This should be discussed in the course of ESPON Hazards. In terms of hazards it was proposed to also consider entry lanes of airports and hazards that develop rather slowly such as climate change, area consumption, resource consumption or electro smog.

Following parameters where proposed for the vulnerability assessment:
- State of the environment
- Intensity of land use
- Population structure
- GDP per area
- Political stability
- Speed of hazard development
- Potentially affected infrastructure per are
- Sealing proportion

Discussion of potential problems

Applied hazards in the case of the Dresden region appeared to be partly misleading the experts. Due to a very close relation of potentially hazardous events and consequent hazards interferences appeared that may have influenced the results. Such interferences exist e.g. between ‘extreme precipitation’ and ‘floods’ as well as between ‘extreme temperatures’ and ‘droughts’. For this reason it can be expected that values obtained for ‘extreme precipitation’ and ‘extreme temperatures can not be fully separated from the weights given to ‘floods’ and ‘droughts’. In case the test would not have included ‘extreme precipitation’ a considerably higher value may have been obtained for the hazard ‘floods’. With regard to the mean estimations it has to be taken into account that Saxony suffered from the most severe floods only two years ago in August 2002. It is therefore conceivable that the respective hazards may be estimated to high.

2.5.2 Central region of Portugal

Hazards and indicators

Despite the fact, that the Central Region of Portugal is predominately affected by only a few hazards mentioned in Delphi methodological tool, the experts were asked to state their mind in regard to all the relevant hazards considered within this project. The results are presented in the section below.

Pondering different vulnerability indicators to hazards risk was another task that has been carried out within the application of this methodology. Additionally to common indicators used at European level, namely, population density and GDP per person, eight additional indicators and parameters where proposed by IGM and CCDRC and weighted by the expert group. They were enclosed in the application of the second table and experts were given a chance to render judgement upon them. Those indicators (marked *) and parameters (marked **) considered, were:

- degree of built-up area**
- % of total forested area*
- % of population loss (desertification)*
- number of doctors / inhabitant *
- % of the budget spent in combat and accident prevention/ GDP**
- number of firemen/area*
- % of ordered forest/ total forested area**
- % of urban areas below flood level**

For the determination of vulnerability only indicators were used considering their relative weight.

Experts

Since risk awareness and risk management are not well established in Portugal, it was rather difficult to locate such a pool of “experts”. Nevertheless, we have tried to combine three major criteria upon which to proceed the required selection of “knowledgeable person” in this field of study. The selected criteria were: a) to cover all the spectrum of professionals from the planning area up to those who deal with the management of risk in the field, b) to cover public and private sectors involved in this process, and c) to warrant that all of them would have a wide and in-depth knowledge of the region and were acquainted with risk issues. Eleven experts were invited to participate in the test. Ten experts from seven public and private institutions were able to respond.

Results

Results where obtained from an anonymous enquiry in three rounds. The following table shows the average values obtained in the enquiries as well as the deviation of estimations. The average estimation value represents the average of all estimations submitted. The deviation value shows the maximum departure of proposed values from the average. The latter also indicates how the estimates developed from round to round.

Table 15. Weighting of hazards: average estimations and deviation from the average in the Central Region of Portugal

	Hazards	average estimation Round 1	average estimation Round 2	final estimation Round 3	deviation Round 1	deviation Round 2	deviation Round 2	Change in estimation Round2 / Round 1 (%) first estimation = 100	Change in estimation Round3 / Round 2 (%) first estimation = 100	Change in estimation Round3 / Round 1 (%) first estimation = 100
Natural Hazards	Volcanic eruptions	0,0	0,0	0,0	0,0	0,0	0,0	-	-	-
	Floods	17,0	16,2	15,2	4,5	3,3	3,9	95,3	93,8	89,4
	Landslides/Avalanches	6,0	5,6	5,8	3,8	2,4	2,2	93,3	103,6	96,7
	Earthquakes	4,4	5,0	4,4	4,2	3,6	3,2	113,6	88,0	100,0
	Droughts	5,0	5,9	6,6	3,1	2,4	2,9	118,0	111,9	132,0
	Forest Fires	33,9	36,1	31,5	18,3	13,8	13,1	106,5	87,3	92,9
	Storms	4,7	4,0	4,5	2,7	1,6	1,8	85,1	112,5	95,7
	Extreme precipitation	4,4	5,0	5,5	1,6	2,4	2,6	113,6	110,0	125,0
	Extreme temperatures	3,6	3,5	5,0	1,7	1,5	3,6	97,2	142,9	138,9
Technological hazards	Nuclear power plants	0,1	0,0	0,2	0,4	0,1	0,4	0,0	-	200,0
	Production plants	6,5	5,8	7,1	3,2	2,6	2,6	89,2	122,4	109,2
	Waste deposits	4,7	4,8	4,9	3,2	1,4	1,4	102,1	102,1	104,3
	Marine transport	3,8	3,8	4,3	1,8	1,7	2,2	100,0	113,2	113,2
	Dams	5,9	4,3	5,0	4,2	2,8	3,5	72,9	116,3	84,7
	Sum	100,0	100,0	100,0	52,6	39,7	43,3			

Data analysis:

- The obtained averages allow us to see clearly that there are two main hazards, which affects the central region of Portugal: forest fires (31,5%) and floods (15,2%). These hazards have been overvalued in the first round of Delphi methodology application, probably due to the fact that experts were experiencing for the first time this methodological approach. Gradually, we achieved a more balanced distribution throughout the different categories of hazards, observing a slight decrease in their (forest fires and floods) relative weight out of the total hazards presented in this table.

- There is no hazard 'volcanic eruption' in this region.

- The low level of percentage (0,2%) associated with the nuclear power plants' risk is due to the fact that, on the one hand there is no nuclear power plant in Portugal. On the other hand the percentage given to this hazard is explained by a Spanish nuclear power plant close to the border.

- Experts have weighted the other risks in such a way that there is not so much difference among them. They varied between 4,3% and 7,1%.

- In relation to the deviation registered, it is important to notice that from the first round to the second, there was a general decrease in the values presented (with the exception of extreme precipitation). This means that experts' opinions got closer (the total value of deviation decreased from 52.6% to 39,7%). From the second round to the third one, for several hazards an increase in deviation of responses was registered (with the total deviation value from 39,7% to 43,3%), regardless of the fact that this increase has never surpassed the average deviation of the first round. In general there was a decrease in total deviation of responses from 52,6% to 43.3%.

Table 16. Weighting of vulnerability indicators: average estimations and deviation from the average in the central region of Portugal

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 Round2 / Round 1 (%) first estimation = 100	Change in estimation Round3 / Round 2 (%) first estimation = 100	Change in estimation Round3 / Round 1 (%) first estimation = 100
Population density	6,3	6,9	6,2	2,2	2,3	2,4	109,5	89,9	98,4
GDP/person	6,3	5,6	7,2	3,8	1,4	4,2	88,9	128,6	114,3
Degree of built-up area	6,7	7,7	7,0	3,9	3,9	3,6	114,9	90,9	104,5
% of total forested area	25,5	26,8	25,6	8,4	5,9	6,4	105,1	95,5	100,4
% of population lost (population lost / 1000 people) (desertification)	13,2	11,1	10,9	5,3	3,9	4,2	84,1	98,2	82,6
Number of doctors / 1000 inhabitant	5,4	4,4	4,6	2,4	1,7	1,6	81,5	104,5	85,2
% of the budget spent in combat and accident prevention/ GDP	7,6	6,9	7,3	3,0	2,7	2,7	90,8	105,8	96,1
Number of firemen/area	5,9	4,9	5,3	4,0	1,4	1,9	83,1	108,2	89,8
% of ordered forest/ total forested area	13,9	14,8	15,2	6,8	5,8	5,3	106,5	102,7	109,4
% of urban areas below flood level	9,2	10,9	10,7	3,6	3,6	3,3	118,5	98,2	116,3
Total	**100,0**	**100,0**	**100,0**	**43,5**	**32,6**	**35,8**			

For the first approach to obtain the aggregated risk profile for the Central region of Portugal (NUTS 3 level) two of the above mentioned vulnerability indicators will be presented, population density and GDP/capita. The other eight vulnerability indicators and parameters reflect more the regional vulnerabilities that will help to support the methodology. Although from the eight only four are available to be indicators, those will be recalculated to hundred. The other four remain as proposed parameters to be integrated when the information is available.

In a second approach new developments are presented. Indicators such as population density, GDP/capita, % of total forested area, population loss/1000 people, number of doctors/1000 inhabitants and number of firemen/area, will be integrated in the aggregated risk map.

Data analysis:

- The three main weighted vulnerability indicators (*% of total forested area* – 25,6%; *% of ordered forest/total forested area*– 15,2%; *% of population lost* – 10,9%) are related with the main hazard that affect the region: forest fires.

- Another main indicator, which relates with the risk of Floods (% of urban areas below flood level (10,7%).

- Population density and GDP per person indicators were not highly pondered, especially when compared with the other mentioned indicators as they are not that relevant to evaluate the vulnerability of the region to those risks. From the first round to the third, these indicators were the only ones that have registered an increase of deviation, marking the growing importance given by experts.

- The dynamics of deviation in this second table were similar to the ones mentioned in the first table. In fact, from the first round to the second the total value of deviation decreased (from 43,5% to 32,6%), but has increased in the final round (from 32,6% to 35,8%). The values presented in the first round have never been reached again, showing that experts' opinions got closer.

Risk Profile of the Central Region of Portugal

As described above, vulnerability is the relation between damage potential and coping capacity. In a first case presented below the coping capacity will not be considered to use the same vulnerability indicators as in European maps.

Hazard estimation
For the purpose of hazard estimation the weighting results from Delphi is combined with potential hazard intensities. Table 17 shows obtained weighting factors for each hazard and hazard factors obtained from the potential hazard intensity, which in this case is also considered the opinion of the experts. These are multiplied to obtain the individual score for each hazard.

Table 17. Aggregated hazard potential in the Central region of Portugal

Hazard	Average estimation Round 3	Assumed hazard intensity in the region	Hazard factor	Individual hazard potential
Volcanic eruptions	**0**	1	0,2	**0,0**
Floods	**16,1**	2	0,4	**6,1**
Landslides/Avalanches	**5,8**	1	0,2	**1,2**
Earthquakes	**4,6**	1	0,2	**0,9**
Droughts	**5,8**	1	0,2	**1,3**
Forest Fires	**33,8**	4	0,8	**25,2**
Storms	**4,4**	1	0,2	**0,9**
Extreme precipitation	**5,0**	1	0,2	**1,1**
Extreme temperatures	**4,0**	1	0,2	**1,0**
Nuclear power plants	**0,1**	1	0,2	**0,0**
Production plants	**6,5**	1	0,2	**1,4**
Waste deposits	**4,8**	1	0,2	**1,0**
Oil spills	**4,0**	1	0,2	**0,9**
Dams	**5,1**	1	0,2	**1,0**
Sum	**100,0**			**41,9**

The hazards intensities presented in the above table are not yet calculated with real data analysis, which means that in a future presentation of this table the quotations of the second column may not be the same for these hazards. These quotations were calculated according to weights given by the experts in the first column. At this moment coping capacity is not yet considered. Exemplary the so far proposed indicators Population density and GDP per capita are implemented considering their relative value from the weighting (46% for population density and 54% for GDP per capita).

Table 18. Vulnerability matrix Central region of Portugal (NUTS 3 level)

	Population density (46)			GDP per capita (54)			vulnerability class
Districts (NUTS 3)	value 1999 (persons/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	**2**
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	**2**
PINHAL INTERIOR NORTE	50	42	2	6.578	32	1	**1**
BAIXO MONDEGO	154	131	3	10.198	49	1	**2**
BAIXO VOUGA	196	166	3	10.568	51	2	**2**
Reference (EU 15 =100)	**118**	**100**		**20.613**	**100**		

The aggregated hazard potential and vulnerability combined draw the following risk pictures of the region, considering sub regions at NUTS 3 level (Figure 6).

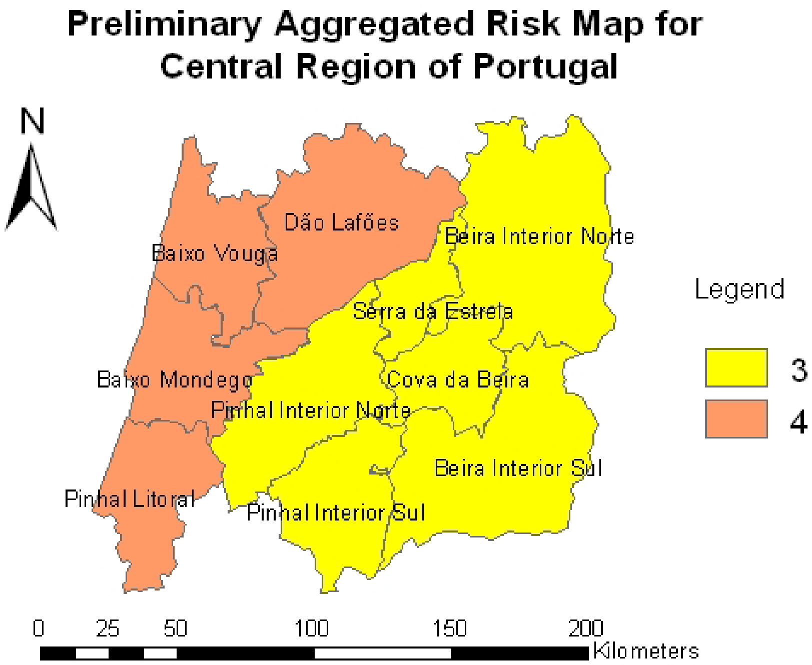


Figure 6. Aggregated Risk map of the Central region of Portugal (NUTS 3 level)

In the following new developments by practicing the Delphi results in respect to regional vulnerability factors are presented. Therefore NUTS 4 level data is introduced in the determination of vulnerability. Furthermore, the original set of two indicators is advanced by two additional indicators for damage potential and two indicators for coping capacity. The damage potential indicator 'forested areas', e.g. is used to advance the economic vulnerability and the indicator 'population loss' is complimenting the social component 'population density'. As coping capacity 'number of fireman/area' and 'number of doctors/1000 inhabitants' are introduced.

From the methodology some adjustments had to be made, as EU reference values were just available for the population density and GDP per capita. For the newly introduced indicators Portuguese reference values where used for classification. To classify from 1 to 5 the percentiles of populations were calculated choosing the appropriate intervals that will be presented in the tables below. For the definition of the aggregated vulnerability weighting factors were correspondent to the weight given by the experts.

Table 19. Indicators of damage potential, weighting factors, classification, reference values

Population density 2000 (11%)*		GDP per capita (1999) (11%)*		% of total forested area (43%)*		% population loss (19%)*	
(damage potential) class	classes (EU-average = 100)	(damage potential) class	classes (EU-average = 100)	(damage potential) class	classes (Portugal average = 100)	(damage potential) class	classes (Portugal average = 100)
I	< 25	I	< 50	I	<0,3	I	<150
II	25 - 100	II	50 - 75	II	0,3 - 0,5	II	150 - 500
III	100 - 200	III	75 - 125	III	0,5 - 0,7	III	500 - 1000
IV	200 - 500	IV	125 - 175	IV	0,7 - 0,9	IV	1000 - 2000
V	> 500	V	> 175	V	>0,9	V	> 2000
EU 15 (100%)	**118**	**EU 15 (100%)**	**20.613**	**Portugal (100%)**	**32.461,00**	**Portugal (100%)**	**0,7**

Table 20. Indicators of coping capacity, weighting factors, classification, reference values

Number of fireman/area (9%)*		Number of doctors /1000 inhabitants (8%)*	
(coping capacity) class	classes (Portugal average = 100)	(coping capacity) class	classes (Portugal average = 100)
V	<60	V	< 30
IV	60-80	IV	30 - 40
III	80-100	III	40 - 70
II	100-200	II	70 - 100
I	>200	I	> 100
Portugal (100%)	152	Portugal (100%)	3,2

From ten proposed vulnerability parameters only six could be operationalised as indicators. Weighting factors are recalculations to 100 of the weighing factors given by the experts because four vulnerability parameters could not be operationalised due to limited data availability. Weighting factors for damage potential indicators are again dimensioned to 100% to reflect the fact that coping capacity (represented by two indicators) can not amount to 100% of the damage potential. The calculation of the aggregated risk map considering the six vulnerability indicators available was calculated considering the subtraction between damage potential and coping capacity. The intervals considered in the national reference indicators, such as, coping capacity indicators and % of total forested area and population loss / 1000 people were balanced by observation of percentiles of the population and the national reference.

Observations showed that population loss/1000 people in central region of Portugal is much higher then the national level. In the case of the indicator doctors/1000 inhabitants only 5% of the municipalities were above the national reference. Thus considering the advanced vulnerability indicator set at the NUTS 4 level the following risk picture of the case study area can be drawn. Table 21 and the resulting aggregated risk map is at this stage over-weighted to the regional vulnerability indicator in relation to the parameters.

Because there is no available information for some of the proposed indicators this map has a tendency to weight certain hazards higher, which does not reflect the actual situation in some municipalities. The vulnerability indicators were developed but the task is not complete and the next step of development should be the relation between these vulnerability indicators and intensity of hazards, based on real data.

Table 21. Aggregated risk matrix for Central region of Portugal (NUTS 4 level)

Aggr. Hazard potential	Degree of vulnerability				
	1	**2**	**3**	**4**	**5**
1	2	3	4	5	6
2	**3** AV, Av, Es, Il, Mea, Mur, OB, O, SV, Vg Coi, CN, Mi, MV, B, MG, PM, Az, Ans, CP, Lou, MC, VNP, AB, CS, Mag, N, OF, SCD, SPS, VNPa, FA, Alm, Gou, FCR, Gua, Med, Pin,	**4** Ag, An, Can, FF,Pen, Lei, Sou, Arg, FV, G, OH, PG, Pen, T, CD, Mor, PC, Sa, Ton, Vis, Vz, VR, S, CB, Man, Sb, Tra, VVR, Bel, Cov,	**5** Pb PS, Mac, PN, Ser, CaB, Pnm, Fun	**6** Ol, IN,	7
3	4	5	6	7	8
4	5	6	7	8	9
5	6	7	8	9	10

Águeda (Ag), Albergaria-a-Velha (AV), Anadia (An), Aveiro (Av), Estarreja (Es), Ílhavo (Il), Mealhada (Mea), Murtosa (Mur), Oliveira do Bairro (OB), Ovar (O), Sever do Vouga (SV), Vagos (Vg), Cantanhede (Can), Coimbra (Coi), Condeixa-a-Nova (CN), Figueira da Foz (FF), Mira (Mi), Montemor-o-Velho (MV), Penacova (Pen), Soure (Sou), Batalha (B), Leiria (Lei), Marinha Grande (MG), Pombal (Pb), Porto de Mós (PM), Alvaiázere (Az), Ansião (Ans), Arganil (Arg), Castanheira de Pêra (CP), Figueiró dos Vinhos (FV), Góis (G), Lousã (Lou), Miranda do Corvo (MC), Oliveira do Hospital (OH), Pampilhosa da Serra (PS), Pedrogão Grande (PG), Penela (Pen), Tábua (T), Vila Nova de Poiares (VNP), Aguiar da Beira (AB), Carregal do Sal (CS), Castro Daire (CD), Mangualde (Mag), Mortágua (Mor), Nelas (N), Oliveira de Frades (OF), Penalva do Castela (PC), Santa Comba Dão (SCD), São Pedro do Sul (SPS), Sátão (Sa), Tondela (Ton), Vila Nova de Paiva (VNPa), Viseu (Vis), Vouzela (Vz), Mação (Mac), Oleiros (Ol), Proença-a-Nova (PN), Sertã (Ser), Vila de Rei (VR), Fornos de Algodres (FA), Gouveia (Gou), Seia (S), Almeida (Alm), Celorico da Beira (CB), Figueira de Castelo Rodrigo (FCR), Guarda (Gua), Manteigas (Man), Meda (Med), Pinhel (Pi), Sabugal (Sb), Trancoso (Tra), Castelo Branco (CaB), Idanha-a-Nova (IN), Penamacor (Pnm), Vila Velha de Rodão (VVR), Belmonte (Bel), Covilhã (Cov), Fundão (Fun)

Considering the experts' opinion and not the real data analysis of individual hazards and aggregated risk assessment the majority of municipalities are included in risk levels 3 and 4. Only two of the municipalities exceed this levels, Oleiros and Idanha-a-Nova refelcting not just the damage potential and the loss of population (that is enormous in these two municipalities) but also the lower coping capacity.

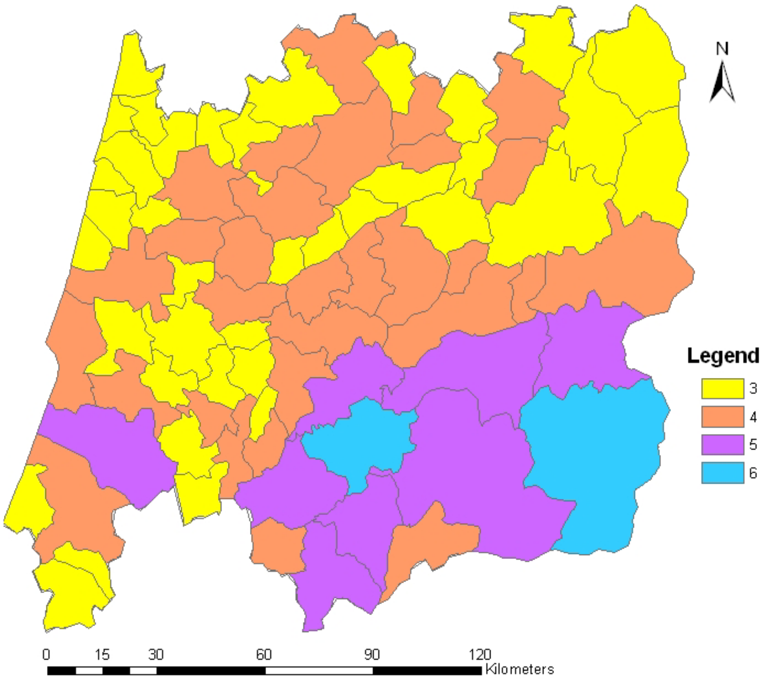


Figure 7. Aggregated Risk map of the Central region of Portugal (NUTS 4 level)

2.5.3 Itä-Uusimaa

Hazards and 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.

Experts

The expert group chosen for the Delphi test contained 4 experts from three different organisations in 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. There are no experts in the region who deal with environmental and technological hazards directly, so general knowledge of the issue was considered sufficient.

Results

The results were obtained from an anonymous enquiry conducted in three rounds. 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 22. Weighting of hazards: average estimations and deviation from the average in the Itä-Uusimaa region

	Hazards	average estimation Round 1	average estimation Round 2	final estimation Round 3	deviation Round 1	deviation Round 2	deviation Round 3	Change in 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
	Sum	**100,4**	**100,1**	**100,1**	**52,8**	**43,6**	**39,9**	

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.

Technological hazards, on the contrary, receive high relevance scores (excluding dams). However, the experts don't seem to agree on the relative relevance of these 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.

The Delphi method was also used for an assessment of vulnerability in Itä-Uusimaa. In addition to the economic vulnerability indicators of the Hazards project, 'GDP per capita' and 'population density', in the first round 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. The results from the first round are not comparable with the results from the second and third rounds due to the fact that suggested vulnerability indicators were weighted alongside GDP/capita and population density in the first round.

Table 23. Weighting of vulnerability indicators: average estimations and deviation from the average in the Itä-Uusimaa region

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

In Itä-Uusimaa, the weighting of GDP/capita and population density differs markedly from the 50/50 weighting of the economic vulnerability in the Hazards project. The experts find 'population density' much 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. 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 proposed vulnerability indicators (listed later in this chapter) do not measure vulnerability, but can instead be considered as new proposals for measuring different hazards in Itä-Uusimaa. One of the experts also called into question why a region with high 'GDP per capita' and high population density is considered especially vulnerable like suggested in the Hazards project. Due to these reasons it must be stressed that this estimation of vulnerability offers only a hint how vulnerability in Itä-Uusimaa should be measured.

Risk Profile of the Itä-Uusimaa region

Hazard estimation

To proceed with the hazard estimation for the Itä-Uusimaa region, the final results from Delphi (weighting of hazards) are combined with the region's potential hazard intensities. Table 24 shows the average final estimation from the Delphi test and hazard factors obtained from the potential hazard intensity. At this stage of the Hazards project, only the hazard intensity for floods is backed up by scientific data, the other intensities had to be estimated and are thus mere assumptions. These are 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 (49,0). According to the methodology developed earlier in the project, this score is translated into an aggregated hazard class, which for Itä-Uusimaa is 2 (scores from 35 to 50).

Table 24. Aggregated hazard potential in the Itä-Uusimaa region

Hazard	Final estimation	Hazard intensity in the region (tentative)	Hazard factor (tentative)	Individual hazard score (tentative)
Floods	3,1	1*	0,2	0,6
Droughts	3,8	1**	0,2	0,8
Storms	0,9	1**	0,2	0,2
Extreme precipitation	2,0	1**	0,2	0,4
Extreme temperatures	0,0	1**	0,2	0
Forest Fires	1,5	1**	0,2	0,3
Landslides	0,0	1**	0,2	0
Nuclear power plants	13,5	2**	0,4	5,4
Waste deposits	9,8	1**	0,2	2,0
Production plants	31,5	3**	0,6	18,9
Marine transport of hazardous goods	34,0	3**	0,6	20,4
Dams	0,0	1**	0,2	0
Sum	**100,1**			**49,0**

* hazard intensities as presented in the 2nd ESPON Hazards Interim Report
** assumption lacking scientific data

In the table below, the vulnerability of Itä-Uusimaa is determined according to the methodology defined in the first ESPON Hazards Interim Report. Following this methodology, GDP per 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 25. Vulnerability matrix of the Itä-Uusimaa region (NUTS 3 level)

	GDP per capita (22,5 %)			**Population density (77,5 %)**			
NUTS 3 level	**value (Euro)**	**% (EU 15 average = 100)**	**class**	**Value (persons/km²)**	**% (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 NUTS 3 level region (see table below).

Table 26. Risk matrix for the Itä-Uusimaa region (NUTS 3 level)

Aggr. hazard potential	Degree of vulnerability (coping capacity not considered)				
	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	10

Application report

From the experiences in Itä-Uusimaa it can be said, that the Delphi method brings interesting results for assessing hazards in a region. The most important issue for the successful functioning of the method is to find suitable and motivated experts. The fact that Itä-Uusimaa is such a small region affects both the number and variety of experts found in the region. It seems especially difficult to find people who deal with both regional planning and hazards, not to mention regional vulnerability. For these reasons it was considered sufficient to approach people that at least have some basic knowledge of these issues and know the region well. 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. No aggregated risk map for the Itä-Uusimaa region could be made. The first reason is, that Itä-Uusimaa in itself is one NUTS 3 region and thus no comparison between regions can be made. It would be possible to use the ten NUTS 5 regions in Itä-Uusimaa for this purpose, but problems in data availability hindered this.

In the first round the experts were requested to list indicators for measuring vulnerability. None of the proposed indicators was directly feasible for the purposes of the Hazards project, and most of them do not measure vulnerability at all. Instead, all but the first three can be considered as proposals for measuring the hazardousness of Itä-Uusimaa:

- Bioindicators
- Noisy/quiet areas
- Number of people living close to airports
- Amount of marine transportation of hazardous goods
- Amount of hazardous substances used in industry
- Risks to water supply and drinking water (contamination of water supplies, destruction of sewage water purification system or sewer network)
- Level of industrialization and number of production plants and storehouses dealing with hazardous substances
- Road transport of hazardous goods

Assessing a region's vulnerability (especially naming and weighting vulnerability indicators) would perhaps require some special competence from the experts, or at least a thorough introduction to the subject. In the future the idea of enquiring possible vulnerability indicators from experts should be further developed.

2.6 Summary

The chapter above shows that the Delphi method can be an appropriate tool for facilitating consensus about vague issues in spatial planning. The success of the application of this tool was largely dependent of the intensity of preparation and accuracy in implementation. The expert groups involved in three case study regions where usually very interested in the issue as well as in the approach proving the effectiveness of the tool. The weighting results obtained formed the basis for the application of a tool to determine the *aggregated hazard potential* for each case study region. The tool has been applied with weighting factors for selected hazards and vulnerability indicators, leading to individual risk profiles and aggregated risk maps of the regions. Using statistic measures, such as the standard deviation and the coefficient of variation, showed that the expert group used the interim averages supplied by the moderator to adapt the previous estimation. However, a total consensus of experts was never achieved.

Limitation in applicability could be shown in terms of available vulnerability indicators, interference selected of hazards and the insufficient acquaintance of experts with the risk/hazard concept and the vulnerability concept.

From the first application of the Delphi method the following conclusions can be drawn:

- The expert group should be homogeneous in terms of knowledge about the area of interests and the hazard and risk concept.

- Precise information should be given to all experts – if necessary through additional contact and explication in the preparation phase. It is inevitable that any expert can clearly differentiate between key issue of interest by unmisunderstandable explanation of key terms like *hazard* and *risk* to avoid a wrong basis for the estimation.

- Expert should have an unbiased relation to the hazards – Delphi may easily be abused for particulate interest.

- The application of the method should be well prepared to insure that the results obtained would fill exactly the existing gap of information and suit ideally for the further working process.

2.7 Discussion

The application of the proposed methodology in three case study areas has shown that it is possible to obtain descriptive results that can form a good basis for spatial planning. The tool not only offers the possibility to assess the current risk profile of a region. By offering the possibility to change in weight and value of e.g. vulnerability indicators scenarios can be tested. However, advancements are possible and should be fostered in the light of the good applicability of the method.

Difficulties remained through the application of the Delphi method and the hazard aggregation tool due to lack of impartial and scientifically backed data on expected hazard intensities. Limiting was also that proposed vulnerability indicators could partly not be operationalised due to lack of background data.

Although applied, the so far proposed indicator system made up by only one social and one economical indicator leaving out ecological indicators and coping capacity needs advancement. In several occasions experts had difficulties in following the presented approach to vulnerability – despite of often not having proposals for advancement. It is also worthwhile considering to refine the set of indicators for use on finer spatial levels than NUTS 3. However, for this reason indicators would have to be developed.

During the application it became apparent that the information derived from the Delphi method and the application of the aggregation tool is good for quick overview on rather abstract levels of spatial planning. Lacking the intersection with modelling data and higher resolving weighting factors the tools application at operational levels of spatial planning is hardly thinkable. Nevertheless the tool as well as the Delphi method seem to be useful for overview evaluations. Especially with respect to the Delphi tool a further refinement in application areas is thinkable.

3 DEVELOPMENT OF THE TYPOLOGY OF REGIONS

3.1 Possible future highly sensitive areas, including climate change scenarios

3.1.1 Methodological basis for the identification of future highly sensitive areas

In the context of risk reducing policies – which often have long term effects –, it is of course also very important to identify those areas that will be highly sensitive in the future. This sub chapter discusses problems concerning such a future risk estimation and presents a methodological basis how the identification of future highly sensitive areas could be done.

According to our definition of risk (= hazard potential x damage potential / coping capacity) there are – on a theoretical level – three paths how an area or region can be come more sensitive in regard to a certain risk:

1. increase of hazard potential,
2. increase of damage potential,
3. decrease of coping capacity.

As explained above and in the 2nd ESPON Hazards interim report, damage potential and coping capacity together represent the vulnerability. When staying within the used methodology to identify the highly sensitive areas, there are two paths remaining on which a region can become more sensitive: an *increase of hazard potential* or an *increase of economic vulnerability*.

Increase of hazard potential

General increase of hazard potentials

A general and solid estimation of the future hazard potential poses some severe methodological problems. The largest problem is the *general uncertainty* about the future development of certain hazards and their interrelationships (e.g. earthquakes and industrial facilities). Another problem is to predict the *spatial occurrence* of a hazard. The latter becomes more difficult, the smaller the regarded spatial units are and the less the spatial distribution of the hazard is determined by physical phenomena like land forms (e.g. river flood compared with gases from a disaster in an industrial plant). In many cases an exact determination of hazard distribution will not be possible by ways of modelling. A forecast of hazard distribution will often have differing probabilities of different distribution scenarios. Further, estimations about future hazard potentials *differ from hazard to hazard*, resulting from their different character. Nevertheless, in most cases, the question is not whether it is possible to predict hazards or not. The question is more how can the uncertainty in the calculations of forecasting in the models be reduced. This, of course, is the task of the development of models and is beyond the scope of the ESPON hazards project. The following methodological aspects have to be taken into account for certain hazards when talking about estimating future hazard potentials:

- *River floods:* Protection constructions for river floods like dams are dimensioned according to certain annualities (e.g. 50 or 100 year flood). These annualities are normative and give no information about the real probability of a river flood. Predictions of high water can only be made short before the expected flood but not for many weeks or months, or even years or decades. Some research has been done (e. g. by SMHI) that aims to recalculate the statistical occurrence of floods by using future climate scenarios from regional climate models. The certainty in the results, as mentioned above, is discussed but the method is not controversial in itself.

- *Tsunamis/Storm surges (coast):* Protection constructions for storm surges are dimensioned according to annualities (e.g. in the Netherlands for a 10,000 year storm surge. The same methodological problems apply for river floods and storm surges.

- *Winter storms:* A multitude of parameters determines the temporal and spatial distribution and the magnitude of storm events. The complexity of the climate system makes it impossible to estimate future storm events on a detailed regional level. Even more advanced climate models still lead to inconsistent simulation results (Münchener Rück 2001, p. 66).

- *Landslides:* Although the relevant influencing factors for land slides are less complex as, e.g. for winter storms, landslides still must be seen as results of a multi cause chain (location factors, e.g. climate; site factors, e.g. slope; inherent factors, e.g. strength; Crozier 1986, p. 34) which makes a probabilistic estimation of their future hazard potential impossible for a European wide estimation.

- *Forest Fires:* It may be possible to make some general remarks about future forest fire events in dependence of the change in forest types. But forest fires mainly occur because of other factors like dryness, often in combination with malicious arson which make a prediction of the surrounding conditions impossible. However, in relation to climate change, some models of fire forecasting are currently being developed.

- *Droughts:* It is impossible to predict droughts because there are not only climatological but also socioeconomic parameters responsible for their occurrence. These socioeconomic factors (change in agricultural land use, change in water use) enhance the difficulties that exist anyway for predicting droughts, like the uncertainty about seasonal variations of precipitation.

- *Earthquakes:* Earthquakes in general comprise all events that set the upper earth's crust into motion. Earthquakes can also have human origins, such as underground atom bomb explosions or collapsing cavities of underground mining areas. These and other kinds of natural earthquakes can occur virtually everywhere in the world. Earthquakes caused by tectonic movements usually happen along major fault lines or in border of upper earth crust plates where sheer stresses appear. Since the earth's crusts are continuously in motion, minor earthquakes happen in their hundreds every single day, only noticed by highly sensitive measuring devices. It is a matter of many variables that turn one of these small earthquakes into a catastrophic earthquake that can then lead to severe damages. These variables are currently impossible to calculate and therefore it is not possible to predict earthquakes.

- *Volcanoes:* Volcanic eruptions occur in areas of major fault lines and cracks where gas and sometimes melted, hot material from the upper mantle reaches the earth's surface. Since the upward movement requires some time and sets parts of the earth's crust in measurable motion, it is possible to make early warnings before a volcano might become active again. Nevertheless it is not possible to predict a volcano's behaviour before it gets into motion. Some volcanoes are constantly active (e.g. Vesuvius and Etna) meanwhile other volcanoes might "sleep" for centuries or millennia before they get active again. As long as a volcano is located on an active fault system there is always a certain possibility that it might become active again in the future (e.g Mount St. Helens).

- *Oil transport and storage, oil spills; Nuclear power plants:* In contrast to natural hazards, the spatial distribution of sources for technological hazards (location of transport routes or nuclear power plants) depends more or less completely on decisions made by society (or at least certain groups). Predictions about decisions of the society or individuals are not possible because often unpredictable events (fall of the iron curtain, September 11 etc.) lead to sudden changes. Concerning the already existing hazardous facilities, a prediction of future hazards might be possible (increase of traffic along marine transport route vs. introduction of double hull vessels; phasing out of permissions for operating nuclear power plants vs. obsolescence of still operating nuclear power plants).

Influence of climate change

Please see Second ESPON Hazards Interim Report, pp. 47-50 for the description of the climate change influence on hazards, the latest research activities concerning this aspect and the difficulties of a regional prediction of climate change impacts.

Sub-chapter 2.1.2 presents some results from analyses of the RCAO-model output in the form of some climatic indicators. These results show the possible future changes in precipitation and temperatures. Thus, only those hazards are of relevance that are highly influenced by the climate. Similar to the „spatial filter“ presented in the First ESPON Hazards Interim Report (p. 86 ff.) we now introduce a „climate relation filter“ to identify the spatially relevant and climate related hazards (see Table 27).

Table 27. Climate relation and spatial relevance of hazards. Based on Fleischhauer, 2004.

Spatial relevance \ Climate relation	High	Medium	Low / non-existent
High	- **River floods** - **Flash floods** - **Landslides/avalanches** - **Extreme precipitation events** - **Extreme heat waves**	- Storm surges	- Volcanic eruptions - Nuclear power plants - Major accident hazards
Medium	- **Droughts** - **Forest fires** - **Storms**	- Hazards from the marine transport of hazardous goods	- Earthquakes - Hazardous waste deposits
Low / non-existent	---	---	---

According to this filter, the climate related spatial hazards are floods, landslides/avalanches, extreme precipitation events, extreme heat waves, droughts, forest fires and storms. Due to current data availability on EU level, so far we concentrate on the following hazards in regard to the influence of climate change (see chapter 3.2):

- river floods,
- extreme precipitation events,
- extreme heat waves,
- droughts,
- forest fires,
- storms

Increase of economic vulnerability

Apart from the hazard factor we use the economic vulnerability factor as the second parameter to describe the European wide spatial risk. As the hazard potential does not seem to be operational, the identification should be based on the future change in the two parameters of economic vulnerability, GDP per capita and population density.

In contrast to the hazard side, the changes of GDP per capita and population density can to a certain extent be predicted because their trends can be more easily integrated into models. This is due to the fact that the influencing factors on changes in GDP or population density are less complex and normally develop more or less smoothly and not abruptly. Therefore we suggest to base the identification of future highly sensitive areas on the economic vulnerability parameter.

Ecological and social vulnerability

It seems justifiable to base the identification of future highly sensitive areas on vulnerability instead of hazard potential. In order to fully incorporate the whole range of vulnerability into the project, it would be important to assess also future changes of the ecological and social dimension of vulnerability. However, only the social dimension can be considered here since it is not possible to consider the ecological dimension of vulnerability in the case of all hazards and in the whole area of EU 27+2 (see explanation in chapter 1.2).

In the case of social vulnerability, the present state of vulnerability has to be considered first and most importantly, the plausibility of the chosen indicators and their weighting has to be tested to make the weighting seem less arbitrary (Delphi method).

Methodology and necessary data

As a result of the discussion above, the methodological procedure would be to collect data about the GDP per capita and the population density for the past years (or even decades) and also estimations for the future years (decades). The following data is regarded as necessary to fulfil the task of dynamizing the methodology:

- Population on NUTS 3 level for the previous and next years (e.g. 1970, 1980, 1990; 2010, 2020, 2030),
- GDP per capita on NUTS 3 level for the previous and next years (e.g. 1970, 1980, 1990; 2010, 2020, 2030).

With this data the following statements about future highly sensitive areas in Europe-27 will be possible that will finally be also presented in European wide maps:

- Vulnerability maps for Europe for different years (e.g. 1970, 2000, 2030),
- Maps of the past and expected regional change of vulnerability (e.g. 1970-2000, 2000-2030),
- A risk map for each hazard for different years (e.g. 1970, 2000, 2030),
- Past and expected change in the risk of each hazard (e.g. 1970-2000, 2000-2030),
- A synthetic risk map for different years (e.g. 1970, 2000, 2030),
- Maps of the past and expected regional change of synthetic risk (e.g. 1970-2000, 2000-2030).

Perhaps estimations on GDP per capita and population are available, but this question has to be raised at least in the case of the social dimension of vulnerability, too. This issue will be discussed towards the Final Report.

3.1.2 Development trends on the hazard side (results from climate change models)

The following chapter contains a short abstract of a detailed article upon current results of SMHI's regional climate model system RCAO that can be found in annex 2.

Introduction

A future climate change can be expected to affect both the frequency and intensity of natural hazards and thus influence discussions on risk management of all climate-induced natural hazards. As stated in the 2nd ESPON Hazards interim report on-going EU projects such as MICE and STARDEX are making use of indices of climatic extremes. A number of different climatic indices for detection of extremes were chosen and applied on scenario data. The indices were chosen to represent both dry and wet conditions as well as warm and cold conditions and were selected based on work done within the European MICE project. The results should be seen as examples of possible future developments.

Indices of climatic extremes

For the present study eight different indices of climatic extremes (table 28) were selected to illustrate how the model simulates changes to the precipitation and temperature climate on a daily time-scale, which in many cases is related to climatic extremes. All indices are calculated as averages of the 30 annual index values for the time period covered by the different RCM scenarios.

Four indices concern precipitation and try to cover different aspects including both dry and wet conditions. "*Longest dry spell*" is the average length of the annually longest period with precipitation below 0.5 mm. "*Highest 7-day precipitation*" is the annual maximum precipitation total over any 7-day period and may be seen as a potential flood indicator, summing up precipitation during rainy periods. "*Heavy precipitation*" and "*Extreme precipitation*" are the annual number of days with precipitation above 10 mm and 25 mm respectively. Those indices represent the amount of wet days and are correlated with total annual and seasonal precipitation in most climates. The selected thresholds may seem rather low in comparison to what is commonly observed during heavy precipitation events where five to ten times higher (or even more) precipitation are occasionally reported for individual stations. The regional climate model however produces output that is representative on the gridcell scale, in this case 49x49 km or 2400 km^2. Because of the high spatial variability of precipitation, a gridcell average exceeding 10 mm (25 mm) is in fact an indicator of that somewhere in the gridcell region there is indeed heavy (extreme) precipitation, and somewhere else there may be no or very little precipitation. The local extremes are smoothed out on the gridcell level.

Daily temperature conditions are represented by four indices. For simplicity and to facilitate comparisons across regions fixed thresholds are preferred instead of indices based on deviations from local climatic conditions. Two indices account for summer daytime and night time conditions: "*Number of warm days*" and "*Number of tropical nights*". The definition of tropical nights, namely minimum temperature above 20°C, is widely used. The threshold for warm days chosen (25°C) is a compromise between what is relevant for climatic conditions in the northern and southern parts of the model domain. While daytime temperatures of 25°C are rarely reached in the north, this threshold is commonly exceeded during extended periods in the Mediterranean region. Nevertheless, a study of changes between today and tomorrow's climate gives information about the length of warm periods and thus information on energy and water demand, as an example.

Two indices are used to depict winter daytime and night time conditions: "*Number of freezing days*" and "*Number of frost nights*" that both use the natural threshold of 0°C. If the daytime maximum temperature stays below 0°C it usually indicate that the whole 24h period is below 0°C, hence a freezing day is also a frost night. However, it occasionally happens, especially during wintertime, that the night time minimum temperature may be warmer than the daytime maximum temperature in which case it may not be a proper freezing day that is characterised by freezing temperatures throughout the 24h period.

Table 28. Summary of the indices of climatic extremes used in this study.

Index	Explanation	Relevance (examples)
Longest dry spell	Average length of the annually longest spells of precipitation <0.5mm	Agriculture, forestry, fire risk, natural environment, water supply
Highest 7-day precipitation	Average annual maximum precipitation accumulated over 7 days	Flooding, slope stability
Heavy precipitation	Average annual number of days with precipitation >10mm	Local flash floods, slope stability
Extreme precipitation	Average annual number of days with precipitation >25mm	Local flash floods, slope stability
Number of warm days	Average of annual number of days with Tmax>25°C	Energy demand, agricultural water demand
Number of tropical nights	Average of annual number of *tropical nights,* i.e. Tmin>20°C	Comfort, energy demand
Number of frost nights	Average of annual number of *frost nights,* i.e. Tmin<0°C	Growing season, snow/sea ice cover, energy demand
Number of freezing days	Average of annual number of *freezing days,* i.e. Tmax<0°C	Snow/sea ice cover, energy demand, slope stability
Wind speed	Mean wind speed	Forestry, buildings

Table 28 presents the indices used in this study together with some examples of relevance of which *"Longest dry spell"* might be interpreted as an indicator of droughts while *"Highest 7-day precipitation", "Heavy precipitation"* and *"Extreme precipitation"* are related to floods.

Results

The overall picture for the climate change signal in "*Heavy precipitation"* (Figure 8, bottom left) follows the changes in annual precipitation: increased number of heavy precipitation events in the north and a decrease in the south. North of a line from France over southern Germany, the Czech Republic and into the northern Ukraine there will be an increase and south there will be a decrease. The change is broadly proportional to the recent climate conditions (Figure 8, upper left) of "*Heavy precipitation"*, i.e. a proportional increase in the north and a proportional decrease in the south. According to this scenario, the western slopes of Norway, Scotland and Iceland will see the largest increase of "*Heavy precipitation"* because of the intensified influx of moist air that increase the orographic precipitation in this region. Interestingly, when we compare the climate change pattern of "*Heavy precipitation"* with that of "*Extreme precipitation"*, they disagree in some important details. The general increase in the north, with its focus on the western slopes is similar, but the decrease in the south is much more localised to some few areas. This means that in this scenario there will be a general decrease in the precipitation in the south but the "*Extreme precipitation"* will not decrease in proportion. In other words, relative to the total precipitation the frequency of "*Extreme precipitation"* will increase. The same has been found on a more local scale in Sweden, where dry future summers show smaller amounts of total precipitation as well as fewer precipitation days but increased extreme precipitation.

The climate change signal in the "*Highest 7-day precipitation"* (Figure 3 in annex 2, bottom left) closely follows the pattern of changes to annual precipitation total, with an increase in the north, as well as in western and central Europe. Again, the most pronounced increase will according to this scenario take place on the western slopes of British Isles, and in Norway, where the "*Highest 7-day precipitation"* may increase with some 40-60mm/7days (locally even more), which corresponds to an increase by 30-50%. Also in France, Belgium, the Netherlands, Denmark and western part of Germany an increase of some 30% is seen in the scenario. Furthermore, in the Bavarian and Carpathian mountains, i.e. the regions that have been the source regions for devastating floods during recent years an increase is seen on the maps. A decrease is noticed mainly in Iberian and Italian peninsulas and along the Balkan coast, as well as in Greece and Turkey.

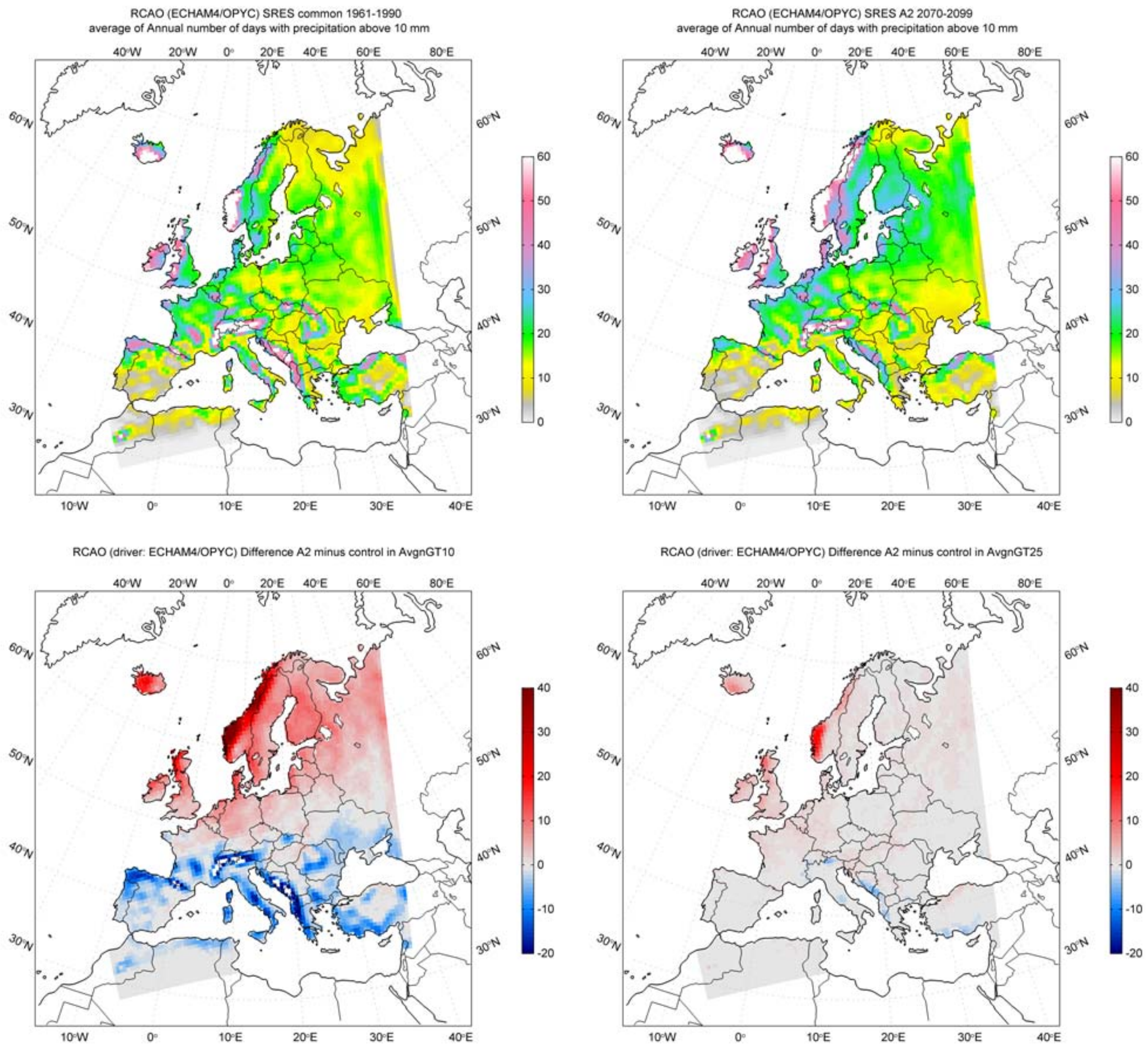


Figure 8. Changes in "Heavy precipitation", i.e. number of days where precipitation is >10 mm/day across the whole gridcell. Top left is the recent climate conditions in the RCAO-H/REF and top right is the future climate according to RCAO-H/A2 scenario run, bottom left is the corresponding climate change signal (RCAO-H/A2 minus RCAO-H/REF). The bottom right map shows the climate change signal for "Extreme precipitation" (precipitation >25 mm/day), see text for discussion.

Importance for hazard and risk mapping

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)

The uncertainties are studied and will, by time, be better characterized and eventually become smaller. Despite this, we have to be aware of that there will always be a certain amount of uncertainty involved when studying the future. To be able to make probability studies ensembles of scenarios are needed and that is the stage where climate research is heading (EU 6th Framework Programme).

Studying the indices of extremes in the *reference climate*, the conditions are similar with the two driving models. The precipitation indices show good agreement while the *"Dry spell length"* shows drier conditions in the Mediterranean and wetter conditions in central and eastern Europe in the ECH model. Summer temperature conditions are very similar while in winter conditions the Hadley model gives somewhat cooler conditions particularly over the Baltic. According to the ECH model, the wind speed will increase by 5-10% in Northern Europe, meanwhile the wind speed will decrease by the same amount in Southern Europe. The Hadley does not predict so strong wind speed changes.

The climate change signal regarding *"Heavy precipitation"* shows a distinct north-south difference with increased number of events in the north and decreased in the south (Figure 8, bottom left). The *"Extreme precipitation"* index shows that despite a general decrease in precipitation in the south the extreme events will be about the same in the future climate scenario as today. The maximum precipitation accumulated over 7 days shows increases in most parts of Europe except the countries along the Mediterranean (Figure 3 in annex 2, bottom left). The length of the annually longest dry spell is increased in most parts of Europe, except most parts of the Nordic countries (Figure 3 in annex 2, bottom right). The signal is most pronounced in areas where in today's climate the average dry spell is more than 40 days.

Both warm days and tropical nights will increase in most parts of Europe according to the scenario in this study, most abundant in southern parts and with an orographic effect (Figure 4 in annex 2, left panels). The *"Number of freezing days"* is increased with a north-northeastern gradient. The *"Number of frost nights"* shows a similar pattern but with a stronger signal also including parts of the Mediterranean area.

3.1.3 Development trends of economic and social vulnerability

Thus far the project has focused on developing hazard maps and maps on present vulnerability. In the final year of the project co-operation will be enhanced with other TPGs to develop indicators on future trends of vulnerability based on data series on changes in population density, trends in GDP and other indicators for aspects of social vulnerability.

Understanding trends of future vulnerabilities is very important for further development of planning guidelines and policy recommendations in the project.

3.2 Identification of future highly sensitive areas

Due to the uncertainties regarding the future development of the climate and moreover, the spatial fuzziness of the climate models, a direct integration into the NUTS 3 level oriented hazard and risk mapping seems to be impossible. Despite this fact, the existing data regarding heavy and extreme precipitation (by means of a differentiation between increasing and decreasing areas of heavy precipitation) can be shown in form of a hatching. By means of an overlaying with the coloured flood hazard map some most likely changes in flood hazards in Europe will be identified in the final ESPON Hazards report. The approach can be explained due to the given interrelationship between precipitation as cause and river floods as result. A similar procedure might be possible for the forest fire hazard map due to the given interrelationship with dry periods. A first approach will nevertheless be a cooperation with other European research institutes (e.g. the Joint Research Centre, JRC) to include more advanced models on floods and forest fires.

4 PRELIMINARY FINDINGS ON AN IDEAL RISK MANAGEMENT WITHIN THE SPATIAL PLANNING PROCESS

As described in chapter 2 of the 2nd ESPON Hazards Interim Report, the large number of relevant hazards, the variety of planning systems in Europe and of course the multitude of natural and socio-economic settings that differ from [place to place] make the formulation of general guidelines almost impossible. In consequence, this means that – if we have the aim to formulate appropriate guidelines – we have to somehow put them in concrete terms. In this context, the formulation of *general guidelines* for a successful planning process seems to be more promising than the formulation of *general measures* that should fit to all hazards. Therefore, this chapter concentrates on planning guidelines that focus on the integration of risk management into the spatial planning process. But at first, the general difference between planning response and policy recommendations in our project have to be clarified:

- *Planning responses* (chapter 4) are all measures, instruments and methodologies that are applied by "planners" respectively the administration or executive level. Therefore, the addressees of the planning response suggestions are planning authorities on different spatial levels. Another distinction is, that suggestions for planning responses aim at possible improvements and further developments inside the given institutional and legal framework.

- *Policy recommendations* (chapter 5), the addressee of the projects' policy recommendations is the European Union / European Commission respectively the political or legislative level. (Of course, policy recommendations that are formulated by the European Commission can nevertheless address any lower – national, regional or local – level.). The implementation of these recommendations needs - in contrast to planning responses - changes in the present institutional and legal framework.

Thus, in chapter 4 we take the "bottom up" perspective and formulate developing policy recommendations that can feed into the more top-down developed policy recommendations of chapter 5.

4.1 Ideal risk management process from a theoretical point of view

4.1.1 Ideal planning process

In this sub chapter, the theoretical or ideal steps of a planning process will be described, followed by a description how the steps of the ideal risk management process can be integrated into the spatial planning process. When looking at different visualisations of planning processes, one can discover a large variety of flowcharts that describe them (e.g. the "classic" flowchart of a planning process of Harris 1967, p. 325). But looking closer, some basic similarities can be found that are typical for every planning process. Four typical phases of a planning process can be distinguished (see figure 9):

1. Normally, a planning process is started when certain conditions in the real world are regarded as unsatisfactory or as demanding urgent action. The first phase of a planning process is therefore called *problem analysis*. A prerequisite for the *identification of problems* is the observation of the environment by planners or other persons and the

description and assessment of the existing information. To avoid an unnecessarily high effort of *data collection* it is reasonable to set planning targets and to develop *goals* that describe the desired future condition. Such goals are generally not fixed but rather flexible and always underlie certain changes. So when collecting data, it is important that only those data should be surveyed that are necessary for describing the relevant conditions. On the basis of the deliberately collected data an *analysis of the existing conditions* can be done. The aim of such an analysis is to identify the dependencies, interactions and interrelations between the observed circumstances and influencing variables.

2. Based on this, in the second phase, the necessary measures can be determined after planning *alternatives have been assessed*. When *measures are identified* to solve a problem, one has to consider, that there is generally always more than one solution. Therefore it is reasonable, and sometimes even stipulated, to develop alternative plans, programmes or instructions. Experience shows that the development of alternatives under thorough consideration of all aspects that come into question generally lead to good results. In this context it is indispensable to also *estimate possible impacts* of the alternatives. To *assess* the alternative measures, a detailed discussion of the presented alternatives shall be done. A crucial point is to examine if, and to which extent, the different measures serve to fulfil the desired goals. The more complex the alternatives are, the more likely formalised assessment methods like cost-benefit analysis or value-benefit analysis have to be taken into consideration.

3. After the discussion of the alternatives has been finished, the third phase of the planning process can be entered. Now a *decision* can be made which suggestion is considered to be the best. Simultaneously, the necessary *measures* for the realisation of the selected alternative can be determined and prepared.

4. The *implementation* of the selected alternative results in a change of the initial conditions. In general it is therefore necessary to examine if the projected impacts and improvements have occurred or if unexpected (and often not desired) side effects have emerged. Over time the general conditions might change and also, often as a result of previous plans, new problems may arise which require to start the planning process from the beginning. Of course, in reality a planning process seldom resembles in such an ideal way but rather has to be adjusted to certain circumstances. The following figure shows the "ideal" planning process.

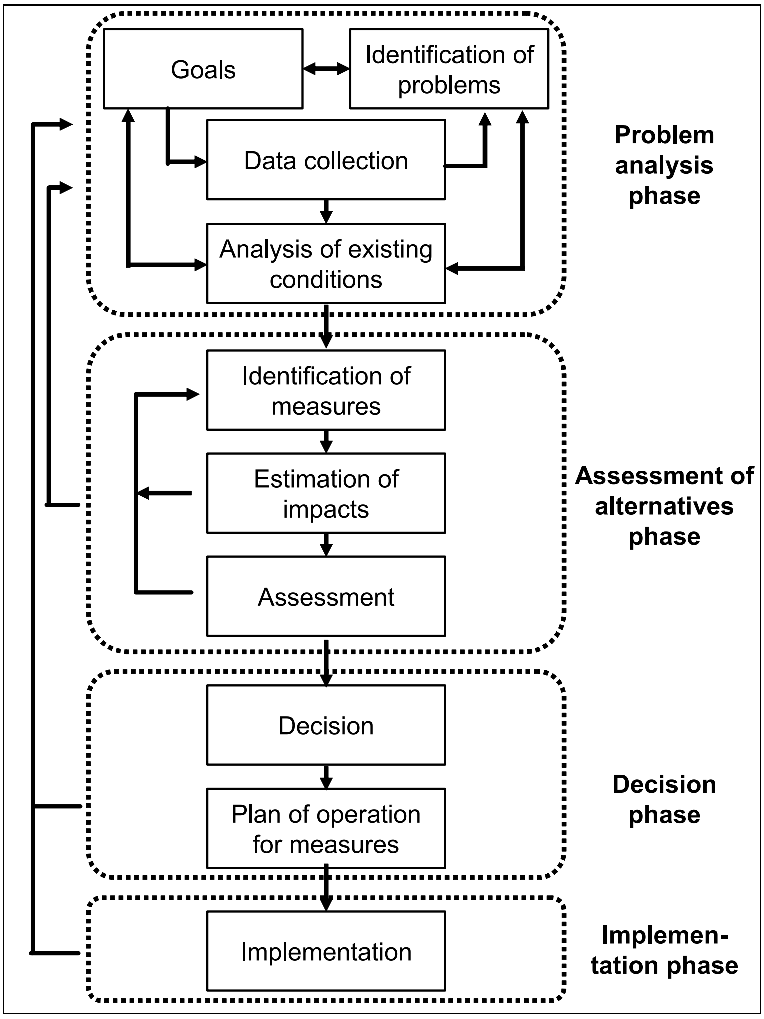


Figure 9. Ideal planning process. (Source: ESPON Hazards, 2003)

After the description of the ideal risk management and planning process, it has to be shown how the two can be integrated. The following figure highlights the main points of contact of the integration of risk management into a spatial planning process.

4.1.2 Risk management as an integrated part of the spatial planning process

It is a fact that often very well designed measures do not have any effect at all because of the existence of typical planning problems (e.g. fit, interplay and scale). Especially the problem of interplay (see 2nd ESPON Hazards Interim Report, p. 152 f.) is a crucial factor for mitigating spatial risks: Most institutions interact with other similar institutions both horizontally and vertically. Horizontal interactions occur at the same level of social organisation. Vertical interplay is a result of cross-scale interactions or links involving institutions located at different levels of social organisation. Interplay between or among institutions may take the form of functional interdependencies or arise as a consequence of politics of institutional design and management (Young 2002, p. 19 ff.). The problem of interplay is a consequence of the existence of a multitude of actors. Normally, national planning systems hold a second, sectoral dimension with own organisational units, instruments and authorities. The differences of the material purpose in connection with the different authorities permit hardly any internal harmonisation through a common superior authority. Thus again and again problems of the co-ordination and the sphere of responsibility occur in planning. The relationship between comprehensive spatial planning and sectoral planning divisions is a crucial factor for mitigating spatial risks. Nevertheless, in contrast to spatial planning, the EC has strong legal competences and hence a great number of powerful directives in the field of sectoral planning, especially environmental planning (SEVESO II; Flora Fauna Habitat, Water Framework Directive).

The problem of interplay shows that the process area plays an important role for a successful planning response towards hazards. In the following, risk management will be understood as the systematic application of management policies, procedures and practices to the task of identifying, analysing, assessing, treating and monitoring risk (see glossary, broader definition of this term). The following explanations go hand in hand with the flowchart of a risk management process (see figure 10).

Hazard identification
The starting point is the identification of hazards. This task is mainly a determination based on scientific and technical findings. Identification as well as analysis of hazards and risks are mainly tasks for the sectoral planning divisions 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, would be an essential prerequisite for an effective planning process.

Risk analysis
This scientific, deterministic approach characterises also the next step, the risk analysis as a mathematical calculation which includes the analysis of a hazard and its consequences. The risk analysis can be understood as a description of certain hazards respectively their elements frequency of occurrence (hazard component) and magnitude of consequences (risk component). Like the hazard identification, the spatial planning authority needs the support of the sectoral planning divisions. In an ideal case, the necessary information could be derivated from existing hazard and risk maps with – of course – an appropriate spatial scale.

Risk evaluation
Risk evaluation as a part of the evaluation of the effects of certain plans on the environment 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. Due to this fact, an extensive participation of the public would be a suitable indicator for fulfilling this requirement.

Risk assessment
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.

Decision making
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 one should deal with hazards: What are the aimed 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? Thereby it is from a cost-benefit point of view indispensable to set the protection goals in relation to the protection objects. While it make 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 this kind of decision needs an adequate information basis, which has to be taken into account in the decision making process.

Planning of measures
Having in mind the defined protection goals, appropriate measures have to be carried out as an integrated part of the decision-making for the respective plan or programme. The measures, respectively alternatives can be differentiated into prevention oriented mitigation, non-structural mitigation and structural mitigation. Moreover, measures regarding disaster preparedness, response and recovery should be an integrated part of a risk management process. Each measure has to be evaluated regarding its technical functionality, economic costs and efficiency as well as social and ecological effects.

Implementation of measures
The implementation of measures is an integrated part of the implementation of the plan or program by the planning authority itself and/or other planning authorities, which are in charge of sectoral tasks. For that reason sectoral planning divisions as well as emergency control units should be part of this implementation. In other cases, companies or private stakeholders who are the addressees of a certain plan or program could be responsible for the improvement of their own buildings or facilities.

Monitoring
An important part of a risk management process consists of the monitoring of the effects of implemented measures. It represents the way in which the outcome of the risk assessment has been carried 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 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.

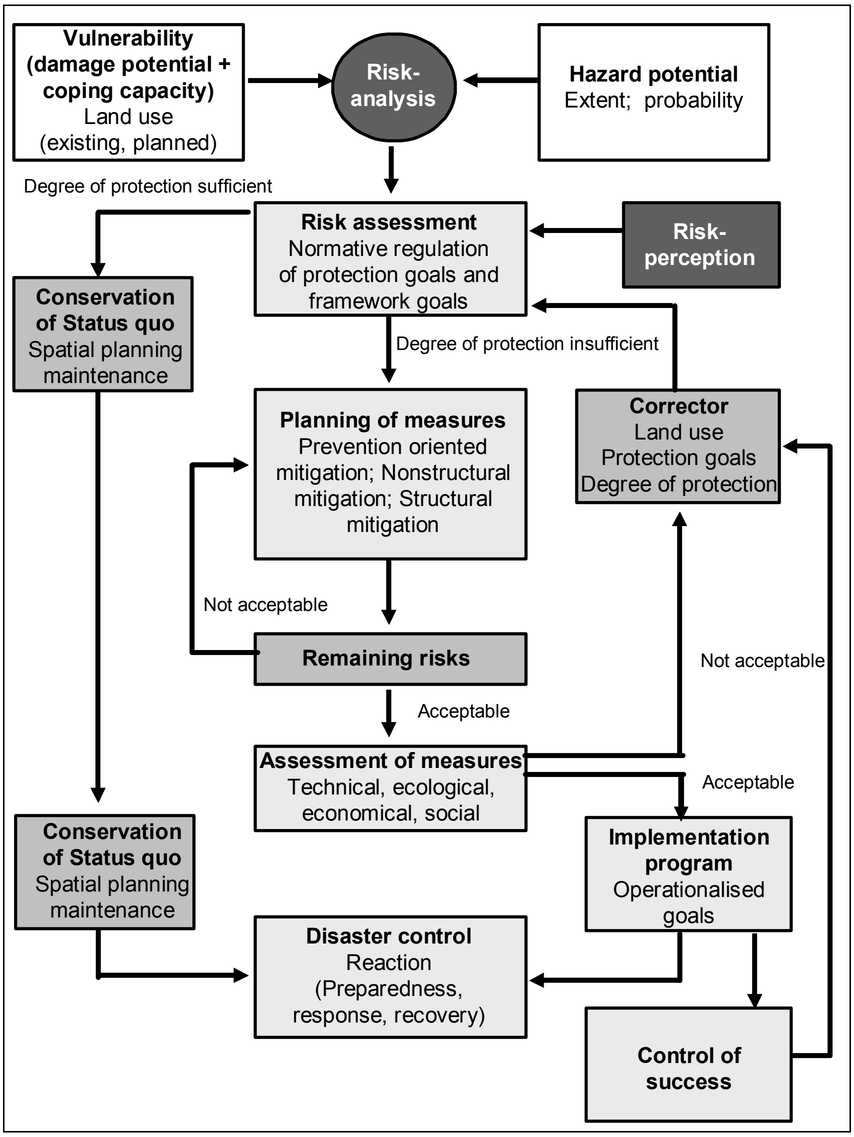


Figure 10. Ideal risk management process (Greiving 2002, p. 248)

4.1.3 Framework for assessing risk related spatial planning

The ideal risk management process as an element within the spatial planning process will be used as a framework (or checklist) for assessing the spatial planning related risk management (which could be described as a part of the regional coping capacity) in the five pilot regions (see chapter 4.2). Such a checklist can be structured along three main argumentation lines:

1. *Scientific basis:* Are there appropriate data, are the necessary data and assessment methods available (e.g. hazard maps, risk maps) for developing a scientifically correct foundation for the decision making process?
2. *Political decisions:* To which extent is the scientific basis considered when political decisions are made? What are the reasons for neglecting information about hazards and risks? How and to what degree had the results of the assessment of risks been taken into account in decision-making about specific plans or programs?

3. *Implementation process:* Once a decision about a measure has been made, how sure will it be implemented in reality? What are the possible hindrances?

The following figure shows how these three argumentation lines are incorporated in the ideal planning and risk management processes.

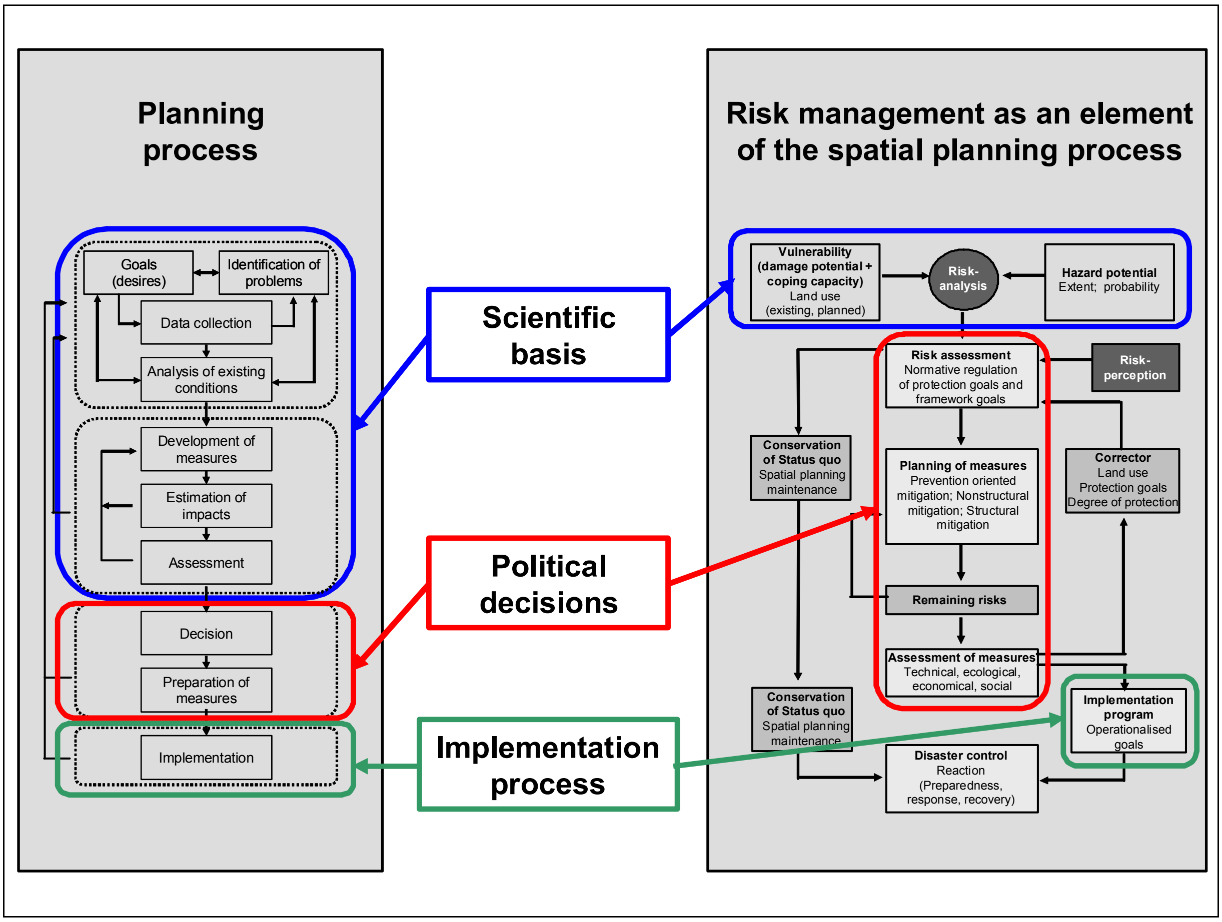


Figure 11. Comparison of ideal planning processes along the criteria of the scientific basis, political decisions and the implementation process. Source: ESPON Hazards, 2003.

4.2 Assessment of risk and hazard related spatial planning in three case study regions

The different steps of the ideal risk management concept set the criteria for a "checklist" to assess risk related spatial planning in the three selected case study regions of Dresden (Germany), the Central Region of Portugal and the Avançon (Switzerland). The German and Portuguese regions were chosen because they differ in their classification of regional planning whereas in the typology of regional authorities they are similar (see also 2nd ESPON Hazards Interim Report, p. 146 f.):

- *Dresden Region:* Institutionalised regional planning that includes binding regional plans (category A in the classification of regional planning in Europe) and a region with no power (type 4 in the typology of regional authorities).

- *Central Region of Portugal:* Institutional regional planning without binding effects (category B) and a region with no power (type 4 in the typology of regional authorities).

Further, the Avançon Region was chosen as a non-EU region. For assessing how well a region performs with its planning related coping capacity towards risks and hazards ("distance from ideal planning process") the three regions have been "checklisted".

For most of the questions in the checklist, the necessary information has already been collected during the work on the case studies done before. The aim of this questionnaire was to use the results of "checklisting" the case study regions as a starting point for formulating planning guidelines and later policy recommendations (the "bottom up" part in contrast to the "top down" part which is a result of the hazard and risk maps). The following table shows the questions that have been sent to the case study partners.

Table 29. Checklist for the assessment of risk management related aspects within the spatial planning process. Source: ESPON Hazards 2004.

Scientific basis	
Hazard identification by sectoral planning divisions or have they at least been involved?	*Which hazards are relevant? Is data about hazards (frequency, magnitude) available? Do hazard maps exist?*
Risk analysis by sectoral planning divisions or have they at least been involved?	*Is data about vulnerability (damage potential, coping capacity) available? Do risk maps exist?*
Coordination between spatial planning authority and sectoral planning divisions about hazards?	*Is data exchange possible? Do institutionalised communication procedures exist?*
Political decisions	
Risk evaluation by spatial planning authorities?	*Is risk perception taken into account? Is there any public participation?*
Risk assessment by spatial planning authorities?	*Is all necessary information of the risk analysis and the risk evaluation available? Is all information taken into account when assessing the risk?*
Risk related planning goals set up by spatial planning authorities?	*What are the protection goals for the protection objects which are threatened by certain hazards? Is the setup of protection goals made on an adequate information basis?*
Measures suggested by spatial planning authorities? To what extent are certain measures (a) coordinated with other (planning) authorities and (b) binding for other (planning) authorities?	*Are different/alternative measures suggested and discussed? Do measures cover the whole range of prevention-oriented, non-structural and structural mitigation? Are measures evaluated regarding its technical functionality, economic costs and efficiency as well as social and ecological effects?*
Implementation process	
Public stakeholders involved in the implementation process?	*Is the implementation process adjusted among the relevant stakeholders (spatial planning authorities, sectoral planning divisions, emergency control units)?*
Private stakeholders involved in the implementation process?	*Are private stakeholders (companies, private households) informed about their roles within the implementation process?*
Monitoring of implementation process?	*Are the effects of the implemented measures monitored? Do indicators exist that answer the question if the chosen measures were able to fulfil the determined protection goals? Is there a critical reflection of the measures?*

For the Dresden region this questionnaire was carried out on the regional level. For the Central Region of Portugal there exists no comparable regional authority so the checklist had to be applied to the municipalities. In the Avançon case the questionnaire was also carried out on the regional level.

The results of this analysis (see annex 3) have proven the former hypothesis that in the EU case studies there is no systematic and spatial oriented approach of analysing, evaluating and mitigating spatial risks – neither on local nor on regional level (like, e. g. in the U.S.). Further, the German and Portuguese case study analyses did not reveal any positive suggestions that could have been used for the formulation of planning guidelines. This deficit state of the art in planning practise highlighted the importance of the development and implementation of the "ideal risk management process". The Swiss case study has shown some evidence on this score. Such a risk management process grounds on a systematic theoretical basis (see chapter 4.1) as well as long term mitigation experience in the USA and other countries (like Switzerland) that are threatened by a couple of serious hazards.

4.3 Preliminary findings for planning guidelines on risk related spatial planning

This sub chapter aims at to formulating planning guidelines for risk management related spatial planning. The resulting planning guidelines presented in this section derive from the study of existing literature (systematic approaches, best practice examples). Our suggestions are supported by the results of the analysis of the spatial risk management in the case study areas (chapter 4.2).

Planning guidelines can go into three directions: They aim to improve measures, processes or methodological tools. At first, these terms are described in the context of our project as follows:

- *Measures:* Planning guidelines finally lead to certain measures which aim to improve a situation. Measures are often very specific and it is a problem to simply apply the same measure in another town or region or to a different problem. This means that, whenever we talk about planning guidelines that focus on measures, we always focus the perspective on *very specific problems and circumstances*.

- *Processes:* The success of spatial planning action is not only a function of the existence of appropriate measures but also of the way how they are embedded into the planning process. The planning process itself is an expression of the existing institutional arrangements, responsibilities and capacities. Although the planning process is also dependent on local or regional characteristics it is more likely to formulate criteria that generally support a successful planning process. So, if we talk about planning guidelines that focus on processes, a *broader point of view,* respectively a harmonisation forward to territorial cohesion is possible.

- *Methodological tools:* For spatial planners, appropriate methodologies could be described as indispensable equipment. Without a suitable set of methodologies, it would be improbable to analyse, asses and estimate a certain hazard on the one hand and manage its consequences on the other hand. Due to the fact that hazards are based on universally valid physical processes, it would be possible to suggest a set of suitable methodologies (e. g. hazard and risk maps) as a part of the planned spatial planning guidelines.

In the 2nd ESPON Hazards Interim Report it was discussed if planning measures could be an area of policy recommendations. For this alternative, we suggested to categorise planning guidelines according to measure categories for certain hazards and different planning levels. But the ongoing work in the project showed that this procedure would not be manageable due to limited financial, personnel and time resources (it is impossible to assess all relevant measures because too many specific aspects have to be taken into account for 14 hazards in 27 countries on 5 spatial levels). Consequently, we do not follow the suggestion made in chapter 2.7 in the 2nd ESPON Hazards Interim Report (p. 154 ff.).

Instead, we suggest to restrict general planning guidelines to the area of processes because the integration of risk management and spatial planning is the most crucial aspect in this context. Also, the focus on processes serves the integrated spatial approach much more than the focus on measures (for single hazards, e. g.). This also enables us to further develop the section on national, regional and local actions or policies addressing risk management and their integration within the spatial planning process. Here, the project follows the remarks made by the European Commission[2]. Some of these further developments belong to planning guidelines and will be described in the following whereas other aspects are policy recommendations and will be discussed in chapter 5.2.

The area of methodological tools will not be discussed as a single point because methodological tools are included in the discussion about the integration of risk management and the planning process (see chapter 5.2.2). In addition we will come back on methodologies when talking about policy recommendations in chapter 5.2.4 (e. g. harmonisation of methodological tools like risk maps and hazard maps).

4.3.1 Regional planning level and land-use planning level of planning guidelines

In terms of institutional vulnerability and coping capacity, the role of spatial planning is a central concern for the ESPON Hazards project. Planning can be seen as a crucial factor in reducing losses from disasters. The setting up of guidelines for a spatial planning response to technical and natural hazards focuses on the regional as well as the local level. First it has to be recognised that spatial planning acts on different spatial levels. Therefore, the appropriate level of space related risk planning has to be addressed by planners and planning instruments.

For natural and technological hazards an important level is the *regional level* because the local level is too small in scale for appropriate risk reduction planning. The main reasons for this are the existence of individual local interests of the municipalities as responsible actors for the land-use planning and the usual large scope of the hazards and their consequences. Therefore, the main task for regional planning and/or regionalised structural funds as responsible actors should be the setting of a framework for local mitigation activities. Having

2 Email from Mr. Albas on October 17, 2003.

in mind the described "ideal risk management process" the regional level has to take the responsibility for setting the protection goals (and objectives) in cooperation with all relevant actors. This includes the municipalities, sectoral planning divisions and private stakeholders.

In the light of the above mentioned process, the *local level* should be responsible for the selection of appropriate measures and their implementation that aim to fulfil the fixed goals, because of its 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.).

Due to this shared responsibility, an appropriate monitoring system on the basis of suitable indicators (see chapter 5.2.3) has to be carried out. The regional authority, which takes the responsibility for the setting of the protection goals, should be responsible for the monitoring in order to assess the success of the arranged measures regarding the relevant protection goals.

4.3.2 Towards a handbook for risk mitigating on regional and local level

The following suggestions for a "Handbook for Mitigating Natural and Technological Risks" are based on the ideal risk management process and the results of the answers to the checklist on risk management in the case study areas. Further, existing risk management approaches have been analysed and applied to the ESPON Hazards context (Cutter, Mitchell and Scott 1997; POMA 1999). The following table gives an overview of the elements of the mitigation planning process on the regional and local level that are explained further below.

Table 30. Overview of the elements of a spatial mitigation planning process. Source: ESPON Hazards, 2004

Scientific basis		
	Region	**Municipality**
Hazard identification	• 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 minimize future losses from the effects of hazards on the regional and local level	• 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")
Risk analysis	• 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)
Coordination between spatial planning authorities and sectoral planning divisions	• 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)	• Many of the databases used for identifying hazards and vulnerabilities need additional verification especially at the local level

Political decisions		
	Region	**Municipality**
Risk evaluation and risk assessment	• 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 (Delphi method, like described and successfully applied in the case study regions, see chapter 2)	• 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) • Weighting / identification of the relevance of risks on the local level (Delphi method; results from the regional level)
Risk related planning goals and measures	• 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) • Reach consensus among all relevant actors (municipalities, sectoral planning divisions, private stakeholders)	• 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.) • A collection of possible measures can be used as a checklist to ensure that every possible measure will be considered
Implementation process		
	Region	**Municipality**
Involvement of public and private stakeholders in the implementation process	• Draft regional mitigation plan made available for review by the residents and businesses who will be affected, appropriate municipal departments, interested organizations, 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 organizations and neighbouring municipalities • Distribute responsibilities for the implementation of measures to persons and institutions
Monitoring and evaluation of implementation process	• 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

In the ESPON Hazards project, mitigation is defined as “a proactive strategy to gear immediate action to long-term goals and objectives” (2nd ESPON Hazards Interim Report, p. 16). 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 emphasized 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.

Elements of a framework for spatial risk mitigation

The ESPON Hazards project suggests that every European region and municipality should be aware of possible risks due to natural and technological hazards and in case of the existence of a certain risk degree should mitigate the risks. The shared responsibilities between the regional and local level is described in chapter 4.3.1. This risk mitigation should be derived from the ideal risk management process. The following framework of a risk mitigation planning guide presents the main elements of this spatial risk mitigation or risk management, respectively, and can be applied on the regional or local level. The specific distinctions of the risk mitigation on the regional and local level are compared in table 30. In general, a spatial risk mitigation planning guide has the following purposes (POMA 1999, p. 4):

- minimize the impacts of the effects of hazards on people and (built) environment,
- review the hazards of the respective area (region, municipality),
- establish goals and objectives,
- review a range of possible approaches to reduce risk,
- identify the highest priority mitigation strategies and policies,
- identify potential future actions to implement those measures that appear to be effective and appropriate for the area,
- provide a background document (on the regional level) for local action.

Scientific basis

Hazard identification: 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 minimize future losses from the effects of such hazards. After the relevant hazards have been identified, the hazards should be examined along the aspects of “source of the hazard”, “area affected”, “threat to life and safety” and “property damage”.

Risk analysis:

a) *Hazard frequency of occurrence:* So far, the hazard frequency of occurrence has been based on the historical occurrence of disasters. There was no actual need to determine the hazard frequency because the hazards were put into relative classes from 1 to 5. Cutter, Mitchell and Scott (1997, p.12) suggest a different way of a relative comparison of hazards. According to their approach, the frequency of occurrence could be a straight-forward calculation from the historical data and the length of that record in years. The number of hazard occurrences divided by the number of years in the record yields the probability of the event occurring in any given year. For instance, if a hypothetical hazard “A” occurred 17 times in a certain area over the past 23 years, the probability of occurrence for that hazard “A” in any given year is 17/23 or 0.739 or less than once a year. No matter which way will be chosen, in the end there has to be a relative scale; we suggest hazard intensity classes from 1 to 5.

b) *Calculating vulnerability scores:* The overall vulnerability (see chapter 1.2) will be determined by a combination of the core indicator of vulnerability (Population density = 50%) with the economic vulnerability (GDP/capita = 25%) and social vulnerability (coping capacity indicator = 25%).

c) *Identification of spatial risk:* The final step in the procedure is to combine the hazards map and the vulnerability map to produce the overall risk analysis

Coordination process: Along with the hazard identification and the risk analysis there is a need for gathering the necessary data. Many of the databases used for identifying hazards and vulnerabilities on the NUTS 3 level, for example, need additional verification especially at the local level. It is extremely important to understand the limitations of the data sets that are used. 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. Therefore, a regional data pool, containing relevant hazard and vulnerability data should be installed as a basis for further investigation. This has to be coordinated among the different institutions.

Political decisions

Risk evaluation and risk assessment: Getting everyone to agree on the relevance of certain risks (or maybe not) is the first step to getting them to agree on goals and solutions. Therefore, after the spatial risk has been analysed the next step is to evaluate risk by taking the aspect of risk perception into account. This can be done if a participation process will be started that includes the public but also experts from spatial and sectoral planning divisions. Therefore, first the significance of hazards has to be evaluated (e. g. with the Delphi method, described in chapter 2, which has lead to plausible results and judged as an adequate method by participating regional authorities). Second, on the ground of the given hazard intensity and the vulnerability of the area, the resulting risk has to be evaluated: To what extent is a certain risk acceptable or not? (see 1st ESPON Hazards Interim Report, p. 80 ff.; WBGU 2000, p. 42 ff.). This has to be taken into consideration when the risk assessment will be finalized.

Planning goals:

- *Set planning goals:* The “Community Planning Handbook for Natural Hazards Mitigation Planning in the Metro Region” describes the step of setting planning goals as follows (POMA 1999, Appendix One, p. 10): Until now, the steps of the risk management process have been relatively non-controversial as there has been a collecting and recording of facts by talking to agencies and organizations. The challenge is to find common agreements on implementation strategies. Goals are general statements of direction, such as “reduce flood damage to existing buildings” whereas objectives are more specific targets. An example of an objective that supports the mentioned goal could be “reduce the damage potential in the area A by X%”. Planning goals will be set on the regional level. Goals and objectives and other potentially controversial issues may have been resolved in previous efforts that resulted in other local plans. More likely, those involved in a certain planning process need to identify and clarify their concerns and goals to reach agreement on the wording of goals and objectives statements (POMA 1999, Appendix One, p. 10). Because risk related goals as described here are not yet implemented in European regions, this aspect will be discussed more deeply in chapter 5.2.2 of the policy recommendations.

- *Reaching agreements:* It is often easy to reach agreements 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. However, the time spent is well worth it in order to gain the agreement and cooperation from all affected. 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 finding process. Positive goal statements provide people with more incentives to work on the mitigation plan than negative statements about a community. Where possible, the focus should lie on goals and objectives that support more than one interest (e.g., implementation of erosion reduction measures to sustain farmland, improvement of water quality and reduction of sedimentation in stream channels.) Generally, "agreement" means consensus or something everyone can live with. It is important to strive for unanimous support or at least the agreement of no active opposition on a goal or objective statement. Short of that, it is important to judge if a decision by majority vote can improve the planning process or hide potentially damaging opposition until the plan is considered by policy makers in a public forum, perhaps resulting in a political battle. (POMA 1999, Appendix One, p. 10).

Measures: As there exists a large variety of mitigation measures it is not possible to name and describe them here. An example for suggested measures for a certain area can be found in the "Regional Hazard Mitigation Policy and Planning Guide" (POMA 1999, p. 23-47). A collection of possible measures can be used as a checklist to ensure that every possible measure will be considered. No measure should be discarded until the issues are fully understood. While some of the measures may be quickly eliminated as in appropriate, most will deserve careful consideration to ensure a full understanding of how they might work, their benefits and costs. After reviewing each possible measure it should only be discarded after the following questions are answered in the negative:

- Is the measure technically appropriate for the hazard (or the risk as a whole)?
- Does it support any of the set goals and objectives?
- Do benefits equal or exceed costs?
- Is it affordable?
- Can a source for funding implementation be identified?
- Will it comply with all local, regional, national and European regulations?
- Does it have a beneficial or neutral impact on the environment?

Implementation process

After assessing the problem, setting goals and objectives and reviewing all the possible solutions, the most appropriate actions have to be selected and recommended which culminates in the *mitigation plan* (see chapter 5.2.3).

Involving public and private stakeholders: The draft plan should be made available for review by the residents and businesses who will be affected, appropriate municipal departments, interested organizations, state and federal agencies and neighboring municipalities. After people have had several weeks to digest the plan, a public meeting or workshop should be held. A public meeting is a requirement for many funding programs. In preparing for a public meeting, adequate notice of the date, time and place must be given and information about the plan should be distributed well in advance. The best notice is a flyer, brochure, or other announcement with a summary of the plan delivered to all parties that may be affected. The notice should tell people where they can obtain a copy of the draft plan for review before the meeting. After the meeting, the relevant planning institution should make appropriate changes to the plan. To have a strong impact, the plan must be adopted by the relevant governing board (POMA 1999, Appendix One, p. 14)

Implementation, Monitoring and Evaluation:

- *Implementation:* The people responsible for various recommendations in the plan must understand and agree to their roles in implementing mitigation measures. Implementation agents – such as representatives of local operations and maintenance agencies – must participate in the planning process. It would help greatly if the plan (or the governing board's resolution of adoption) clearly identified a person responsible for each recommendation. It is also helpful to make some mitigation plan recommendations a core activity of the implementing agency or organization. For example, people responsible for implementing specific mitigation measures might have those duties included in their job descriptions or annual performance plans. The plan should identify some very visible but inexpensive projects that can be quickly implemented. This helps assure the public and the planning committee participants that the work of planning generates results. For example, locally funded projects (because they typically get done more quickly) such as a stream cleanup or distribution of public information materials may be initiated shortly after mitigation plan adoption (POMA 1999, Appendix One, p. 15).

- *Monitoring:* No plan is perfect. As implementation proceeds, flaws will be discovered and changes will be needed. A plan should have a formal process to measure progress, assess how things are proceeding and recommend needed changes. Those responsible for implementing the various recommendations probably have many other jobs to do. A monitoring system helps ensure that people remember their assignments and project timelines. Monitoring can be as simple as a checklist maintained by the person designated as responsible for the plan or a more formal reporting system, such as regular reports to the governing board or an oversight committee (POMA 1999, Appendix One, p. 15).

- *Evaluation:* Even with full implementation, the plan should be evaluated in light of progress and changed conditions. The planning committee should meet periodically to review progress and submit its recommendations to the agencies and organizations responsible for implementation. While a plan will usually produce the best and most efficient program, a municipality should be ready to act fast to take advantage of opportunities provided by disasters, receipt of unanticipated revenue, changes in the municipality's priorities or heightened public interest due to disasters elsewhere. These changes may represent opportunities to implement mitigation measures more quickly (POMA 1999, Appendix One, p. 15 f.).

4.3.3 Further investigations

The section about planning guidelines is still open for further investigations. The following aspects have to be elaborated more in detail for the final report:

- *Handbook for Mitigating Natural and Technological Risks:* The proposed handbook has to be described in more detail. Towards the Final Report we suggest to further develop the first findings for a handbook for risk mitigation that take into account different categories and typologies of regional planning and regional authorities in

Europe. The final output would be different combined modules of risk mitigation elements in a handbook that can be applied in different Member States of the European Union.

- *Ideal planning process:* The steps of the ideal risk management process have only been basically sketched so far. Here, a more detailed description is desirable, too.

5 FIRST POLICY RECOMMENDATIONS

5.1 Introduction

The unequal distribution of natural and technological hazards in Europe presents a challenge for balanced and sustainable development in Europe. Citizens, cities and regions are exposed to hazards in varying degrees, placing them very different "risk positions" across Europe. Policy instruments should contribute to even out these differences. 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.
The need for a risk management perspective is comparable to that of the inclusion of the "environment" in-to community legislation and policy measures. This has grounds in the EU-treaty. Territorial cohesion adds an extra dimension to economic and social cohesion (SUD 2003, 20). 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 EU policies also relevant to territorial cohesion.

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".*

Summing up, 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. Yet another necessary task at the local and regional levels is to integrate different hazards into one management scheme, taking into account their interrelated nature.

With a multitude of hazard-relevant actors and institutions, the issues of integration of policies as well as the interplay between actors becomes 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 of 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 and is emphasised still visible in the 3rd cohesion report and the ESDP.

Moreover, natural and technological hazards do not simply fall in the category of "environmental protection". Rather, they are hybrid phenomena involving complex socio-ecological processes and bring together 'distant relatives' such as nature protection and civil protection. Furthermore, hazards expand the perspective of environmental policy into the areas of security policy through the notion of environmental security.

Focus on vulnerability

Another 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. From this perspective, spatial and urban planning should be seen as key tool in reducing vulnerability. In accordance with the preventive orientation, stress should be put on a broader strategy of *vulnerability reduction, i.e.* not putting people and other valuables in harms' way. Such efforts should be coordinated with civil protection measures.[3]

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, among other things, that extreme events are *created by context* and that vulnerability reduction is a human rights issue while risk reduction is not.

Hence, more attention should be paid to the context of extreme events, instead of the events themselves. This means shifting attention and resources from predictive measures to robust preventive measures. Consequently, the processes that put people and valuable assets in harm's way, should be better understood.

One implication of this is that '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 fact, climate change seems to have acquired attention from the policy and research communities, which is disproportionate to it's significance as a driving force affecting risk patterns across Europe.

The greatest damage potentials in both human and monetary terms are concentrated in European cities and urban agglomerations. These areas are clearly a priority in risk reduction efforts. However, major cities have traditionally been rather well protected against different hazards. Today, the 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). It should also be noted that vulnerability is not determined only by relative distance from hazards but is coupled with social factors such

[3] Since the ESPON 1.3.1 project has concentrated on the spatial planning dimension of risk management, all aspects of civil protection (e.g. emergency response) are not within the scope of the project. Civil protection tasks relating to spatial planning are most interesting in this perspective.

as poverty and low levels of education etc. Therefore social and economic cohesion are also very important contributors to coping capacity in the face of hazard and disasters. From the vulnerability perspective, understanding forces that put people 'at risk' is just as important as understanding the mechanisms of hazards and disaster events *per se*.

The use of EU instruments is especially crucial in those regions where growth and development are very fast. The rapid growth of GDP figures implies that risks might be increasingly taken in relation to environmental regulation. In the new member states it will be especially important that the Structural Funds don't emphasize economic development at the expense of environmental protection or social welfare. This is especially true in the case of natural and technological hazards, since unrestricted development in hazardous regions needs to be halted. (Roberts 2001)

The rest of this chapter shall first focus on aspects of resilient regional planning, including preventive mitigation planning (chapter 5.2). Second, policy recommendations are discussed at the EU-level (chapter 5.3) focusing on the role of hazards and risk reduction in the key areas of EU regional policy and Environmental policy. Finally, some recommendations are made concerning research and monitoring needs.

5.2 Resilient regional planning

Policy recommendations go beyond the improvement of the work within already existing administrative structures or the already existing planning system which was the main aspect of chapter 4.3. In this chapter, resilient regional planning focuses on policy recommendations that are of spatial relevance and that extend the present set of strategies, concepts or instruments. The suggested policy recommendations are based on three columns: (a) case studies, (b) literature research/best practice examples, (c) taking into consideration different categories of regional planning.

The following spatial relevant policy recommendations cannot be applied to every member country equally. Therefore it has to be pointed out that the *space-type-concept* is valid for member states with a legally binding regional planning whereas the *arrangement of objectives* and the *mitigation plan* are valid for all member states.

5.2.1 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. According to the classification of regional planning in Europe, these countries belong to category A (see 2nd ESPON Hazards Interim Report, p. 146). 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 that 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 ESPON Hazards 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 floods 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. Diploma Thesis at the Faculty of Spatial Planning, University of Dortmund, Germany, supervised by Stefan Greiving).

5.2.2 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 (categories B and C; see 2nd ESPON Hazards Interim Report, p. 146). 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 4.2). 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 explains 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 that threaten a certain area.

Table 31. Arrangement of objectives – example. Source: ESPON Hazards, 2004.

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 €

5.2.3 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 most important output of the risk management process (see chapter 4.2). Although not only restricted to spatial issues, a mitigation plan offers the possibility to integrate sectoral and spatial goals, as well as objectives and measures, and is therefore 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. Mitigation plans 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 organization is shown in figure 7. 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) understand the background and rationale for 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 organization'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 7. Example of a Mitigation Plan Organization (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 below, Ch. 5.3.5)

5.2.4 Obstacles and measures for achieving the ideal risk mitigation process

The problem of interplay (see chapter 4.3) is vital on many national levels in Europe and especially on the European level as there exists no central coordination unit like, e. g. the Federal Emergency Management Agency (FEMA) in the U.S. which 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. A solution to the problem of interplay could be the creation of such a coordination unit on the European level, e. g. a European Emergency Management Agency (EEMA), similar to the Federal Emergency Management Agency (FEMA) or the European Environment Agency (EEA).

This organisation should be responsible for:

- the continuing coordinated observation and monitoring of hazards including the given interrelationships between certain hazards in the member states
- the 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.
- Coordination of cross-border activities between the member states, as well as 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
- Providing of competitions for regional and local mitigation activities
- harmonising the methodological tools within the mitigation process (hazard maps, risk maps, weighting of risks etc.).

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.

5.3 Hazards and risk management in relation to EU policies and programs

So 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 than those addressing natural hazards. (e.g. EEA 2003, 62-63)

There are several elements in EU legislation, policies and programmes, however, pointing at the need 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. These points are discussed below, addressing both EU Regional policy and Environmental policy and the integration between the two.

5.3.1 Hazards and the ESDP

The European Spatial Development Perspective (European Communities 1999), Goal 142 underlines, that *"[...] spatial planning at suitable government and administrative levels can play a decisive role here, as well as 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."*

Moreover, as part of the so-called "post-ESDP" process, 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).

Conclusively, the ESDP and the SUD call for the inclusion of hazards into regional policy. They specifically stress the importance of natural hazards, while man-made and technological hazards receive less attention. This bias, however, has grounds in the fact that technological hazards are better covered through existing EU legislation (especially the "SEVESO II" directive). Overall, the unofficial and non-compulsory character of the ESDP means that is – at least for the moment – unlikely to significantly influence EU policy (e.g. Atkinson, 2001, 399). The lack of EU-level authority in spatial planning makes it all the more important to ensure that the sectoral policies of the union support risk reduction in a complementary fashion. Hence the key message here is that the linkage between spatial planning instruments at different spatial scales should be increasingly used as a tool for vulnerability reduction and risk management.

5.3.2 EU Structural Funds in relation to risks and hazards

Structural Funds general provisions

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. The General Provisions on the Structural Funds do not mention natural or technological hazards, and nor do the official regulations on the four Structural Funds for the period 2000-2006. However, a closer look at guidelines and programming documents shows that taking natural and technological hazards into consideration has become more important when applying for finance from Structural Funds and the Cohesion Fund.

The Commission has set indicative guidelines to help member states draft their programming documents for Objectives 1, 2 and 3 of the Structural Funds and their links with the Cohesion Fund. These guidelines have to be taken into account when the Member States define their priorities for development. The guidelines are structured on the basis of three strategic priorities (regional competitiveness, social cohesion and employment, and the development of urban and rural areas).

The first priority (regional competitiveness) acknowledges natural hazards under "Infrastructure for a high-quality environment". Here preventative measures in natural areas exposed to disasters are considered important for attaining high-quality environment. 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.

Revised indicative guidelines aim at allowing the Member States to adapt their programming documents for the second part of the period 2000-2006, although the old guidelines remain valid. Natural and technological hazards have been given much more emphasis than before, espacially in chapter "*Prevention of risks*". Due to the large number of disastrous natural hazards in recent years, the Commission has set up the Community solidarity fund to help regions recover. 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 slicks.

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. Therefore the emphasis has to lie on *prevention*. A European strategy for the prevention of risks has been proposed, and the Commission already encourages the Member States to adopt measures in the field of prevention. It is suggested, that Structural financial instruments should make a contribution to taking the prevention of natural, technological and environmental hazards into account in regional development.

The fact that these guidelines exist and they acknowledge, at least to some extent, natural and technological hazards, doesn't necessarily mean that they are practically applied. 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. Different Member States take risks differently into account in their programming documents for the three priorities. E.g. in the case of Objective 1 (aid to regions behind in development) a quick scanning of the national programming documents (Community Support Frameworks, CSFs) shows that hazards are taken into account at least in the Southern European countries of Italy, Portugal and Spain.

Environment in Structural Funds provisions

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.

Future trends of risk aspects in the Structural Funds

The 3rd Report on Economic and Social Cohesion shows a new consideration of risk aspects in the Structural Funds. The Commission proposes a set of key themes for the regional programmes, that are especially important for the cohesion of the EU. One of these key themes is *environment and risk prevention*. For the pursuit of the chosen key themes actions supported by cohesion policy will focus on three new priority objectives: convergence, regional competitiveness and employment, and territorial co-operation.

Risks from natural and technological hazards are acknowledged in two of the priorities. The first priority, convergence, acknowledges the need to help the least developed Member States and regions e.g. by supporting measures to prevent natural and technological risks. The third priority, territorial co-operation, acknowledges risk prevention at cross-border, transnational and interregional level.

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. 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.

Preliminary policy recommendations

Looking into the future, 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 can be seen in the Revised indicative guidelines, where it is suggested, that Structural financial instruments should make a contribution to taking the prevention of natural, technological and environmental hazards into account in regional development. It is also visible in the Report on economic and social cohesion, where one of the key themes proposed by the Commission for the regional programmes is environment and risk prevention. It is crucial that the emphasis of actions lies on the prevention of risks, not 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 risk prevention application in national programming documents can be guaranteed. There are three preliminary suggestions:

1. The criteria that is 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.).
2. 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).
3. The monitoring in the field of structural assistance should focus on environmental effects of the concerned programmes. According to this, the general attitude has recently changed significantly, but practices in member states are heterogeneous. Exemplary practices have been adopted to certain extent in some member states such as France and Austria (Barth and Fuder 2002, 67)

5.3.3 Interreg initiatives

The Interreg initiative can be seen as an important channel to develop, apply and test ideas furthering ESDP objectives in practice. In the context of risk management these objectives provide good opportunities for working with European 'meso-level' governance issues.[4] As such, the Interreg programmes address the transboundary aspect or hazards and thus help overcome the discrepancy between ecological regions and administrative jurisdictions (i.e. the *problem of fit*, see Young 2002). Furthermore, the Interreg initiatives provide an opportunity for horizontal networking and information exchange for a wide variety of actors such as regional governments, towns and cities (Thematic strategy on urban environment, 39)

Interreg cooperation seems especially promising in relation to hazards that cut across specific environmental conditions such as the Alpine region and European water bodies (e.g. Mediterranean, North Sea.) Thus they can be useful in risk management efforts concerning risks related to respective environmental conditions such as avalanches and landslides or coastal flooding and oil spills caused by marine transport.

Transnational Interreg programmes have several interesting projects related to hazards and risk management 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 and EUROBALTIC, creating networks in the Baltic area between actors involved in civil protection.[5]

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[4] **Under Interreg there are cross-border initiatives, transnational programmes and interregional programs. The transnational Interreg areas are kind of "meso-regions" in Europe – there are around ten of them in the "continental" Europe.**
http://europa.eu.int/comm/regional_policy/interreg3/abc/progweb_en.htm

[5]**CADSES project "Hydroadria": http://www.cadses.net/projects/approved_projects/Hydroadria.html**
North Sea project "COMRISK": http://www.comrisk.org/
Baltic Sea project "SEAREG": http://www.gsf.fi/projects/seareg/
Baltic Sea "Eurobaltic":
http://www.helsinki.fi/aleksanteri/english/projects/eurobaltic_civil_protection.htm
North West Europe "ESPACE": http://www.hants.gov.uk/lrt/test/index.html
(also http://www.hants.gov.uk/environment/climatechange/spatialplanning.html)

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. The core objectives of ESPACE are: 1) To develop a transnational approach to adaptation to climate change within spatial planning mechanisms which can be implemented by the partners; 2) To recommend a suitable approach at European, national, regional and local 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.

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.

5.3.4 EU Environmental policy

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. 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)[6] 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.

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[6] **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**

Regarding natural hazards, Climate change is seen as an important driving force, which is specifically mentioned in Article 5 of the 6EAP: "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".

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. Indeed, it is a fallacy that natural science has all the relevant expertise concerning natural hazards.

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

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).

The strategy includes the following points:

- Initiative for developing action plans to reduce the level of risks in the most vulnerable areas and to ensure that these areas are covered by emergency management plans that can be implemented.
- Integration of the risk component in all Community policies, in the same way as the "environmental component" is taken into account (For example, no support to projects that would increase the risk to people, request to carry out a Risk or Vulnerability Assessment of a project in the same way that an Environmental Impact Assessment are requested).
- Access to best practices based on the experience gained during recent emergencies.
- To promote, as possible and necessary, further preventive measures within the Structural Fund

(http://europa.eu.int/comm/environment/civil/pdfdocs/integrated_strategy_meeting021112.pdf).

[7] **Commission workplan 2002: COM (2001) 620 final.**
http://europa.eu.int/eur-lex/en/com/cnc/2001/com2001_0620en01.pdf

The coordination between member states activities and different sectors is a considerable task. One way to proceed with the coordination problem is to establish a European Emergency Management Authority as outlined above (see above chapter 5.2, p.8).

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. 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[8] is of high interest for the 1.3.1 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)[9] 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).

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.

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.

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[8] **COM(2004)60 final. http://europa.eu.int/eur-lex/en/com/cnc/2004/com2004_0060en01.pdf**
[9] **See http://europa.eu.int/eur-lex/pri/en/oj/dat/2000/l_327/l_32720001222en00010072.pdf**
On the Implementation of the WFD, see
http://europa.eu.int/comm/environment/water/water-framework/implementation.html

5.3.5 Impact assessment

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") 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.

5.3.6 Civil Protection

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.

The activities in the field of civil protection can be split into three main parts: prevention, preparedness/intervention and response/restoration. In response to the events of September 11th, the EU civil protection activities have mainly focussed on intervention, primarily through a swift 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. New initiatives are also necessary in the field of prevention and restoration. So far, there is no holistic approach to face natural and man-made risks. While technological hazards arising from specific installations are covered quite extensively (mainly through the Seveso directive), natural risks and many man-made risks are only covered partially and at different levels by existing Community instruments.

Civil Protection, however, is only part of coping with hazards. Cooperation should be strengthened also in the fields of hazard-sensitive planning.

Civil protection and disaster (ex-post) response are important factors in the way individuals, families, localities and regions cope with natural and technological hazards and disaster events. However, the task of the ESPON 1.3.1 project is not to examine such responsive capacities of regions and member states. Instead, the project focuses on prevention and mitigation measures that are crucial in the long run and also directly linked to concerns of the whole ESPON framework, namely spatial planning instruments.

The activities in the field of civil protection can be split into three main parts: prevention, preparedness/intervention and response/restoration. In response to the events of September 11th, the EU civil protection activities have mainly focussed on preparedness and intervention, primarily through a swift implementation of the Community Mechanism for Civil Protection.

The EU solidarity fund

To enable efficient response in urgent situations, the Community has established a Solidarity Fund, which 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**)

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:

- ”Immediate restoration to working order of infrastructure and plant in the fields of energy, drinking water, waste water, telecommunications, transport, health and education.
- Providing temporary accommodation and funding rescue services to meet the immediate needs of the population concerned.
- Immediate securing of preventive infrastructures and measures of immediate protection of the cultural heritage.
- Immediate cleaning up of disaster-stricken areas, including natural zones”.

The solidarity fund is a welcome novelty in EU policy. It addresses hazards directly and is welcome, even if it is clearly a disaster-based instrument, helping to cope with events in terms of aid and relief. The Fund is meant to finance non-insurable damages, but the question here remains whether claiming compensation through the solidarity fund should be made somehow conditional, requiring that member states or regions have implemented EU environmental legislation.

5.4 Summary of the first policy recommendations in ESPON 1.3.1 "Hazards"

I. EU-level

1. Need for better inclusion of risks related to natural and technological hazards in EU policies. This calls for better integration of environmental and regional policy measures at all spatial scales. Risk management should be made an integral and explicit part of EU cohesion policy.

2. Stress *vulnerability reduction* as a key strategy in policy and planning. There should be more emphasis on prevention and vulnerability reduction through spatial planning, based on the "precautionary principle" and "redundancy", i.e. developing robust policies which cover multiple hazards. Such measures are more cost-effective than risk reduction of single risks based on exact scientific predictions.

3. Deliberate use of Stuctural 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); 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.

4. Establish an European Emergency Management Agency (EEMA) for coordinating European risk management efforts. The EEMA should, among other functions, coordinate emerging EU intiatives in the field of risk management and guarantee the coherence between EU policies.

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

6. Ensure fluent co-operation between different ongoing initiatives in the field of hazard and risk management, including legislative and financial instruments.

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

7. 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 *safety impact assessment* should be integrated with other impact assessment methods.

8. Create governance networks to address risk managmenet in regions with special environmental characteristics and related challenges. Use instruments such as the river basin management plans of the Water Framework Directive (2000/60/EC) for risk management purposes.

9. 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.

10. Transnational Interreg areas with common ecological denominators should be used as ‘breeding and testing’ grounds for meso-level risk management programmes.

11. Make financial aid in disaster events conditional upon the complience to national guidelines of risk management.

III. Regional level

12. 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 make use of the *space-type concept* as outlined in (Ch. 5.2.)

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

14. 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.

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

IV. Local/Community level

16. 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 (see DPSIR chain, ESPON Hazards 2nd Interim Report p. 150).
- Public participation; integration of private stakeholders in risk assessment, decision making, choice of measures and implementation

17. 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.).

5.5 Further work on Policy recommendations

The section about policy recommendations still open for further investigations. The following aspects have to be discussed or deepened for the final report:

- *Space-type-concept:* The suggestions concerning the space-type-concept have to be described in more detail in order to prove their relevance for achieving a successful spatial risk mitigation.
- *Arrangement of objectives:* This recommendation has to be tested in a case-study area for its applicability.
- *Completion of risk mitigation suggestions:* The proposed ideal planning process and the "Handbook for Risk Mitigation" may be described in more detail if these suggestions will be approved by the commission. A possible final output could then be a step-by-step guidance paper for regions and communities about how to mitigate to natural and technological risks.
- *Contextualise the case-based spatial planning response with national policies and regulations:* What are key national regulations and policies which either help or hinder the realisation of an ideal planning process? We already mentioned the problem of interplay. A full European wide evaluation of this point, of course, will not be possible. The suggestion is to reflect this question with our own case studies.
- The Interreg offices could be addressed with a very brief questionnaire about projects that relate to risk reduction. Checking of the programme web-pages has produced some results, but many www-sites are incomplete.
- Beyond the Interreg initiatives, it would be interesting to study other possible forms of meso-regional cooperation in common risk issues, existing outside of the project-bound world, e.g. VASAB-activities, Integrated Coastal Zone Management and other similar tools.
- Hazard and vulnerability patterns in Europe will be analysed further after the 3rd ESPON Hazards Interim report. Hazard profiles of Interreg areas should be drafted and these should be examined compared to Interreg financed instruments. Are Interreg measures helping in risk reduction?
- *Description of European Emergency Management Agency (EEMA):* Similar to the Federal Emergency Management Agency (FEMA) in the U.S. and placed on the same level as the European Environment Agency (EEA), the organization and duties of a European Emergency Management Agency can be described in more detail.
- The *CAP* should be reviewed from a risk management perspective. Issues pertaining to 'set-aside' land and its use for agriculture in case of loss of farm land due to flooding or other hazard events. Similar measures should also be adopted for mitigation; set-aside land should function, as far as possible, as reserve land for flooding. Expert interviews in Brussels (DG Agri) would be useful.
- Cooperation with other ongoing efforts of hazard mapping (check on the process initiated by DG Environment/ Civil protection.)
- Interviews at the EC Commission. CURS proposes to make interviews with responsible persons at DG Regio concerning key community policies and initiatives and their relations to risk reduction. Interviews should be conducted in DG Regio, DG Environment and DG Agriculture.
- The question should be asked whether the present interest (and resources) on climate change as a driving force behind natural hazards exaggerated compared to other driving forces influencing European vulnerability?

- Financial instruments such as public-private partnerships in risk reduction and different insurance instruments should be discussed
- Monitoring (not only risks but vulnerabilities, social and economic trends) and research activities: Where should the focus be? What does Europe need to know more?
- Arrangement of policy recommendations by order of priority.

EU documentation and relevant Internet sources (not exhaustive)

Regional policy

Structural Funds: general provisions
http://europa.eu.int/scadplus/leg/en/lvb/l60014.htm
http://europa.eu.int/eur-lex/pri/en/oj/dat/1999/l_161/l_16119990626en00010042.pdf

Interreg III Programme
http://europa.eu.int/comm/regional_policy/interreg3/abc/progweb_en.htm

Interreg projects
CADSES project "Hydroadria"
http://www.cadses.net/projects/approved_projects/Hydroadria.html
North Sea project "COMRISK"
http://www.comrisk.org/
Baltic Sea project "SEAREG"
http://www.gsf.fi/projects/seareg/
Baltic Sea project "Eurobaltic"
http://www.helsinki.fi/aleksanteri/english/projects/eurobaltic_civil_protection.htm
North West Europe "ESPACE"
http://www.hants.gov.uk/lrt/test/index.html
http://www.hants.gov.uk/environment/climatechange/spatialplanning.html

Integrated Coastal Zone Management: A Strategy for Europe. COM(2000) 547 final
http://europa.eu.int/eur-lex/en/com/cnc/2000/com2000_0547en01.pdf

Environmental policy

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

The EU water framework directive
http://europa.eu.int/eur-lex/pri/en/oj/dat/2000/l_327/l_32720001222en00010072.pdf
http://europa.eu.int/comm/environment/water/water-framework/implementation.html

Civil protection:
http://europa.eu.int/comm/environment/civil/index.htm

Vade-mecum of civil protection in the European Union
http://www.europa.eu.int/comm/environment/civil/pdfdocs/vademec.pdf

Links to national civil protection authorities
http://www.europa.eu.int/comm/environment/civil/prote/cp10_en.htm

A hazard mapping questionnaire has been sent at some point to the Member States:
http://www.europa.eu.int/comm/environment/civil/pdfdocs/questionnairehazardmapping.pdf

On disaster prevention, there is mainly material about risk assessment, more related to the engineering perspective and rescuing than real prevention…
http://www.europa.eu.int/comm/environment/civil/prote/cpactiv/cpact02.htm

Addressing the role of the EEA in Hazard data development
http://www.unece.org/stats/documents/2001/10/env/wp.5.e.pdf

2003 Evaluation of the EEA
http://europa.eu.int/comm/environment/pubs/eea_a_en.pdf

Early warning systems (Cardiff process & Göteborg process, policy conclusions in ch 8)
http://www.ewc2.org/upload/downloads/Brauch2003AbstractEWC2.pdf

Research

What is Europe doing?
http://europa.eu.int/comm/research/leaflets/disasters/en/

Concerning floods, a project was funded under the 4th Framework:
http://www.hrwallingford.co.uk/projects/RIBAMOD/

Earthquake project under 5th Framework:
www.ingv.it/paleo/RELIEF/Docs/ReliefC_dani.doc

European Mediterranean Disaster Information Network (EU-MEDIN)
http://www.eu-medin.org/

JRC: Major Accident Hazards Bureau
http://mahbsrv.jrc.it/

JRC: Natural Hazards Project:
http://natural-hazards.jrc.it/

The EU Solidarity Fund
http://europa.eu.int/scadplus/leg/en/lvb/g24217.htm

About earlier responses: Central Europe
http://europa.eu.int/scadplus/leg/en/lvb/g24216.htm

as well as, concerning ”Prestige”
http://www.health.fgov.be/WHI3/krant/krantarch2003/kranttekstjuly3/030717r07eu.htm

ANNEX 1
Case study area Avançon basin / aggregation of risks

Case study area

The valley of Avançon is situated in the western par of the Alps, at east of the Vaud canton (figure 1). The climate of this mountainous region is temperate, but varies with altitude: cold and cloudy, with rain and snow during winters; cool to warm, cloudy, humid with occasional showers in summer.

Figure 1. Location of the Avançon basin in Switzerland.

Population data (12.2002)

	Population	Area (km²)	Density (inh./km²)
Switzerland	7’250’000	41’290	176
Canton de Vaud	627’933	2’822	223
District of Aigle	34’404	434	79
Avançon basin	6’850	90	76

National 2002 gross revenue in Switzerland: 38’570 US$ / year per capita.

Figure 2. Vaud canton administrative map and Avançon basin, which covers the main territories of Bex and Gryon villages (orange).

Natural hazards

Considered natural hazard are floods, landslides and avalanches, Earthquakes, storms, in particular winter storms, and extreme precipitation events. Most of the data are issued from the natural hazards database of Vaud canton (CADANAV).

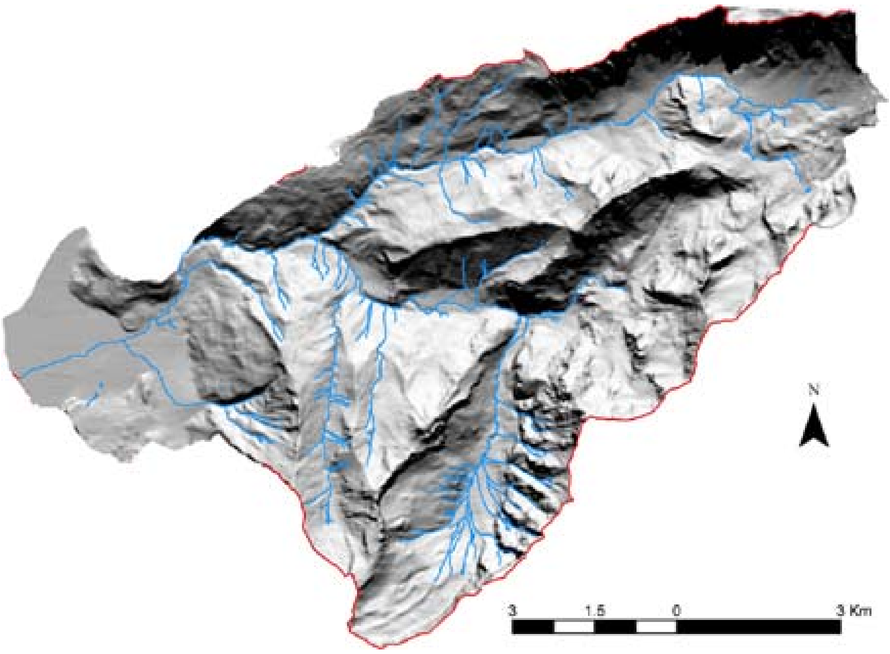


Figure 3. Shaded topography of the Avançon basin.

Hazards related to water

The regime of infiltration is irregular. During winter time, snow accumulates on the mountains and melts in spring, causing peaks of rivers rates. This adds to the important rainfalls of April to June.

In summer, long periods of drought can be interrupted by sudden and intense rainfalls. As the soil is dry, infiltration is low and a large part of water streams to the valley

The drainage network of the basin is characterised by short and steep sided waterways, till they reach the Rhône valley. Then the profile becomes flatter, close to the Bex city. The Avançon valley is mostly uninhabited, villages being far enough from the river, except downstream, where the Bex city (ca. 6'000 inh.) is situated at the confluent with the Rhône.

For these reasons, erosion of the banks, floods and torrential lava occur (fig. 4 and 5). They are considered together in the Delphi method, having the same origins. Hydrological data are collected by Office for water, canton de Vaud (SESA).

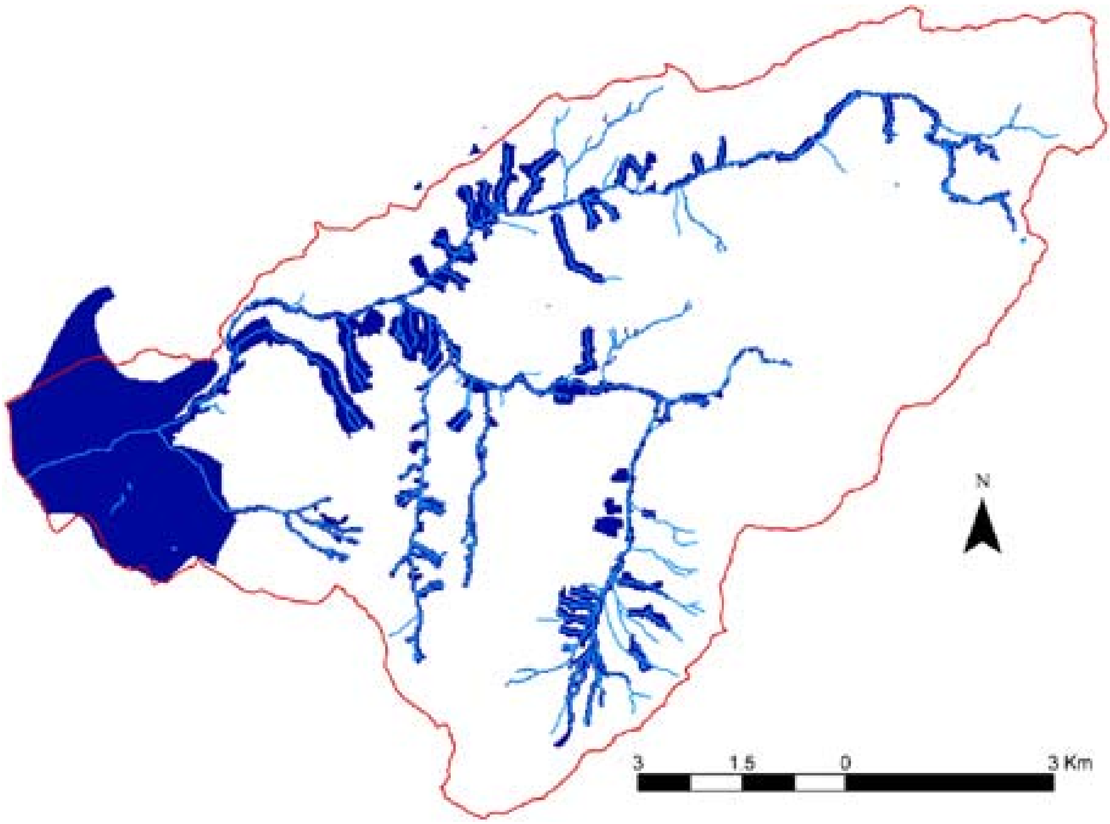


Figure 4. Flood distribution in Avançon basin.

Figure 5. Torrential lava in Avançon river in Bex.

Earthquakes

Residual movements of the Alps cause seismic hazard to be considered in the South of Switzerland (figure 6). The Aigle district is the most active of the Vaud canton. Seismologic data are provided by the Swiss Institute of Technology in Zurich, using the Swiss digital seismograph network (SDSNet, figure 7). Earthquakes can provoke other hazards, especially landslides.

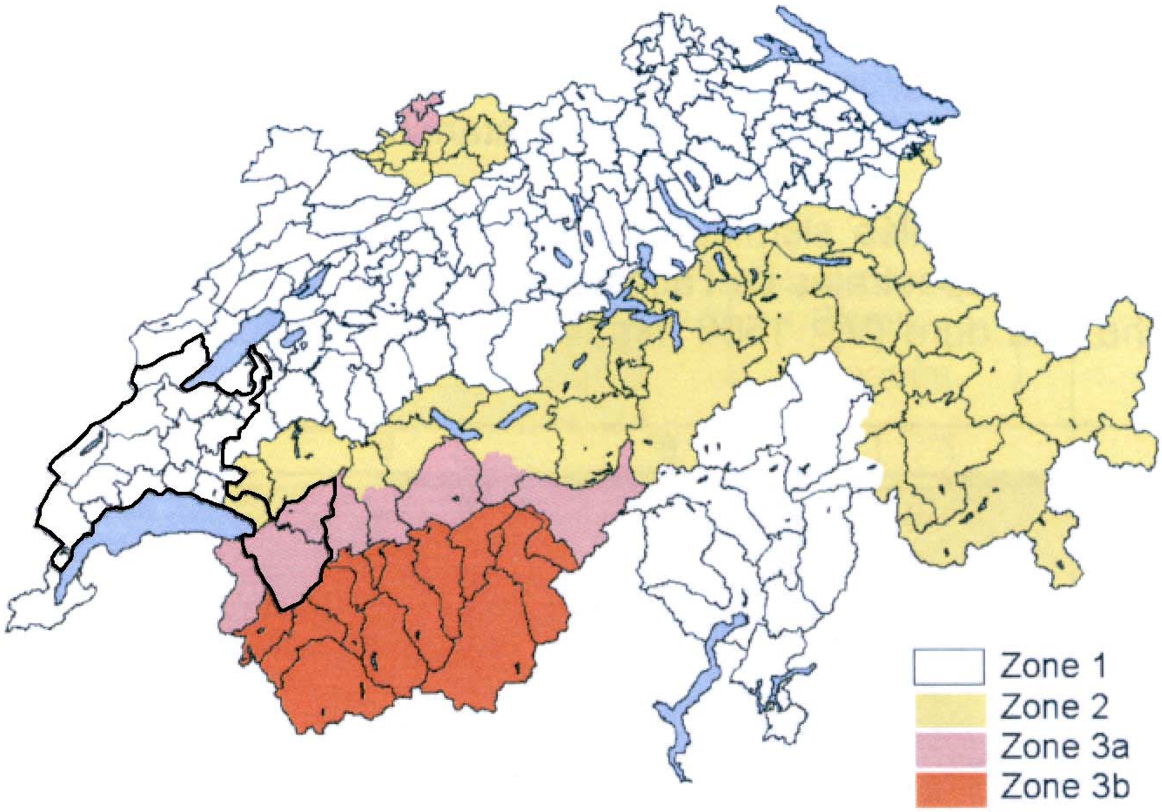


Figure 6. Swiss map of horizontal acceleration values for a come back period of 475 years (Source CREALP, 2000) Z1: 0.6 m/s^2, Z2: 1 m/s^2, Z3a : 1.3 m/s^2, Z3b : 1.6 m/s^2. Thick black line: Vaud canton boundary.

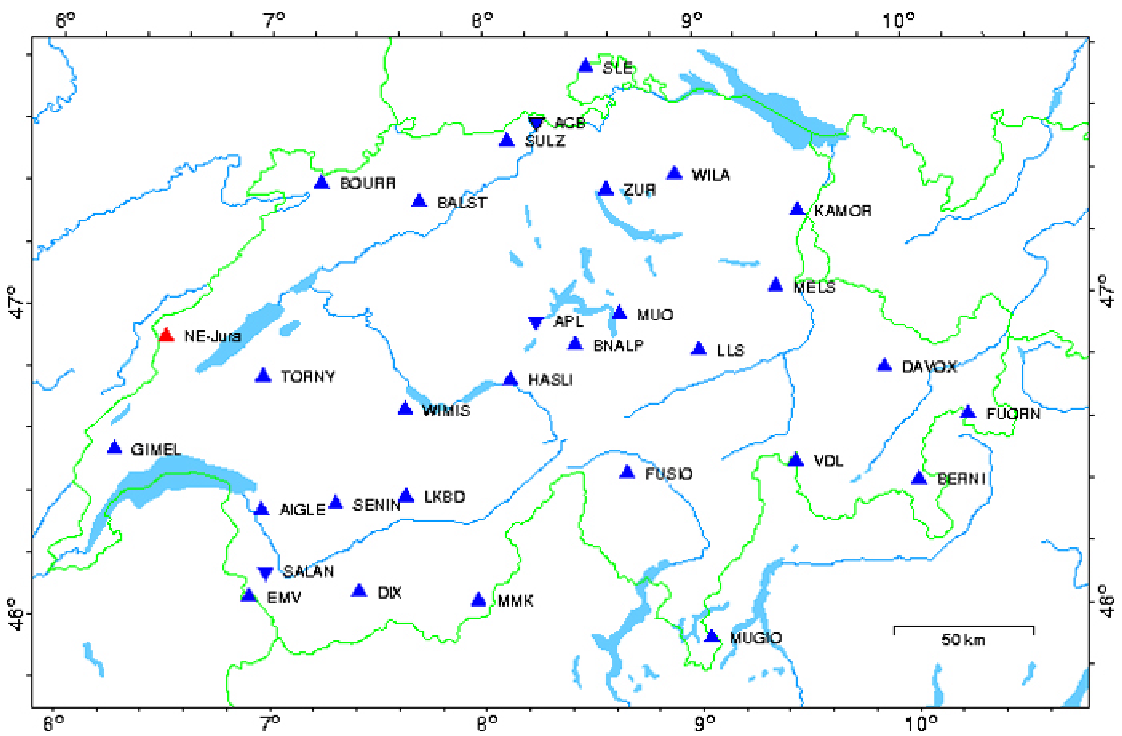


Figure 7. Map of the Swiss digital seismograph network (SDSNet).

Geological hazards

Landslides and karstic phenomena like sinkholes must be considered. The main karstic dissolution consequence is collapsing of cavities, which can lead to catastrophic situations. Their location is highly related to geological context (presence of limestones, figure 8)

In Delphi method, sinkholes are classified with landslides.

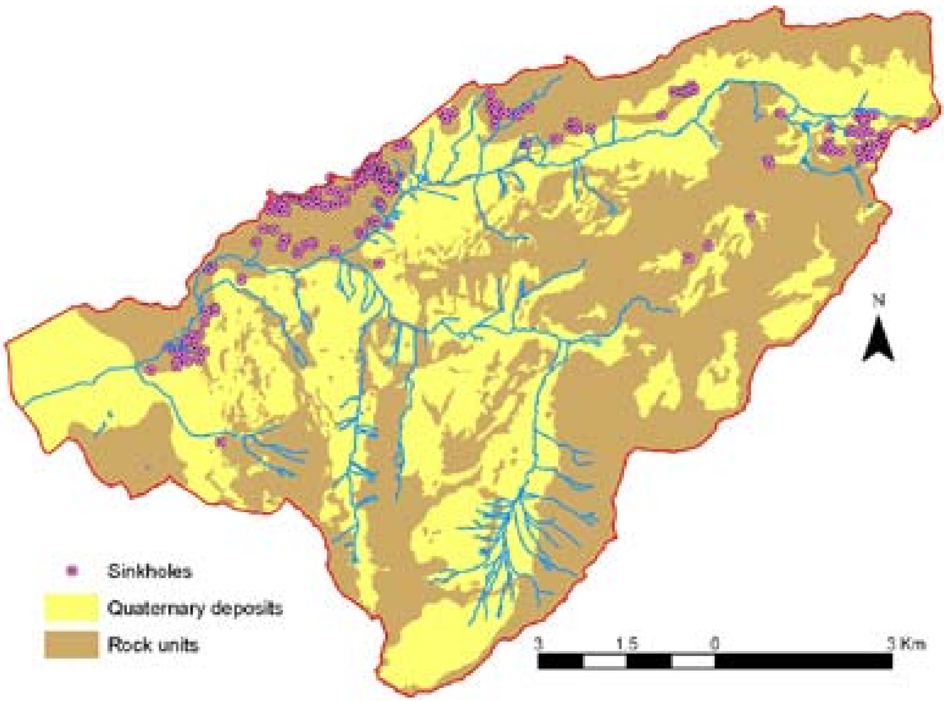


Figure 8. Sinkholes and main geological units.

Landslides cover a large part of the Avançon basin (figure 9). They do not concern directly buildings, because people know for centuries where they are located. On the other hand, even small, they accelerate surface erosion and strip agricultural soils (figure 10).

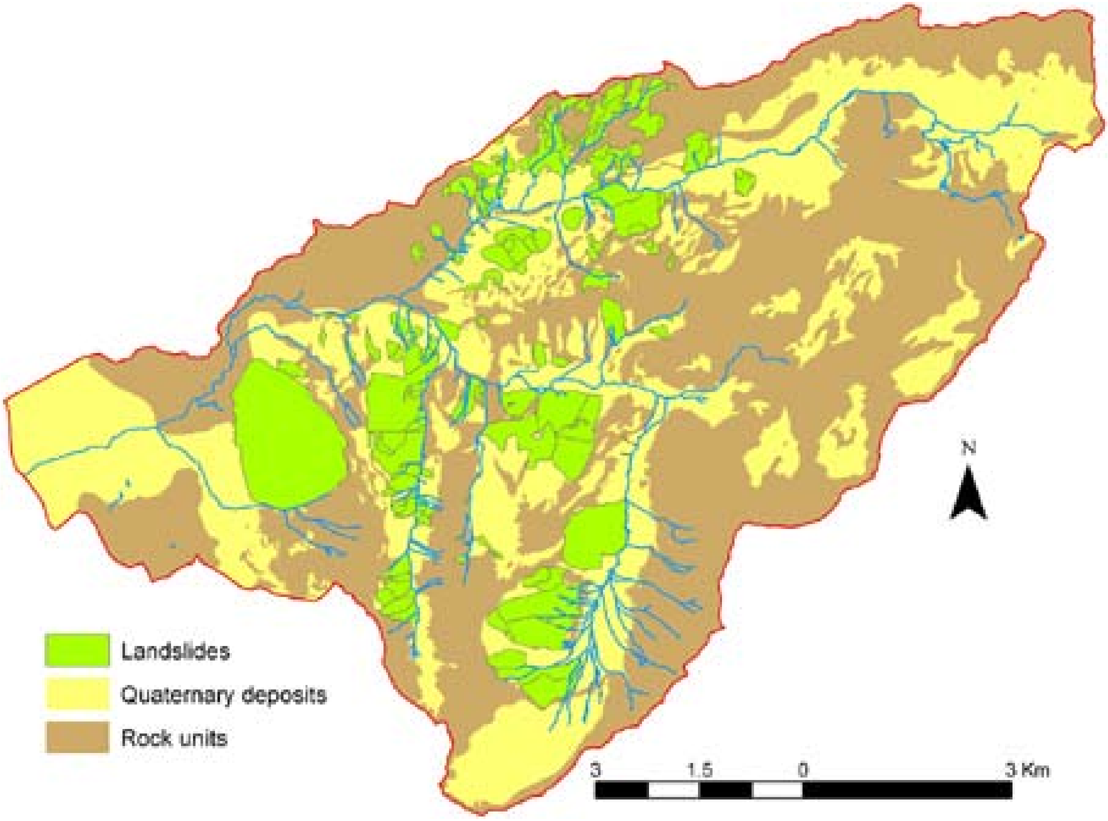


Figure 9. Landslides occurrence in Avançon basin.

Figure 10. Rhône river at entering the Geneva lake, dumping alpine sediments after severe rainfalls.

Rockfalls cover the major part of the basin (figure 11) with varying intensity. They are classified with "landslides/avalanches" in the Delphi method.

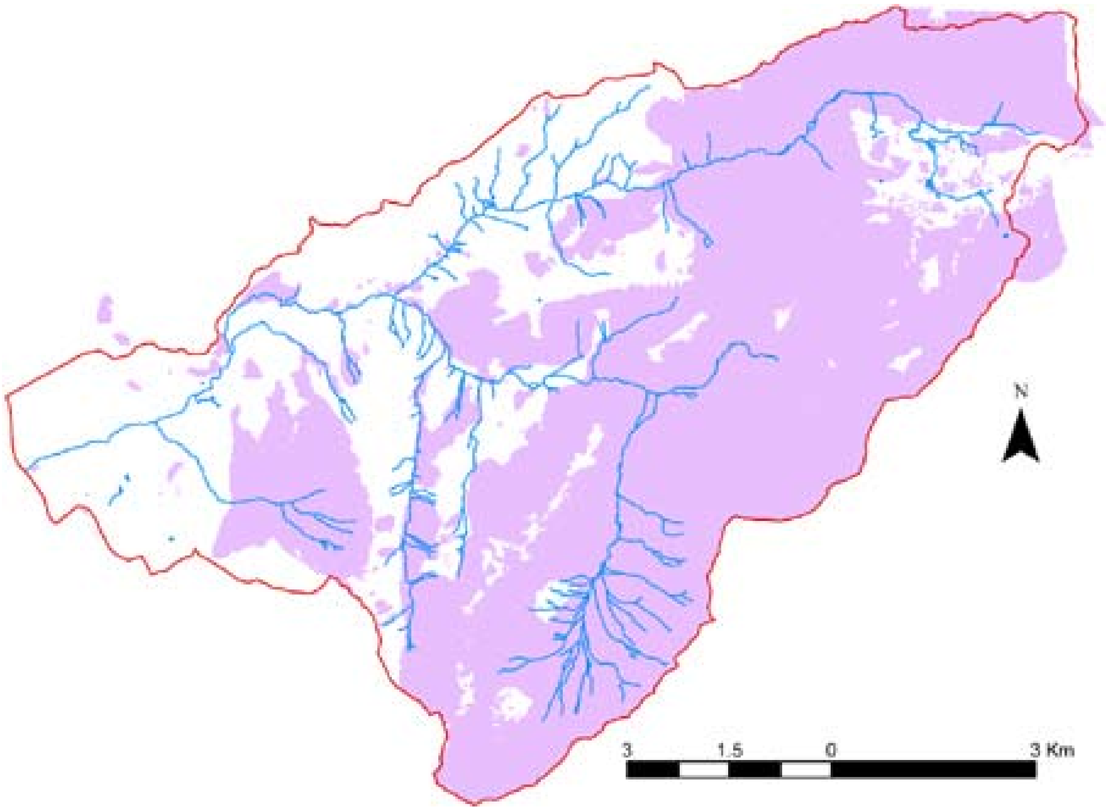


Figure 11. Rock instabilities distribution, including both source and transit areas.

Avalanche corridors are more seldom (figure 12), located in uninhabited steep sided small valleys.

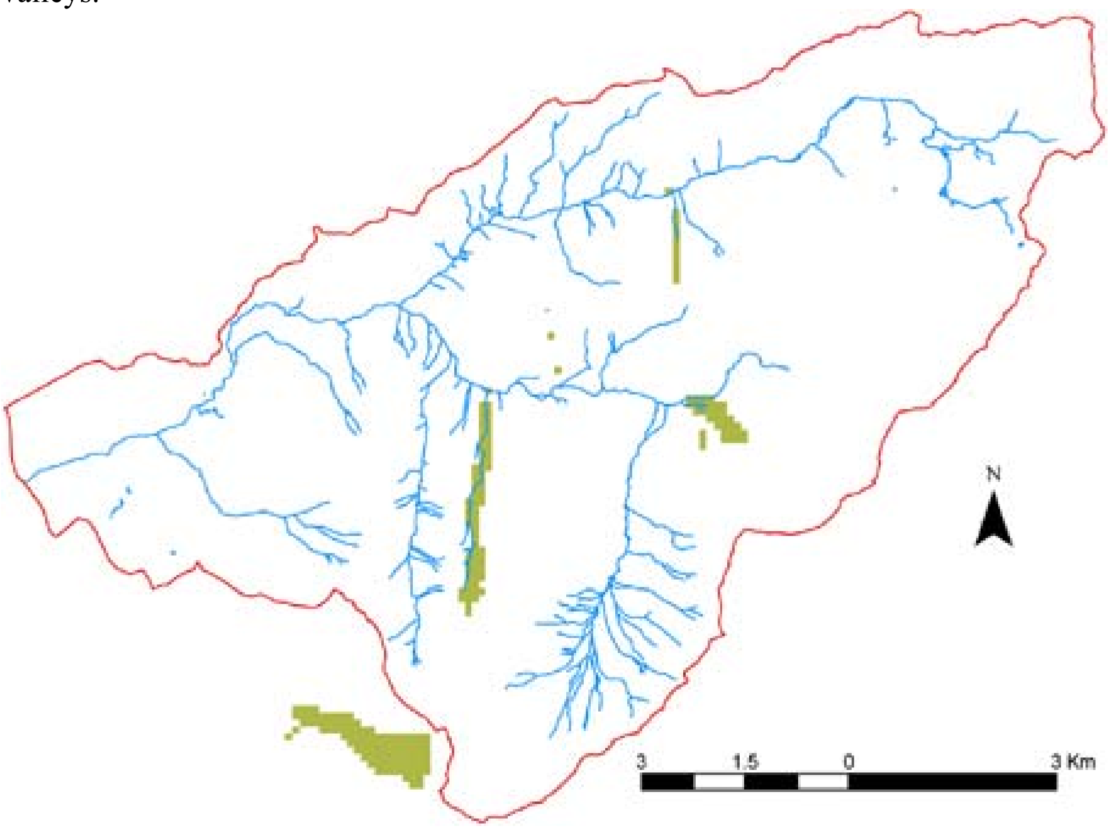


Figure 12. Avalanche corridors.

Storm and extreme precipitations

Winter storms and extreme precipitation events are related to floods, torrential lava, landslides, rockfalls and avalanches since they cause them. In the Avançon basin, these indirect consequences are the most important. The World Map of Natural Hazards compiled by the Munich Reinsurance Company (Map 7, ESPON 2nd ESPON Hazards Interim Report) shows that Switzerland has medium to high probability for winter storms.

Technological hazards

Technological hazards are weak since agriculture and tourism are the major economical activities of the Avançon basin. Human activity is concentrated along the Rhône river as shows the map of objects to protect (figure 13).

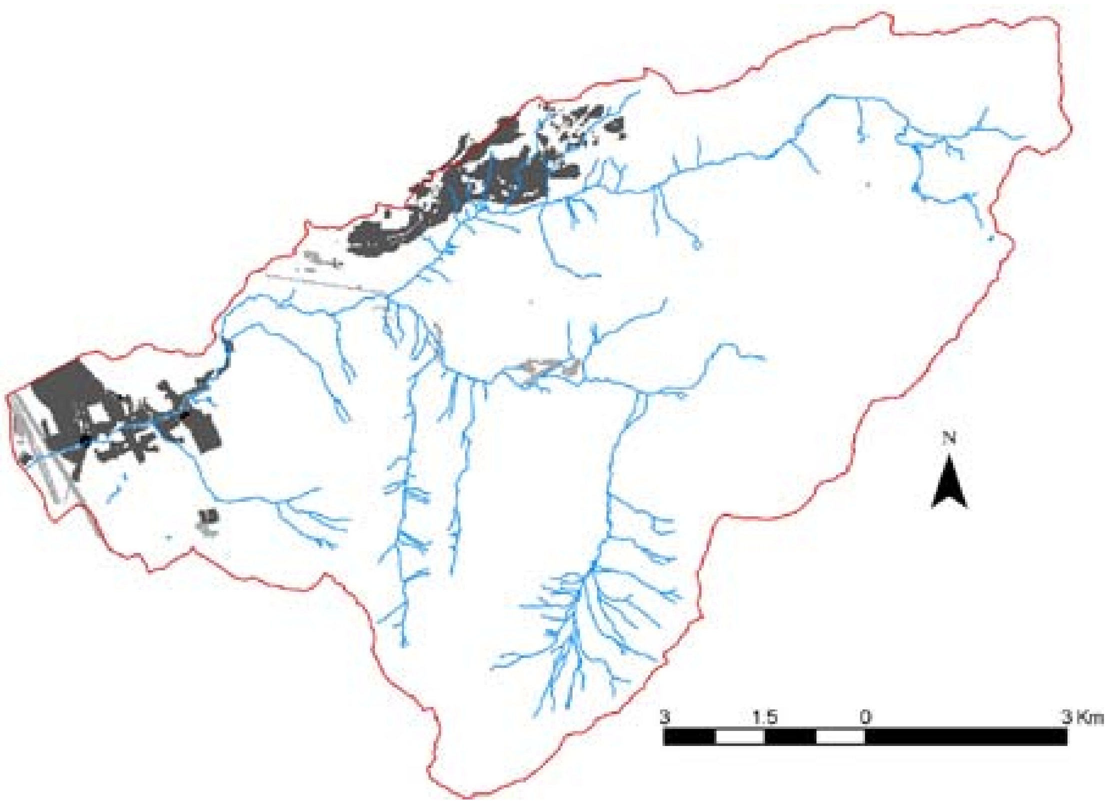


Figure 13. Objects to protect in the Avançon basin.

Aggregated Risk in the Avançon basin

Due to organisational Difficulties the weighting of hazards and indicators in the Avançon basin took place by expert interviews. The Avançon basin is small (90.2 km2) but representative of many alpine regions . It presents a part of the NUTS 3 level region, the Swiss canton Vaud. Due to extreme variability of topography, geology, climatology in the Alps, natural borders of a case study region was found to be more representative than any administrative delimitation.

Experts and application

Four experts were consulted. Two are chosen among specialized senior scientists at the Swiss Institute of Technology in Lausanne, one in soil mechanics and one in engineering geology. The two others come from national and cantonal offices responsible for land planning and hazards. Due to temporal limitations, only extensive interviews of these two experts could be realised. They were consulted only once, their first evaluation being collected. Then the evaluation of the two other experts was discussed with them, and a new evaluation was done directly.

Results

Table 1. Average estimations of the relevance of chosen hazards in the Avençon basin

	Hazards	Average estimation
Natural Hazards	Volcanic eruption	0
	Floods	37.6
	Landslides/avalanches	22.5
	Earthquakes	18.1
	Drought	0
	Forest fires	0
	Storms	3.9
	Extreme precipitation	11.9
	Extreme temperatures	0
Technological hazards	Nuclear power plants	0
	Production plants	0
	Waste deposits	6.1
	Marine transport	0
	Dams	0
	Sum	**100**

Table 2. Weighting of vulnerability indicators in the Avençon basin

Indicators and parameters	Average estimations
Population density	41.2
GDP/person	13.8
Construction quality	16.2
Population distribution	18.8
Rescue organization	10.0

Experts pointed out that the list of two main indicators ‘GDP per capita’ and ‘population density’ should be extended. The proposed parameters where ‘Construction quality’, ‘Population distribution’ and ‘Rescue organisation’. In the Avançon basin the quality and the age of buildings is related to the spatial distribution of constructions. Constructions of the past centuries have no specific properties to resist to natural hazards but were located in safer places, known by ancestral knowledge. Constructions of the 20th century are sometimes located in dangerous areas; their sensitivity to hazards then depends on the quality of building, variable in the 1950s. However these parameters can not be operationalised by measured values so far.

Weighting with only ESPON indicators, i.e. considering that 'GDP per capita' and 'population density' constitute 100% of indicators, one obtains:

- population density : 41.2 / (41.2 + 13.8) = 75%
- GDP per capita : 13.8 / (41.2 + 13.8) = 25%

Risk profile of the Avançon basin

Hazard estimation

Table 3. Aggregated hazard potential in the Avançon basin

Hazard	**Average estimation**	**Hazard intensity**	**Hazard factor**	**Hazard score**
Volcanic eruptions	0	0	0	0
Floods	37.6	2	0.4	15
Landslides/Avalanches	22.5	2	0.4	9
Earthquakes	18.1	2	0.4	7.3
Droughts	0	0	0	0
Forest Fires	0	0	0	0
Storms	3.9	3	0.6	2.3
Extreme precipitation	11.9	2	0.4	4.8
Extreme temperatures	0	0	0	0
Nuclear power plants	0	0	0	0
Production plants	0	0	0	0
Waste deposits	6.1	1	0.2	1.2
Oil spills	0	0	0	0
Dams	0	0	0	0
Sum	**100**			**39.6**

The obtained aggregated hazard score for the Avençon region corresponds with the **aggregated hazard class II** (classification see above).

Vulnerability estimation

Table 4. Vulnerability estimation according indicators in the Avençon basin

			Pop. density		GDP per capita	
	Population	**Area (km²)**	**(inh./km²)**	**class**	**in EU average***	**class**
Switzerland	7'250'000	41'290	176			
Canton de Vaud (NUTS 3)	716 209	3211.7	223		161.98804*	
District of Aigle (NUTS 4)	34'404	434	79		Unavailable	
Avançon basin	6'850	90	76	II	Unavailable 161.98804**	IV
* EUROSTAT ** supposed on the basis of NUTS 3 data						

GDP data in Switzerland are not available more detailed than for NUTS 3 regions. Therefore cantonal data (NUTS 3) are used instead and considered to be relevant for the basin. This approximation seems reasonable since the basin is mainly agricultural, touristic and has industrial activity in the Bex city, which is the general context of the canton.

Considering the supposed weight of the vulnerability indicators as described above, the vulnerability class of the Avencon basin is calculated as follows:

II * 0.75 + IV * 0.25 = **III** (2,5)

Table 5. Avençon basin risk matrix obtained from the aggregated hazard potential and vulnerability class (damage potential)

Aggr. hazard potential	Degree of vulnerability (coping capacity not considered)				
	1	**2**	**3**	**4**	**5**
1	2	3	4	5	6
2	3	4	**5 Avançon basin**	6	7
3	4	5	6	7	8
4	5	6	7	8	9
5	6	7	8	9	10

Two municipalities cover the Avençon basin, having similar population density.

- Bex: 96.6 km^2, 5800 inhabitants in 2002 (60 inh/ km^2)
- Gryon: 15.15 km^2 , 993 inhabitants en 2000 (65 inh/ km^2)

Bex and Gryon are partially included in the Avençon basin, so that the total basin area is 90 km^2.

Thus, the risk matrix is relevant for both municipalities and aggregated risk map is homogenous.

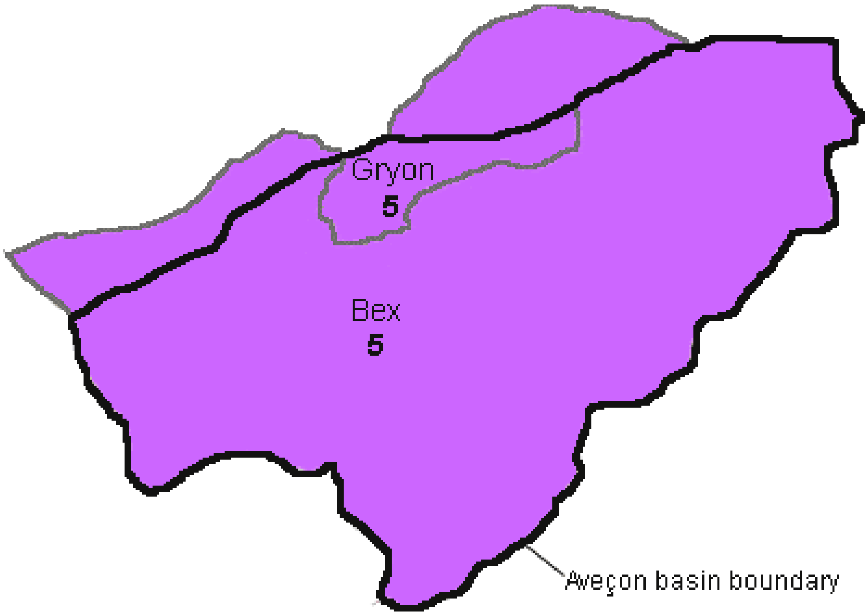


Figure 14. Aggregated risk map of the Avençon basin.

Application report

It appears that the evaluation varies mostly with the scale at which experts are used to work, not with their origin (scientific or administrative). More local experts tend to heavily weight specific hazards of an area that they well know, while national experts have a more moderate evaluation. The experts evaluation has not been influenced by provided results from the other ones. The necessity of three evaluation rounds was contested, mainly for the weighting of indicators.

Experts had somewhat different backgrounds and were interested in the issue. Each has an own approach of hazard assessment, so that the major difficulty is to apply the Delphi method. All experts pointed that an efficient parameter is the quality and age of buildings, as well as land planning laws (new buildings quality and location).

ANNEX 2
Future climate change

Introduction

A future climate change can be expected to affect both the frequency and intensity of natural hazards and thus influence discussions on risk management of all climate-induced natural hazards. As stated in the 2nd ESPON Hazards Interim Report on-going EU projects such as MICE and STARDEX are making use of indices of climatic extremes. The projects also include assessment of climate change scenarios. The results from those studies will not be available until year 2005 though. In this report we have instead focused on climate change scenarios from the Rossby Centre regional climate modelling. A number of different climatic indices for detection of extremes were chosen and applied on scenario data. The indices were chosen to both represent dry and wet conditions as well as warm and cold conditions. The indices of climatic extremes were selected based on work done within the European MICE project. The results should be seen as examples of possible future developments.

Model description

In this work, the regional climate model system RCAO is used (Döscher et al., 2002; Räisänen et al., 2003). RCAO is a coupled climate model consisting of an atmospheric part, RCA (Jones, 2001, Jones et al., 2004) and an oceanic part, RCO (Meier et al., 1999 and 2003). The model has been run both for a control period, 1961-1990 representing the recent climate conditions (‘reference climate’), and for a future time period, 2071-2100 given two different emission scenarios. These emission scenarios are the IPCC SRES A2, representing rather high future greenhouse gas emissions, and B2, representing more modestly increasing future emissions. Both A2 and B2 scenarios are described in detail in Nakićenović et al. (2000). The regional model is driven with boundary conditions that are taken from two different global models; HadAM3H (Gordon et al., 2000), and ECHAM4/OPYC3 (Roeckner et al., 1999). In the following these simulations are referred to as RCAO-H/A2, RCAO-H/B2, RCAO-E/A2 and RCAO-E/B2 depending on which global model and which emission scenario is used (Table 1). The control simulations are referred to as RCAO-E/REF and RCAO-H/REF respectively. By comparing the scenario runs to the control runs four different realisations of climate change can be analysed. RCAO is run at a horizontal resolution of 49 km and with 24 layers in the vertical direction. The RCAO model system and the runs used here are described in more detail in Räisänen et al. (2004).

The HadAM3H data used as boundary conditions for the RCAO-simulations were provided by the Hadley Centre of the Meteorological Office (U.K.), the ECHAM4/OPYC3 data by the Max Planck Institute for Meteorology in Hamburg (Germany) and the Danish Climate Centre of the Danish Meteorological Institute.

Table 1. Overview of the climate model runs discussed in this report

Acronym	Forcing GCM	Time slice	Greenhouse gas emissions
RCAO-E/REF	ECHAM4/OPYC3	1961-1990	observed for the period
RCAO-H/REF	HadRM3H	1961-1990	observed for the period
RCAO-E/A2	ECHAM4/OPYC3	2071-2100	SRES A2
RCAO-H/A2	HadRM3H	2071-2100	SRES A2
RCAO-E/B2	ECHAM4/OPYC3	2071-2100	SRES B2
RCAO-H/B2	HadRM3H	2071-2100	SRES B2

Indices of climatic extremes

There exist a large number of different indices of climatic extremes in previously published analyses (e.g. Frich et al., 2002) and the European Climate Assessments (Klein Tank et al., 2002) and used in several current European projects (e.g. MICE www.cru.uea.ac.uk/projects/mice, STARDEX www.cru.uea.ac.uk/projects/stardex and PRUDENCE http://prudence.dmi.dk). From a preliminary overview of many different indices it is clear that they can be broadly divided into groups that characterises different aspects of the climate.

For the present study we have selected eight different indices of climatic extremes (Table 2) to illustrate how the model simulates changes to the precipitation and temperature climate on a daily time-scale, which in many cases is related to climatic extremes. All indices are calculated as averages of the 30 annual index values for the time period covered by the different RCM scenarios.

Four indices concern precipitation and we have tried to cover different aspects including both dry and wet conditions. "*Longest dry spell*" is the average length of the annually longest period with precipitation below 0.5mm. "*Highest 7-day precipitation*" is the annual maximum precipitation total over any 7-day period and may be seen as a potential flood indicator, summing up precipitation during rainy periods. "*Heavy precipitation*" and "*Extreme precipitation*" is the annual number of days with precipitation above 10mm and 25mm respectively. Those indices represents amount of wet days and is correlated with total annual and seasonal precipitation in most climates. The selected thresholds may seem rather low in comparison to what is commonly observed during heavy precipitation events where five to ten times higher (or even more) precipitation are occasionally reported for individual stations. The regional climate model however produces output that is representative on the gridcell scale, in this case 49x49km or 2400km^2. Because of the high spatial variability of precipitation, a gridcell average exceeding 10mm (25mm) is in fact an indicator of that somewhere in the gridcell region there is indeed heavy (extreme) precipitation, and somewhere else there may be no or very little precipitation. The local extremes are smoothed out on the gridcell level.

Daily temperature conditions are represented by four indices. For simplicity and to facilitate comparisons across regions we prefer fixed thresholds instead of indices based on deviations from local climatic conditions. Two indices account for summer daytime and nighttime conditions: "*Number of warm days*" and "*Number of tropical nights*". The definition of tropical nights, namely minimum temperature above 20°C, is widely used. The threshold for warm days chosen (25^{o}C) is a compromise between what is relevant for climatic conditions in the northern and southern parts of the model domain. While daytime temperatures of 25^{o}C are rarely reached in the north, this threshold is commonly exceeded during extended periods in the Mediterranean region. Nevertheless, a study of changes between todays and tomorrows climate gives information about the length of warm periods and thus information on energy and water demand, as an example.

Two indices are used to depict winter daytime and nighttime conditions: "*Number of freezing days*" and "*Number of frost nights*" that both use the natural threshold of 0^{o}C. If the daytime maximum temperature stays below 0^{o}C it usually indicate that the whole 24h period is below 0^{o}C, hence a freezing day is also a frost night. However, it occasionally happens, especially during wintertime, that the nighttime minimum temperature may be warmer than the daytime maximum temperature in which case it may not be a proper freezing day that is characterised by freezing temperatures throughout the 24h period.

Table 2. Summary of the indices of climatic extremes used in this study

Index	Explanation	Relevance (examples)
Longest dry spell	Average length of the annually longest spells of precipitation <0.5mm	Agriculture, forestry, fire risk, natural environment, water supply
Highest 7-day precipitation	Average annual maximum precipitation accumulated over 7 days	Flooding
Heavy precipitation	Average annual number of days with precipitation >10mm	Local flashfloods, slope stability
Extreme precipitation	Average annual number of days with precipitation >25mm	Local flashfloods, slope stability
Number of warm days	Average of annual number of days with Tmax>25^{o}C	Energy demand, agricultural water demand
Number of tropical nights	Average of annual number of *tropical nights,* i.e. Tmin>20^{o}C	Comfort, energy demand
Number of frost nights	Average of annual number of *frost nights,* i.e. Tmin<0^{o}C	Growing season, snow/sea ice cover, energy demand
Number of freezing days	Average of annual number of *freezing days,* i.e. Tmax<0^{o}C	Snow/sea ice cover, energy demand, slope stability

Table 2 presents the indices used in this study together with some examples of relevance of which *"Longest dry spell"* might be interpreted as an indicator of droughts while *"Highest 7-day precipitation", "Heavy precipitation"* and *"Extreme precipitation"* are related to floods.

Results

Differences due to driving model

The model simulations that are used for calculating the indices in this study are described in detail in Räisänen *et al.* (2003 and 2004). Here only some main characteristics are summarised before we present the indices listed above.

The maybe most striking feature of the climate change experiments are the large differences due to the fact that the boundary conditions are taken from two different GCMs. Figure 1 presents results from the SRES/A2-based climate change calculations. Both the HadAM3H- and the ECHAM4/OPYC3-driven runs are presented illustrating the profound impact of the choice of lateral as well as sea surface temperature (SST) boundary conditions. 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 1. This difference leads to stronger westerlies in northern Europe in the RCAO-E experiments and thus to warmer and wetter conditions in the north. These systematic differences in the large-scale climate between the two driving models also show up in some of the indices of extremes.

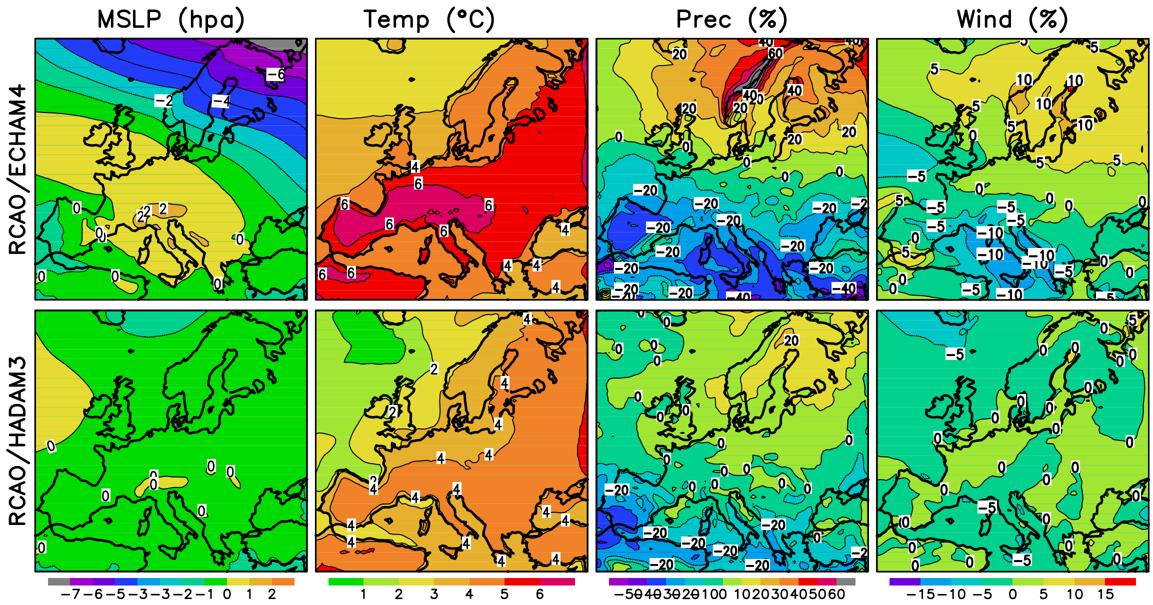


Figure 1. Changes in annual mean sea level pressure, surface air temperature, precipitation and mean wind speed from 1961-1990 to 2071-2100 for the SRES A2 forcing scenario. The first row shows results for the ECHAM4-driven and the second for the HadAM3H-driven RCAO simulation.

With respect to the indices of extremes, the recent climate conditions are similar in the RCAO-H/REF and the RCAO-E/REF runs. For the "*Highest 7-day precipitation*" the agreement is generally within ±10%, and for the "*Heavy precipitation*" and "*Extreme precipitation*" the agreement is within ±20%. For the "*Dry spell length*" the differences are however more pronounced, with the RCAO-E/REF run being 20-40% drier in North Africa and the Mediterranean and 20-40% wetter in central and Eastern Europe compared to the RCAO-H/REF run. Recent summer temperature conditions are very similar. For "*Number of tropical nights*" the only discernible difference is over the Mediterranean water mass, which is cooler in the RCAO-E/REF run. Also with respect to "*Number of warm days*" the Mediterranean water mass is cooler whereas the Iberian peninsula, the Balkan and north Africa is somewhat warmer (5-10% more days in the RCAO-E/REF). These differences in summer-time conditions are mainly related to how the forcing models handle the Mediterranean water mass. For winter conditions, both "*Number of freezing days*" and "*Number of frost nights*" differ over the central and eastern Europe and in particular over the Baltic. The RCAO-H/REF run is somewhat cooler, generally about 10-15% but up to 30-40% cooler over the Baltic (because of more extensive sea-ice coverage).

We now turn to describing general differences between RCAO-E/A2 and RCAO-H/A2 describing future climate conditions. These large-scale differences are closely related to differences in the driving models. The RCAO-E/A2 run show more "*Heavy precipitation*" and "*Extreme precipitation*" days, as well as larger "*Highest 7-day precipitation*" totals in British Isles and, in particular over Norway (west of the Scandinavian mountain range) compared to the RCAO-H/A2 run. This is in accordance with the differences in average precipitation (Figure 1). Likewise, the situation is reversed in the south where there are comparatively fewer "*Heavy precipitation*" and "*Extreme precipitation*" days, as well as lower "*Highest 7-day precipitation*" amounts in the RCAO-E/A2 run compared to the RCAO-H/A2 run. While the decrease in "*Highest 7-day precipitation*" appears over broad areas in the south, the differences in "*Heavy precipitation*" and "*Extreme precipitation*" closely follow the orography. With respect to "*Dry spell length*" there are more pronounced differences between the two runs. The general picture is the same; RCAO-E/A2 produce wetter (drier) conditions in the north (south) compared to the RCAO-H/A2. But the differences are more pronounced, up to ±50%, in particular in the south. It should be stated though that relatively small changes give high percentage rates when the amounts are small.

While differences, related to the driving GCM, in how RCAO represents recent temperature conditions are small, there are larger differences in the two A2 runs. In all four (4) temperature indices the RCAO-H/A2 run is somewhat cooler than the RCAO-E/A2 (Figure 1). In particular, the "*Number of tropical nights*" are higher in the RCAO-E/A2 as a result of higher sea surface temperatures being fed into RCAO from the driving model. Another difference is that the two summer temperature indices show anomalous low values over the Black Sea and in the Aegean Sea. This anomaly does however only very marginally extend in over land.

The SRES B2 scenario runs show the same general patterns of differences due to the two driving models, but less distinct, compared to the A2 scenario runs discussed above. This is what to expect, because the greenhouse gas (GHG) forcing is mainly introduced through the driving models and they respond in a consistent manner spatially. RCAO provides only a small additional response to the GHG forcing (Rummukainen et al., 2001).

Climate change signals

In the following we focus on results from the RCAO-E/REF and RCAO-E/A2 runs when discussing precipitation condition. The signals look the same with the two drivers but is generally more pronounced with the E-driver. When discussing temperature conditions we select the RCAO-H/REF and RCAO-H/A2 runs. The HadAM3H (H-driver) run shows a slightly more moderate temperature response compared to the ECHAM4/OPYC3 (E-driver) run.

The overall picture for the climate change signal in "*Heavy precipitation*" (Figure 2, bottom left) follows the changes in annual precipitation (Figure 1): increased number of heavy precipitation events in the north and a decrease in the south. North of a line from France over southern Germany, the Czech Republic and into the northern Ukraine there will be an increase and south there will be a decrease. The change is broadly proportional to the recent climate conditions (Figure 2, upper left) of "*Heavy precipitation*", i.e. a proportional increase in the north and a proportional decrease in the south. According to this scenario, the western slopes of Norway, Scotland and Iceland will see the largest increase of "*Heavy precipitation*" because of the intensified influx of moist air that increase the orographic precipitation in this region. Interestingly, when we compare the climate change pattern of "*Heavy precipitation"* with that of "*Extreme precipitation"*, they disagree in some important details. The general increase in the north, with its focus on the western slopes is similar, but the decrease in the south is much more localised to some few areas. This means that in this scenario there will be a general decrease in the precipitation in the south but the "*Extreme precipitation"* will not decrease in proportion. In other words, relative to the total precipitation the frequency of "*Extreme precipitation"* will increase. The same has been found on a more local scale, Sweden, where dry future summers show smaller amounts of total precipitation as well as fewer precipitation days but increased extreme precipitation.

The climate change signal in the "*Highest 7-day precipitation"* (Figur 3, bottom left) closely follows the pattern of changes to annual precipitation total, with an increase in the north, as well as in western and central Europe. Again, the most pronounced increase will according to this scenario take place on the western slopes of British Isles, and in Norway, where the "*Highest 7-day precipitation"* may increase with some 40-60mm/7days (locally even more), which corresponds to an increase by 30-50%. Also in France, Belgium, the Netherlands, Denmark and western part of Germany an increase of some 30% is seen in the scenario. Furthermore, the Bavarian and Carpatian mountains, i.e. the regions that has been the source regions for devastating floods during recent years an increase is seen on the maps. A decrease is noticed mainly in Iberian and Italian peninsulas and along the Balkan coast, as well as in Greece and Turkey.

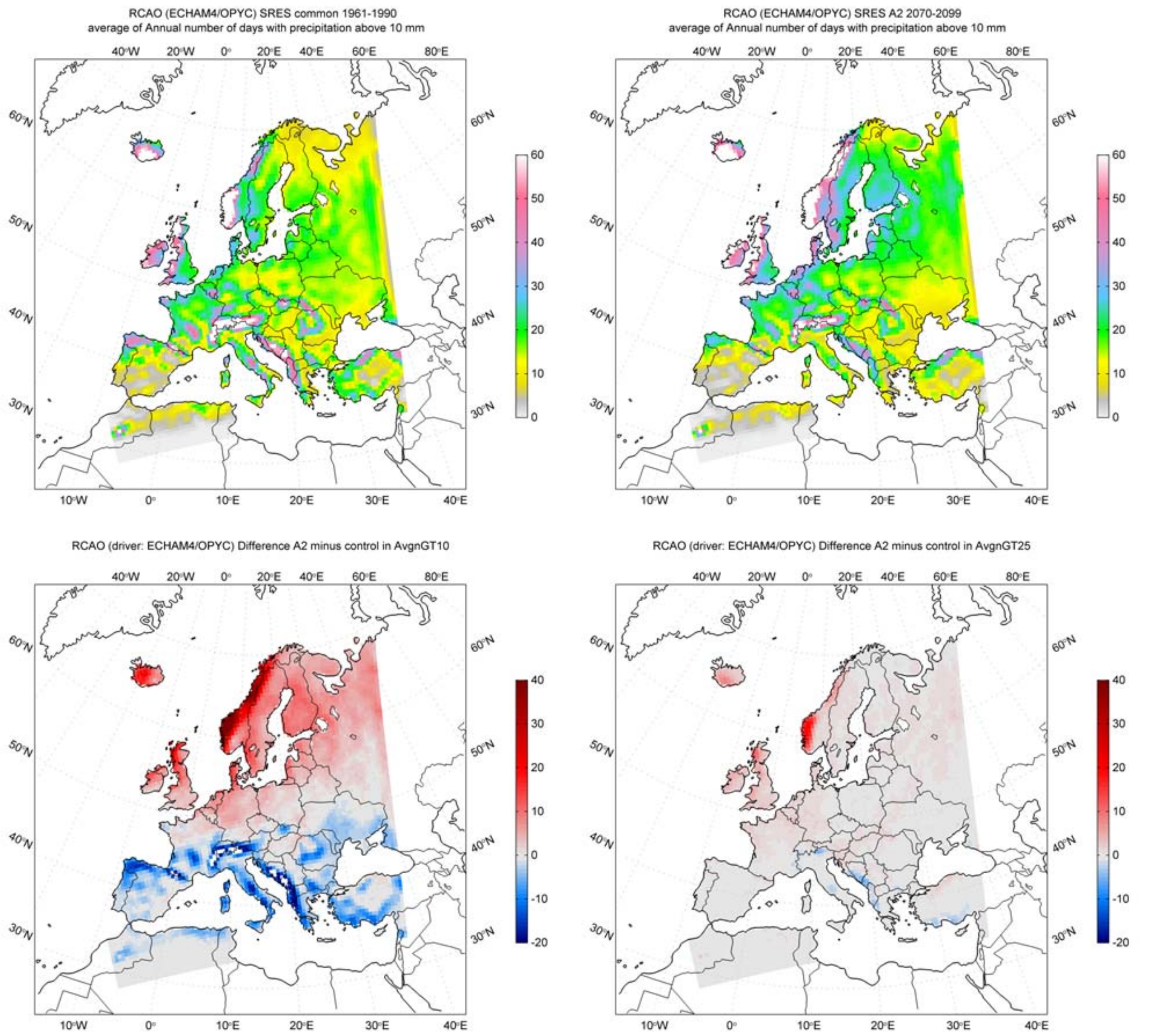


Figure 2. Changes in "*Heavy precipitation*", i.e. number of days where precipitation >10 mm/day across the whole gridcell. Top left is the recent climate conditions in the RCAO-H/REF and top right is the future climate according to RCAO-H/A2 scenario run, bottom left is the corresponding climate change signal (RCAO-H/A2 minus RCAO-H/REF). The bottom right map shows the climate change signal for "*Extreme precipitation*" (precip>25 mm/day), see text for discussion.

The *"Number of warm days"* show a distinct increase in the main part of Europe excluding most of the Nordic area as well as Scotland (Figure 4, upper left). The mountaineous area in northern Italy is also excluded. This orographic effect is also seen in the climate signal regarding *"Number of tropical nights"* which also show a less strong increase compared to the warm days index (Figure 4, lower left). The main signal is though that the number of both warm nights and warm days (summertime) increase in most areas in Europe. The maps with the signal from winterperiod indices (Figure 4, right panels) almost show a reversed gradient compared to the summerperiod indices. Both freezing days and frost nights are mostly decreased in the nort-northeastern parts. The frost index shows a stronger signal stretching to parts of the Meditteranean area. The mountaneous areas can also be depicted.in the maps.

Summary and discussion

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:

- uncertaintes 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)

The uncertainties are studied and will, by time, be better characterized and eventually smaller. Despite this, we have to be aware of that there will always be a certain amount of uncertainty involved when studying the future. To be able to make probability studies ensembles of scenarios are needed and that is the stage where climate research is heading (EU 6th Framework Programme).

In this report we have studied some climate extreme indices from model simulations by the regional climate model system RCAO, covering Europe. Four different future climate scenarios, from two driving models and two emission scenarios, were available. They were compared to a reference climate simulated by both driving models. Eight different indices of climatic extremes are presented in this paper. A summary of results follows.

Studying the indices of extremes in the *reference climate*, the conditions are similar with the two driving models. The precipitation indices show good agreement while the *"Dry spell length*" show drier conditions in the Meditteranean and wetter conditions in central and eastern Europe with the E-driver. Summer temperature conditions are very similar while in winter conditions the H-driver give somewhat cooler conditions particularly over the Baltic.

The B2 emission scenario runs show the same general pattern as the A2 but less pronounced. In this paper the A2 scenarios are presented.

There are systematic differences in the large-scale climate between the two driving models which is also seen in the indices of extremes when comparing the scenarios. The E-driver produce wetter (drier) conditions in the north (south) of Europe while the H-driver produce cooler conditions generally.

The climate change signal regarding *"Heavy precipitation"* show a distinct north-south difference with increased number of events in the north and decreased in the south (Figure 2, bottom left). The *"Extreme precipitation"* index show that despite a general decrease in precipitation in the south the extreme events will be about the same in the future climate scenario as today. The maximum precipitation accumulated over 7 days show increases in most parts of Europe except the countries along the Meditteranean (Figure 3, bottom left). The length of the annually longest dry spell is increased in most parts of Europe, except most parts of the Nordic countries (Figure 3, bottom right). The signal is most pronounced in areas where in today´s climate the average dry spell is more than 40 days.

Both warm days and tropical nights will increase in most parts of Europe according to the scenario in this study, most abundant in southern parts and with an orographic effect (Figure 4, left panels). The *"Number of freezing days"* are increased with a north-northeastern gradient. The *"Number of frost nights"* shows a similar pattern but with a stronger signal also including parts of the Meditteranean area.

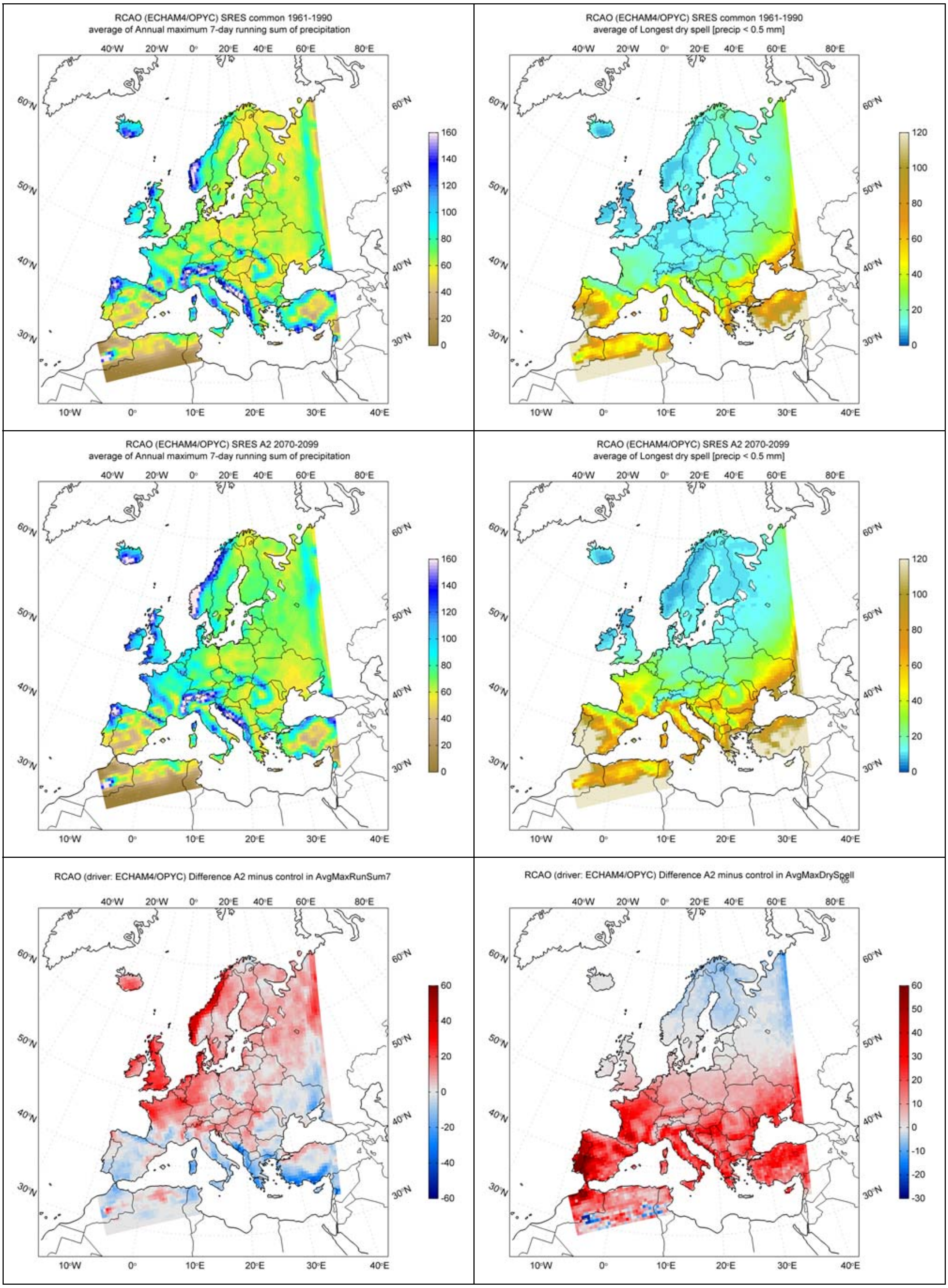

RCAO (ECHAM4/OPYC) SRES common 1961-1990
average of Annual maximum 7-day running sum of precipitation
RCAO (ECHAM4/OPYC) SRES common 1961-1990
average of Longest dry spell [precip < 0.5 mm]
RCAO (ECHAM4/OPYC) SRES A2 2070-2099
average of Annual maximum 7-day running sum of precipitation
RCAO (ECHAM4/OPYC) SRES A2 2070-2099
average of Longest dry spell [precip < 0.5 mm]
RCAO (driver: ECHAM4/OPYC) Difference A2 minus control in AvgMaxRunSum7
RCAO (driver: ECHAM4/OPYC) Difference A2 minus control in AvgMaxDrySpell
40°W 20°W 0° 20°E 40°E 60°E 80°E
60°N 50°N 40°N 30°N
10°W 0° 10°E 20°E 30°E 40°E
160 140 120 100 80 60 40 20 0
120 100 80 60 40 20 0
60 40 20 0 -20 -40 -60
60 50 40 30 20 10 0 -10 -20 -30

Figure 3. Changes to the *Highest 7-day precipitation* amounts (left column) and to *Dry spell length*. The top row shows present-day conditions (1961-1990), the middle row shows future SRES A2 coditions (2071-2100). The bottom row depicts the climate change signal (i.e. SRES A2 minus present day conditions).

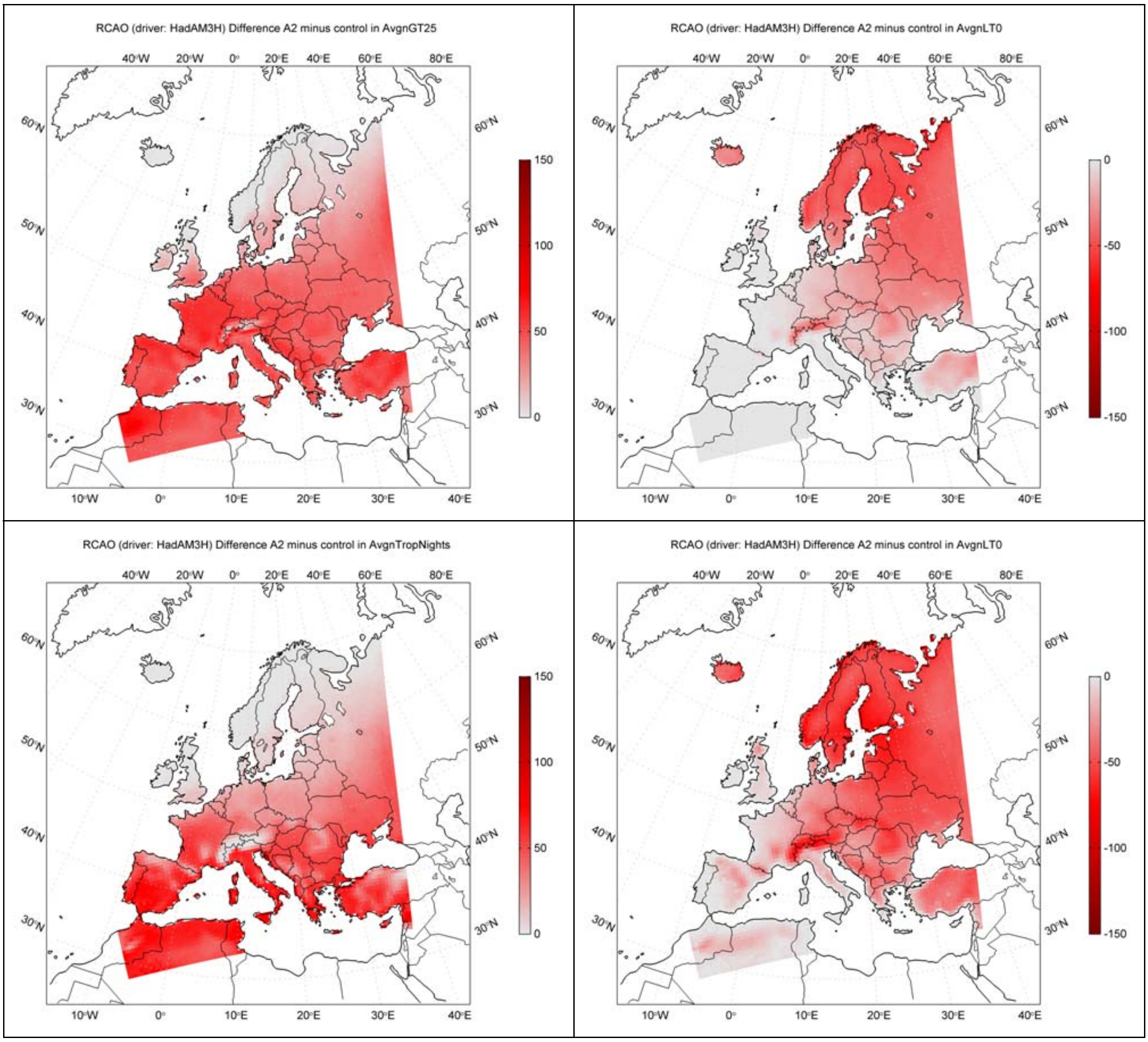


Figure 4. The temperature climate conditions are represented by four indices that are related to summer/winter day-/nighttime conditions. Summer daytime conditions (upper left) are represented by the index "*Number of warm days*" (Tmax>25°C), summer nighttime conditions (lower left) are represented by "*Number of tropical nights*" (Tmin>20°C). Winter daytime conditions (upper right) are represented by " *Number of freezing days*" (Tmax<0°C) and winter nighttime conditions are represented by "*Number of frost nights*" (Tmin<0°C).

The *"Number of warm days"* show a distinct increase in the main part of Europe

ANNEX 3
Checklist answers from the Dresden Region, the Central Region of Portugal and the Avançon

The following table compares the answers to the checklist for the assessment of risk management related aspects within the spatial planning process of the Dresden Region (Germany), the Central Region of Portugal and the Avançon (Switzerland).

Scientific basis	Dresden Region	Central Region of Portugal	Avançon
Hazard identification by sectoral planning divisions or have they at least been involved?	• There is continuous cooperation between spatial planning authorities and sectoral authorities. However, no systematic hazard identification is being done by any of the partners. This issue relies on the initiative from spatial planning partners but lacks systematic basis. • So far hazard and risk identification only in the field of environmental hazards – soil erosion by water, deflation. • Indirect consideration of hazards takes place by spatial planning authorities: e.g. implicit hazard mitigation in the fields of droughts and storms or heavy precipitation by integrating these issues into spatial development recommendations. E.g.: recommendations to restructure the combination of tree species in forests to mitigate drought or storm risks or to lower surface runoff during precipitation to lower floods (depending on the hazard the area is prone to). However, this is being done on a purely qualitative basis. • Flood hazard maps for main rivers are currently under preparation. In this context also maps of so called 'flood source areas' will be prepared in future. Other thematic maps can be used by local authorities such as the map of subsurface cavities from the mining authority of the state.	• In the central region of Portugal we deal mainly with four major hazards (they are ranked according to their importance, being the first two, the most important ones): forest fires, flooding, landslides and hazards related with uranium contamination. • *Forest fires* – there are information on frequency of forest fires as well as the extension (magnitude) covered by them; there are hazards map available on burned areas. • *Floods* – there are information on frequency and magnitude of these hazards. But there are no hazards maps. • *Landslides* **–** In most of the cases there are no hazards map, only when severe accidents take place. • *Hazards related with uranium contamination* – there are no accidents registered, therefore, there is no hazardous waste deposit maps.	• Major hazards in the Avançon are firstly floods and secondly landslides. The quality of information about hazards intensity and frequency is very heterogeneous. • Floods and debris flow : indicative map (1:25'000) about the extension of floods is under preparation by the sectoral (cantonal) planning division. • Sectoral hazard maps already exist for particularly vulnerable areas. • *Landslides* – indicative map (1.25'000) about the extension of landslides is available for the whole site. On this map, rapid and slow landslides are differentiated. Detailed information (1:5'000) about specific landslides are also available • *Sinkholes* – indicative information (1:25'000) about the location of the main sinkholes is available for the whole site. • *Rockfall* – no hazard map. Severe rock fall areas are known. • *Snow avalanches* – indicative map (1:25'000) about the extension of snow avalanches is available for the whole site. • *Earthquakes* – A seismic macro-zonation map is available. No micro-zonation map on the test site. • *Meteorological hazards* – meteorological hazards maps (rainfall, snowfall, wind, air temperature, glaze) do exist at the national and regional scales (meteosuisse). • *Waste deposits* – A register of waste deposits is under preparation by the sectoral (cantonal) planning division.

Risk analysis by sectoral planning divisions or have they at least been involved?	• No risk analysis, no risk maps. Assumptions on a qualitative basis. • First risk maps may be prepared for flood hazard.	• *Floods* – Following the publication of the decree-law 364/98 of November 21st, all Municipal Spatial Plans (PDM) are enforced to complied with this regulation, which compulsory determines that every single PDM will have to mark down the potential risk area which may be affected by floods. Though, only some city councils are able to provide it. • This kind of mapping is able to provide us with the level of vulnerability, which may affect urban areas. • Despite the fact that city councils are accountable for the evaluation of the damage potential as well as the available coping capacity, only few of them (out of 78 city councils within this region) hold this kind of information. • *Forest fires* – there are some municipalities within the region, which hold forest fires maps. (Please check 2nd ESPON Hazards Interim Report)	• *Floods* – Risk maps are generally not available except in local/specific cases. • *Landslides* – Risk map are not yet available. Detailed risk analyses on some active landslide cases are nevertheless available. • No specific risk analysis of coupled hazards (e.g. landslide and floods)
Coordination between spatial planning authority and sectoral planning divisions about hazards?	• There is no systematic approach to spatially relevant hazards and risks. • Coordination starts in the field of floods.	• There is one commission called *"Comissão Mista de Coordenação"* (Joint Coordination Commission) which is the face of these institutionalised communication procedures. • While municipal spatial plans are being conceived, this commission allows all the intervenient in the process to participate and exchange information. Its major aim is to monitor all the planning process in order to warrant the compliance with national sectoral legislation. • Though, it is important to mention that there are two factors, which restrain this exchange. The first one deals with the fact that we lack of a "sharing" culture, and sometimes there is information but people are not able to partake it. On the other hand, there are some national sectoral departments that, at this stage of the process, should have comprehensive and scientific studies on different sectors (sectoral plans) and in the majority of the cases they are not there (they don't exist), which may cripple all the process.	• Spatial planning is under the responsibility of the municipality and hazard policy is dispersed among different services of the cantonal authority (according to the type of hazard and the object at risk). • A method for coordinating spatial and hazard planning is presently developed by the canton. • The integration of the component "risk" in the spatial planning policy strongly varies from one municipality to another

Political decisions	Dresden Region	Central Region of Portugal	Avançon
Risk evaluation by spatial planning authorities?	• No risk evaluation in spatial planning or politics.	• In Portugal, and particularly within this region, there is still no culture of risk evaluation since there is no safety culture. That is why it is possible to say that only now the first steps are being made. • From the interviews that we have been able to do, it is possible to find out that the planning professionals still have a long way to go in order to persuade the politicians (mayor of city councils) of the importance of risk analysis (and risk prevention), and the need for a specialized team of technicians operating in this area. • Nevertheless, it is important to notice that prior to the ratification of municipal spatial plans there is a wide public consultation, where issues related with risk perception may be queried and this quest depends must upon the awareness of citizens and local institution.	• Federal authorities will provide the cantons with recommendations about the evaluation of the various risks. Federal subsidies will incite the cantons to apply these recommendations. • In principle, the cantons should decide on specific policies of application and information to the population. Due to the large autonomy of the cantons these policies can strongly differ from one canton to another. • For many hazards, the cantons have a two-step analysis: an indicative step (1:25'000) to identify hazards areas and a second step (1:10'000, 1:5'000) where selected hazards areas are analysed in detail (intensity and frequency data) • Risk evaluation by planning authorities is based on the detailed hazard maps.
Risk assessment by spatial planning authorities?	• No systematic risk assessment. This starts to change in terms of 'flood hazard' but there remains a long way towards 'flood risk'. • Qualitative assumptions lead to the formulation of spatial development goals.	• There is some information available. Though, as we previously mention, there are some lack of data due to missing sectoral plans.	• As detailed hazard maps are not available for the test site, its risk evaluation is still largely based on the experience of the concerned municipalities (most critical events, frequent hazards, population concern, etc.)

Risk related planning goals set up by spatial planning authorities?	• Spatial planning has to cope with individual restrictions set by (thematic) lows valid for various (potentially hazardous) issues (e.g. Emissions protection low; in future a new part of the Federal Environment Law will regulate construction in flood prone areas etc.). These lows often contain clear information on security issues and are to be considered in the course of approval procedures for so called spatially significant development projects. • Risk or hazards are not explicitly considered in spatial planning documentation on either regional or local levels. When disclosing development areas at different levels of spatial planning security reasons may play a role (e.g. authorities would probably try to avoid to disclose an area for new housing development in the very vicinity of an hazardous industrial plant and vice versa), but not based on a systematic hazard prevention approach. This way of strategic planning targets new development, but it does not apply for existing structures.	• The protection goals are the same whichever is the hazard in question: they look to protect people and equipment. • It is important to notice, though, these set of protections goals are based on different kind of information. For instance, in regard to the risk of flooding, while mapping potential flood areas in urban areas are based on rigorous data, every time the same exercise is done to areas placed out of urban areas they are based only in empirical data (it is the case, for some areas which are included in National Ecological Reserve – REN)	• Protection goals are set up according to the type of affectation of the territory. In some specific cases they can be directly object-related (hospital, school, power plant, natural reserve, etc).

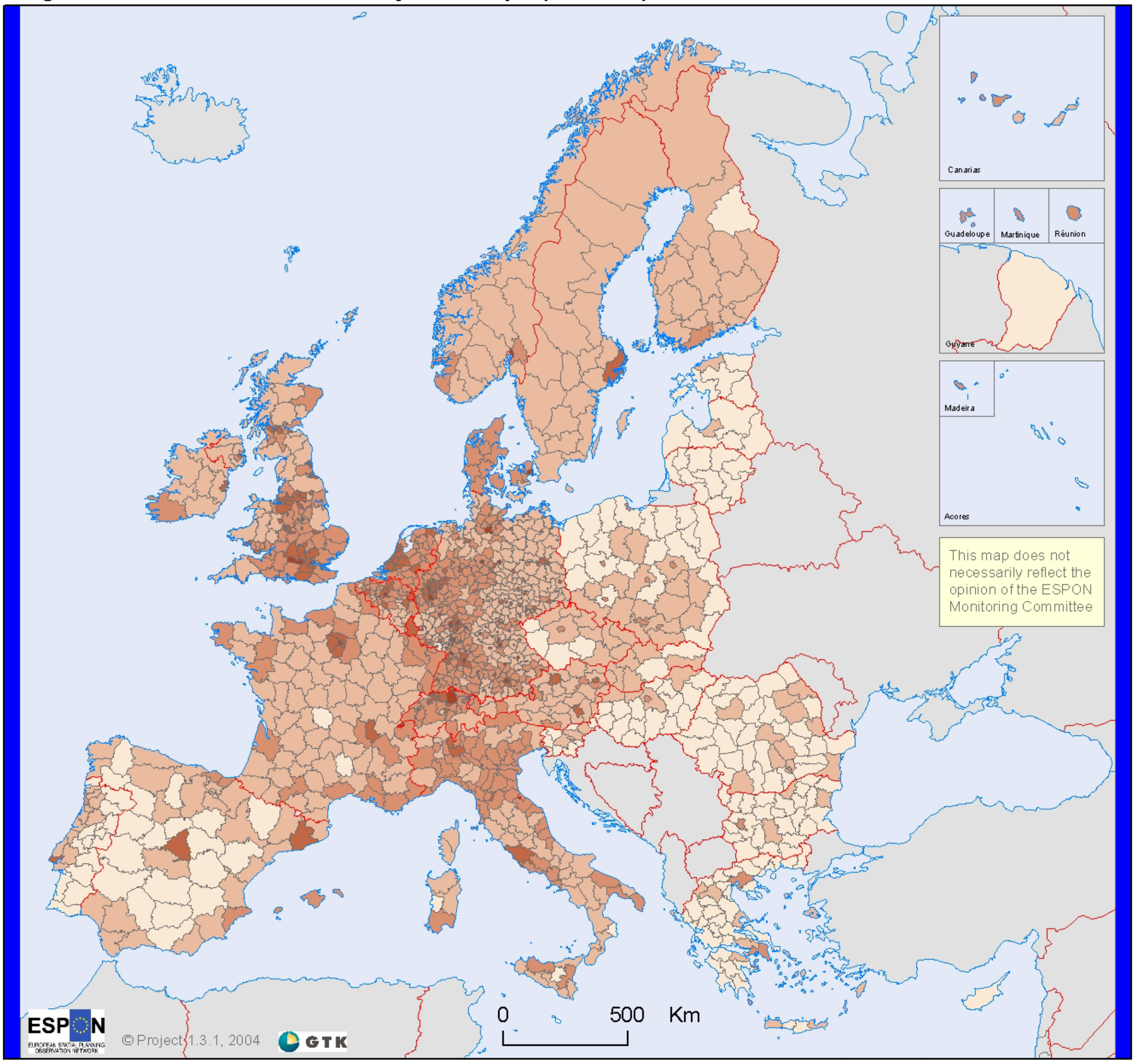
Measures suggested by spatial planning authorities? **To what extent are certain measures** **- coordinated with other (planning) authorities?** **- binding for other (planning authorities)?**	• The operative planning and implementation level is on the local level. These have to cope with own and subordinated legislature and so called goals of spatial development set at regional levels. However in most cases all spatially relevant decisions are taken and implemented at and by the local level. For the single hazard 'flood' there exists a state agency responsible for flood hazard, but this works rather in a linear manner along the water courses not using spatial planning approaches (LTV-Landestalsperrenverwaltung – State Reservoir Authority). • Generally no risk related alternatives can be considered by spatial planning authorities in the course of spatial planning as there so far is no strategic approach to this issue. Spatial planning authorities respectively other approving units of the local or any subordinate level are usually confronted with single projects during planning and development phases and treat them individually. • However, an important issue is risk against natural subjects of protection which are considered by the EIA. In accordance with the size of any project subordinate levels of spatial planning might be called for approval. • There are no measures for risk prevention except for those directed against floods, but here as well without a real spatial planning process including conceptually different alternatives. This is in change at the moment. • Cost analysis is done but only in terms of realising more or less the same alternative by different means. Spatial planning is hardly conceptually involved. Social costs are usually not involved. Ecological risk issues are addressed by project EAI's	• All measures are discussed and analysed within *" Comissão Mista de Coordenação"* (Joint Coordination Comission). Usually, they don't cover all the spectrum of prevention measures needed, focusing mainly in those, which relate with structural issues. • There is no evaluation in regard to technical functionality, economic costs and efficiency as well as social and ecological effects, since as we have mentioned previously, city councils have no specialised team on these issues on top of dealing with financial constraints.	• Measures to reduce the risk can be taken at federal, cantonal, municipal or individual level according to the object under consideration and the risk involved. • Measures generally result from a multi-level agreement as they frequently imply expenses and impacts for the cantons, the municipalities and the private sector.

Implementation process	Dresden Region	Central Region of Portugal	Avançon
Public stakeholders involved in the implementation process?	• Official stakeholders are working closely together. In the process of plan elaboration different sectoral plans are integrated into the final comprehensive plan. But also here is true, as there is no planning for hazards respectively risks, they can neither be addressed nor discussed nor integrated. • Emergency units exist, but independently from spatial planning.	• City councils are liable for the implementation process and management of these plans. When facing with difficulties on the management process, they may ask for further advice to those as regional spatial planning authorities and sectoral authorities.	• Implementation process can be carried out by the municipalities, the cantons or the confederation according to the object to be protected (road, building, river, etc) and the dimension of the task. As already said, the role of the municipalities in the promotion of the implementation process can be highly variable.
Private stakeholders involved in the implementation process?	• In planning processes as well as in the EIA-process public stakeholders are involved in the course of plan elaboration. Public stakeholders here have the right to access the planning documentation and to comment the plan and parts of it as well as single issues. However, as there is no systematic risk theme in the plans public participation cannot be done on it. • It is expected that private and commercial stakeholders are aware of their participatory rights. The participation process is announced in official newsletters.	• In the majority of the cases private stakeholders are not properly informed about their role in the process due two set of reasons: • Their main interlocutor is the mayor who as we previously mention is not always aware of the spatial plan and therefore is not able to provide an in depth knowledge of types of land used and the level of the risks that are associated to them. Their only concern is to guarantee that an investment is done in their municipality. • In most of the cases, private stakeholders buy a land without even ask what is its designated use within the devised spatial plan. Therefore, quite often land acquisition is done with an objective in mind regardless what the plan establishes.	• Implementation processes carried out by the private sector are regulated by the legislation and the constructive norms. • Municipalities and cantons are responsible for the application of these regulations/norms and for their dissemination among the population (private sector included). • This task is only possible when risk maps are available.
Monitoring of implementation process?	• Since implementation so far only exists in terms of flood protection, implementation has not to be monitored since measures are structural single actions implemented according to modelling. Monitoring here exists at the level of involved state authorities monitoring flood frequencies thus allowing conclusions about the validity of the announced security level. • In reference to flood protection measures there has been some reflection after the August 2002 flood which caused some conceptual changes disemboguing in a new flood protection program soon to be released at the state level and valid for watercourses with state competence.	• There is some monitoring but without a systematic character. • It is possible to say that in the case of floods, the established rules within the decree-law 364/98 are based on previous monitoring processes, leaving scope for further adjustments if it will prove necessary. • In regard to forest fires there are annual accounting of inflicted areas, which are properly mapped, and take part of PDM.	• Cantons and municipalities are responsible for the monitoring of the implementation process. Cantons are active when protective actions are beyond the scope of municipalities. • Both authorities should set up a planning and application rules for the measures to be taken. They should regularly control and monitor the protective works to guarantee their efficiency in the long-term. • A large heterogeneity do exist in this process according to the hazard under consideration and the vulnerability of the area under study.

ANNEX 4
Updated maps

This annex contains some updated maps, please see the 2nd ESPON Hazards Interim report for original maps and detailed explanations. The vulnerability map is nowadays called economical vulnerability map (see chapter 1.2) and contains data on Norway and Switzerland. The earthquake and winter storm economical risk maps now also contain NUTS III economical vulnerability data on Norway and Switzerland. A new map is the economical risk map on nuclear power plants, meanwhile the colour legend of the nuclear power plant hazard map was changed.

Degree of economic vulnerability in Europe (NUTS 3)



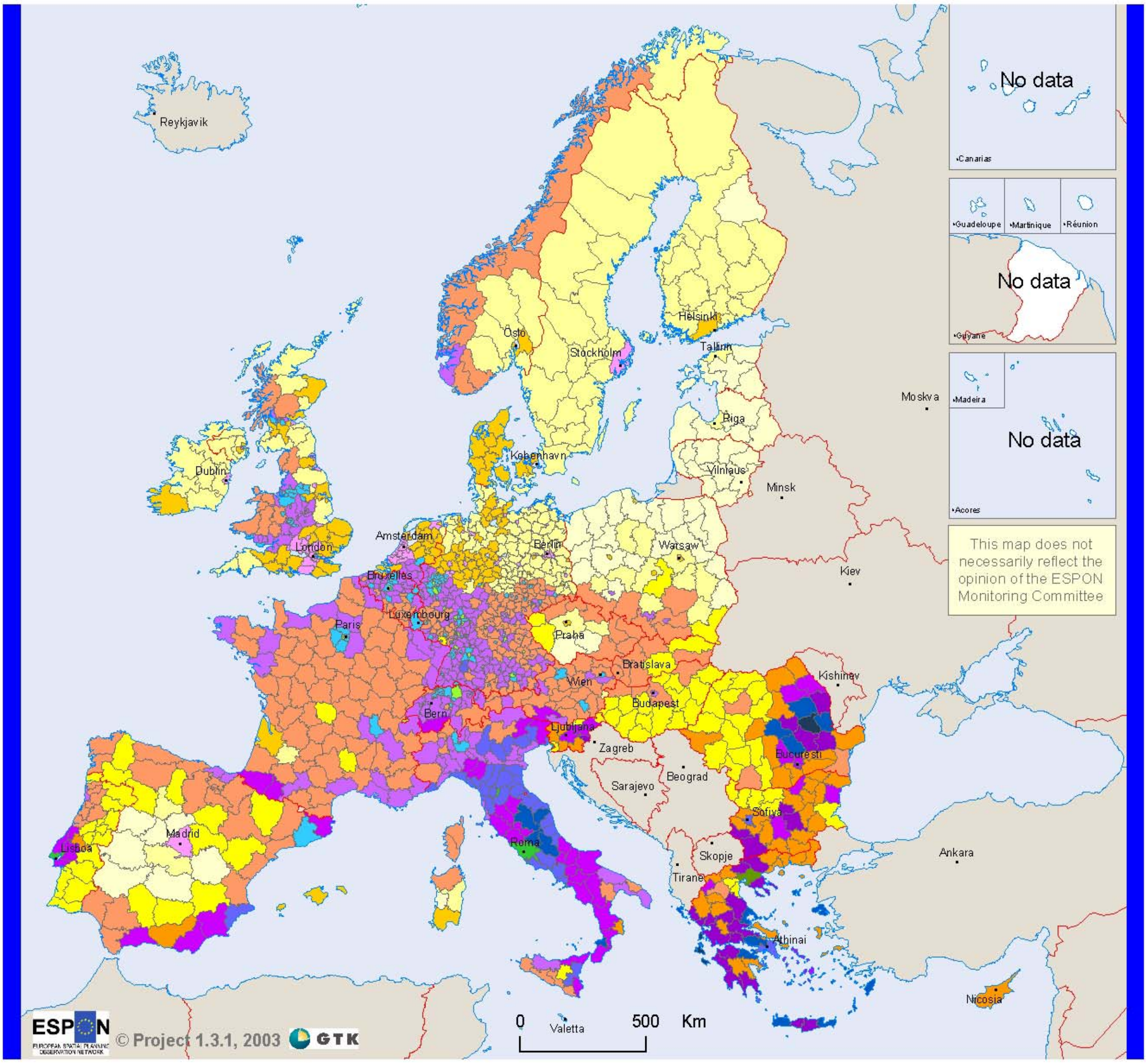
Origin of the data: © EuroGeographics Association for the administrative boundaries
Population density and GDP Eurostat
Source: ESPON Data Base

Degree of vulnerability

- I
- II
- III
- IV
- V
- No data
- Non ESPON space

Degree of economic vulnerability based on GDP per capita and population density, equally weighted (50:50).

Economic earthquake risk in Europe (NUTS 3)



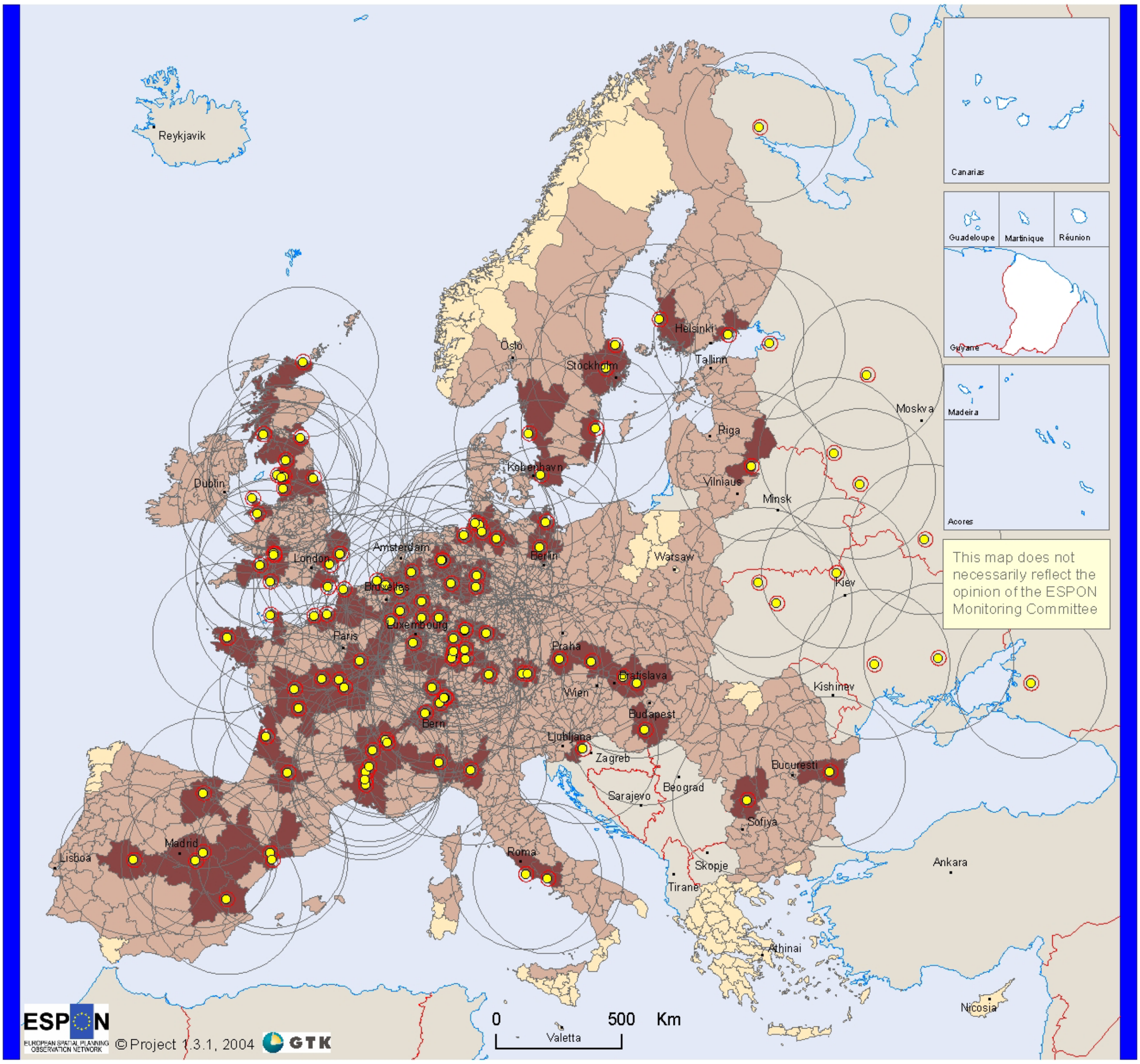
Origin of the data: © EuroGeographics Association for the administrative boundaries
Pga data © Global Seismic Hazard Assessment Program

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

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



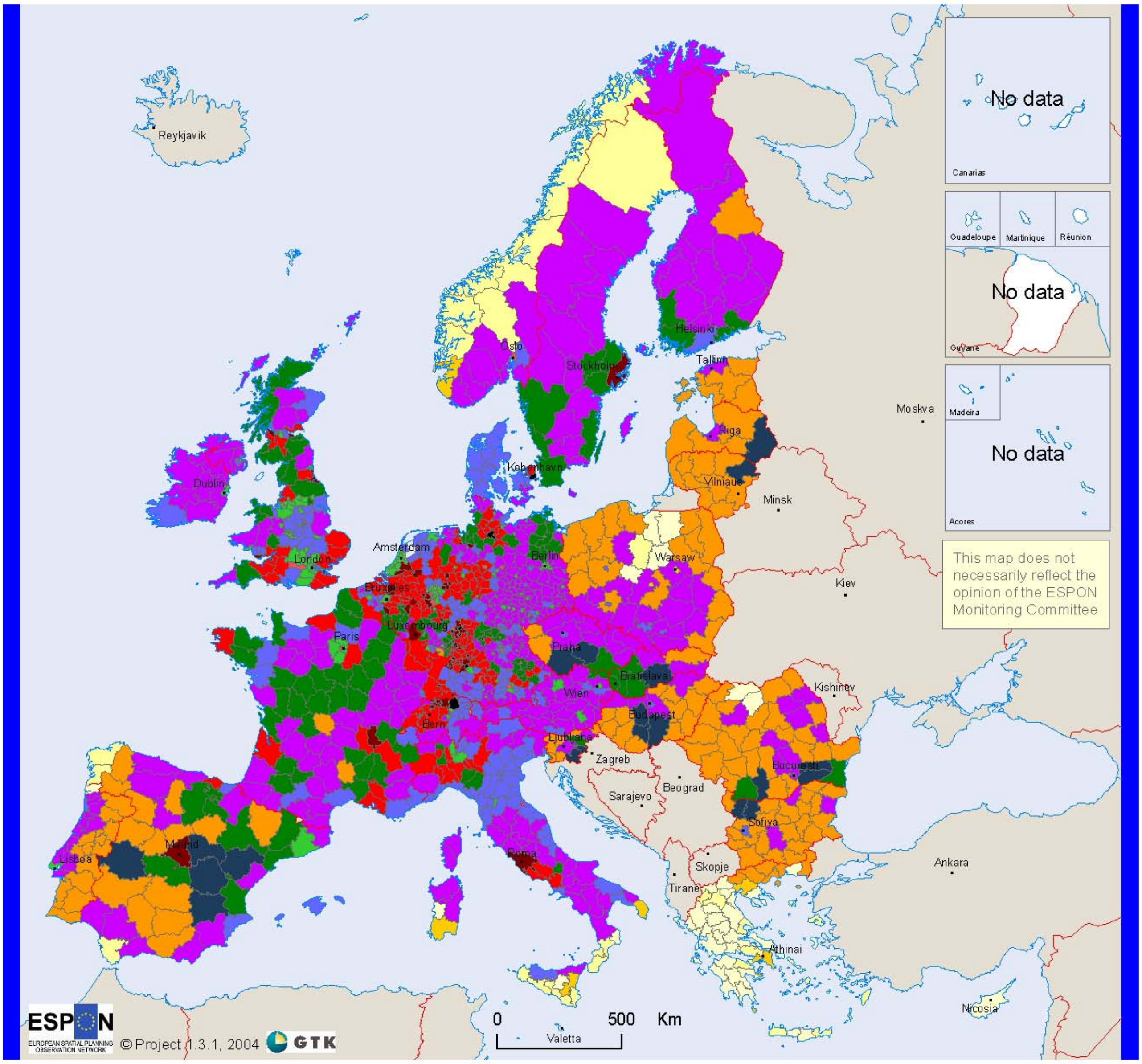
Origin of the data: © EuroGeographics Association for the administrative boundaries
Nuclear Power Plant © Nuke Data Base System, Ljubljana, Slovenia
Eurostat GISCO

Source: ESPON Data Base

The potential risk of radioactive contamination on NUTS 3 level

- Nuclear power plant
- Area to be evacuated (radius 30km)
- Area with a possible severe caesium 137 contamination (radius 300km)
- Areas outside 300 km Radius in ESPON space
- Indirectly affected areas
- Directly affected areas
- Non ESPON space
- No data

Economic nuclear power plant accident risk in Europe (NUTS 3)



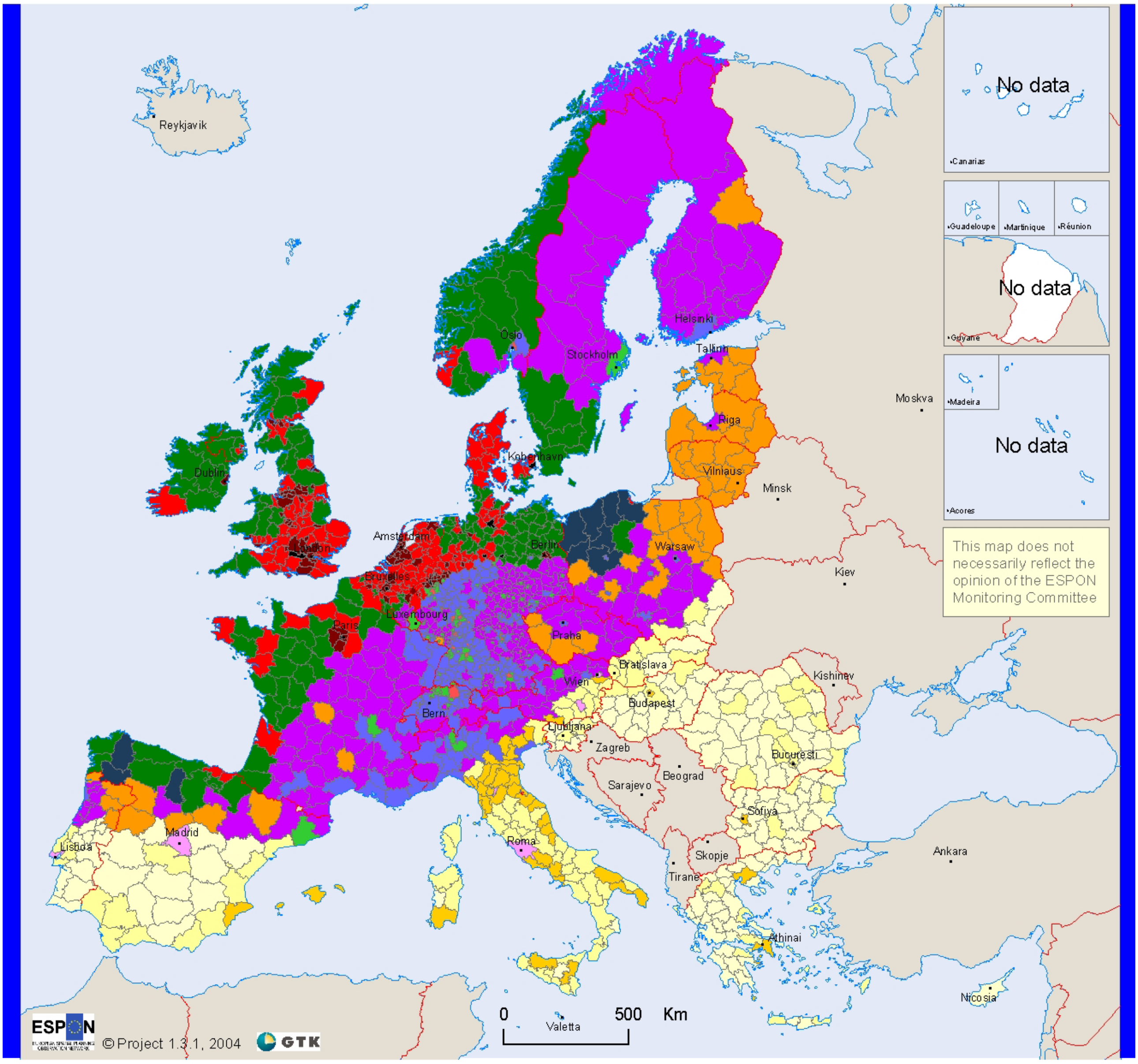
Origin of the data: © EuroGeographics Association for the administrative boundaries
Nuclear Power Plant © Nuke Data Base System, Ljubljana, Slovenia
Eurostat GISCO

Source: ESPON Data Base

Typology of the regions

Nuclear power plant 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

Economic winter storm risk in Europe (NUTS 3)



Origin of the data: © EuroGeographics Association for the administrative boundaries
Winter storms © Munich Re

Source: ESPON Data Base

Typology of regions

Intensity of winter 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

ANNEX 5
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