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REGIONAL MULTI-RISK REVIEW, HAZARD WEIGHTING AND SPATIAL PLANNING RESPONSE TO RISK – RESULTS FROM EUROPEAN CASE STUDIES

by
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The presence of multiple natural and technological risks in an area is typical for most European regions. However, systematic consideration of multiple risks by spatial planning remains a major challenge. Within the scope of the ESPON Hazards project, a method for (multi-) risk review at regional level was tested, which combines easily available indicators for hazards and vulnerability. As a result, regional risk profiles are derived for four case study regions, providing indicative information for spatial planning at regional level. As part of the risk review, multiple hazards are weighted by expert panels using the Delphi Method. The Delphi Method has proved an appropriate and easily applicable method for deriving consensus between experts regarding the weighting of hazards for planning purposes in multi-risk situations. Weighting by different expert panels has confirmed that results partly depend on subjective risk perception of the participating experts. Methodological modifications in the case studies show that the scale of risk review and the set of indicators used can have a significant impact on the expressiveness of results. Detailed results from the Dresden Region and Centre Region of Portugal are presented.

Key words: natural hazards, technological hazards, risk assessment, spatial planning, weighting case studies, Germany, Portugal

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1 APPLIED METHODS AND SUMMARY OF FINDINGS

1.1 Introduction – Case studies within ESPON Hazards

Risk management has long been recognised as an important task of spatial planning (Greiving 2003, Karl and Pohl 2003) and is also assigned high importance in the European Spatial Development Perspective paper (CEC 1999, § 142).

> *Spatial planning at suitable government and administrative levels can play a decisive role… in the protection of humans and resources against natural disasters. In decisions concerning territorial development, potential risks – such as floods; fires; earthquakes; landslides; erosion; mudflows; and avalanches and the expansion of arid zones should be considered. In dealing with risks, it is important, in particular, to take the regional and trans-national dimensions into account.*

As a result, the spatial planning response as part of the overall risk management is a special research interest. In the ESPON Hazards project, case studies are conducted with the aim of supplying practice-level information into the EU-wide approach of the project. The investigation in case study areas provides information for the development of indicators and methods and for testing their applicability and limitations in practice. As well, case studies allow for detailed investigations including document reviews and expert interviews (e.g. in spatial planning administrations) to highlight specific aspects of regional hazards, vulnerability, coping strategies, risk awareness, official response or administrative capacity and other issues. On the one hand, this is important for methodological advancement, which can form the basis for systematic consideration of hazards and risks in spatial planning as a first step towards comprehensive risk management. On the other hand, findings uncovering planning reality lead towards specific recommendations for future development of risk management by spatial planning in Europe. The reference level chosen for case study investigations is the NUTS level III.

In total, four case studies are completed to extract information for different parts and phases of the ESPON Hazards project, comprising the Dresden Region (D), the Centre Region of Portugal (P), the Region of Itä-Uusimaa (Fi), and the Ruhr District (D). The main objectives of the case studies is the screening of spatial planning responses to issues of risk management and the development and testing of methodologies for regional risk review.

In the following, methodological approaches and results of the case study investigations are presented and discussed. First, a Strengths-Weaknesses-Opportunities-Threats (SWOT) based review will give a brief summary of the reality of spatial planning response to natural and technological risks in the case study areas. Second, the application of the Delphi method will be described and discussed. It will be shown that with the use of the Delphi method coordinated results can be achieved as a basis for systematic consideration of multiple risks in spatial planning. Third, a simplified method will be presented which allows for the derivation of an indicative inner-regional risk profiles depicting potential hotspots for risk management.

Finally, detailed results are presented for the case studies Dresden Region and the Centre Region of Portugal. The remaining two case studies are documented in the ESPON Hazards Final Report (Schmidt-Thomé).

1.2 SWOT-based review of the spatial planning response

The spatial planning response is reviewed in cooperation with regional planning authorities and mainly by document analysis and interviews with stakeholders of regional planning. By these investigations, light is shed into selected aspects of existing regional planning related to risk management. The SWOT-based review summarises main features with regard to the spatial planning reality of response to risk.

The case study areas show different planning responses to risks. However, certain characteristics seem to be generic. While planning systems generally offer effective frameworks for spatial planning, the consideration of risks is systematically underdeveloped. All case studies report only selected treatment of hazards, with rudimentary risk related planning. Methodological deficiencies and data gaps offer only a limited potential for risk assessment and thus prevent the systematic integration of risk management aspects into spatial planning.

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

The main opportunities lie in the partially growing sensitivity to risk and in the emerging risk management approaches in practice. Established administrative capacity and effective implementation of European regulations pave the way for a European-wide introduction of systematic (multi-) risk management in spatial planning. However, growing sensitivity and methodological advancements may not be effective if risk management in spatial planning is not settled upon a systematic approach that considers all relevant hazards and if insufficient competences, capacities and resources for their implementation and controlling are allocated to stakeholders of regional planning.

Table 1. SWOT-based review of regional planning response in case study areas.

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

1.3 Applying the Delphi-method to the inner-regional weighting of hazards

1.3.1 Background

The importance of risk management is underlined by many international (IDNDR, Plate et al.1993, ISDR 2004), supranational (European research projects, EC structural funds) as well as national and regional activities developed and supported in the last years. Regional risk management in most cases faces the problem of multiple hazards. Multi-hazard cases can be described as settings where a multitude of hazards need to be included in the risk management of a certain area. Therefore, in order to allow for a consistent regional planning response, a multi-risk perspective is indispensable that considers the *entirety of spatial planning relevant hazards* and which integrates all responsible stakeholders in the region. The latter are typically spatial planning authorities at various administrative levels (regional planning, comprehensive land use planning), insurance and re-insurance companies, emergency response managers and other.

Whenever a multitude of hazards has to be considered in risk management, the question of weighting is raised. Weighting of hazards or risks can be accomplished by deriving weighting factors empirically, commonly based on loss data (damages) from historic events (by using insurance data such as Munich Re 2000, 2004). Nonetheless, this procedure would only cover a part of the issue. First, rare events (hazards) can easily be overlooked if no event has been recorded in the considered period. Second, loss data in general are not necessarily complete and may leave large data gaps. Third monetary loss data only cover monetary values whereas other (often intangible) aspects of loss like psychological stress would remain unconsidered (cf. Penning-Rowsell et al. 2000 and other). Finally, the exclusive consideration of loss data neglects differences in the perception of risk. But, beside the impartial risk analysis, 'risk' is also influenced by societally determined values such as risk perception (cf. Plate 1999) or risk aversion (PLANAT 2000), which can vary considerably between individuals and societies.

Thus, weighting of risks should also consider the 'subjective factor' of risk perception by going beyond factual information. This is possible through the use of feed back methods such as the Delphi method as a tool to generate weighting factors in multi-hazard cases that are relevant in the context of spatial planning (cf. Hollenstein 1997, p. 82ff, Lass et al. 1998, p. 23). The Delphi method was adapted for the specific use of multi-hazard weighting and tested several times in the four case study areas. In this application, the Delphi method should be seen as an assuming and embedded methodological tool for deriving weighting factors for the assessment of the overall risk of a certain area. For the application of results, a quantitative method is needed that uses the weighting factors in addition to pre-existing impartial information (see 1.4).

Furthermore, the derivation of weighting factors can have several advantages:

- Weighting can produce a common understanding of the severity of hazards compared to each other as part of risk assessment and as a basis for risk mitigation in spatial planning.
- Purposeful variation of weighting factors can be used for simulating different risk profiles depending on different conditions and including risk perception. This can be used for the development of scenarios for risk management.
- Regular iteration of weighting can allow the surveillance of the development of risk perception and thus illustrate changes over time.

1.3.2 Delphi as a weighting method in uncertain cases

The Delphi method is a study method that generates ideas and facilitates consensus among individuals with special knowledge in a certain field of interest. Unlike survey research, which requires random samples representing all parts of the population, for a Delphi study individuals are carefully selected, who have the knowledge needed for the analysis of a specific problem. The method is typically applied with mono-dimensional, uncertain issues which cannot be confirmed by impartial information. Developed in the 1960ies (Helmer 1966), the Delphi method has become widely accepted over the past decades, which becomes manifest in a broad range of applications by institutions, government departments and in research (cf. Turoff and Linstone 1975, Cooke 1991, Hollenstein 1997, Scholles 2001).

The method's original attitude is the investigation of opinions and ratings from different experts without necessarily establishing face to face contact and thus avoiding disadvantages of direct interaction such as communication barriers between individuals with different attitudes or positions, the dominance of key persons, travel and meeting costs and other aspects.

The Delphi Method is based on a structured process for collecting and synthesising knowledge from a group of experts through iterative and anonymous investigation of opinions by means of questionnaires accompanied by controlled opinion feedback (EVALSED 2003). The feedback is provided to encourage the recasting of individual opinions in the light of the summary of opinions given (for example the average or median of estimation or other statistical measures). The procedure is repeated several times. The goal is to reach convergence of opinions to produce an applicable result. Figure 1 shows an idealised convergence process. Due to the usually high degree of uncertainty of investigated issues, convergence may not follow a linear path as suggested. Particularly from the first to second repeat experts may more or less fundamentally recast their initial estimation.

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

In the first instance, the method is useful for subjects with a high level of uncertainty. This fully applies to risk assessment. While frequency, magnitude and consequences of occurring hazards are uncertain per se, each individual in a certain area can also be expected to perceive hazards and vulnerability differently. Therefore, in the public debate about risks the separation of objective and subjective notions such as risk analysis and risk perception (German Advisory Council on Global Change 2000, p. 38–39) is not possible. A wide variety of opinions exist regarding each single hazard or risk and possible options for mitigation. Therefore, each risk-related decision is subject to societal discourse. Thus, one goal achievable through the use of the Delphi method is the creation of a certain consensus among stakeholders with special knowledge on the issue as a basis for transparent risk related decision making.

However, in the past also criticism has been raised with regard to the Delphi method. The most important criticism refers to the often inappropriate application of the method rather than to the method in general. Application problems can embrace use with

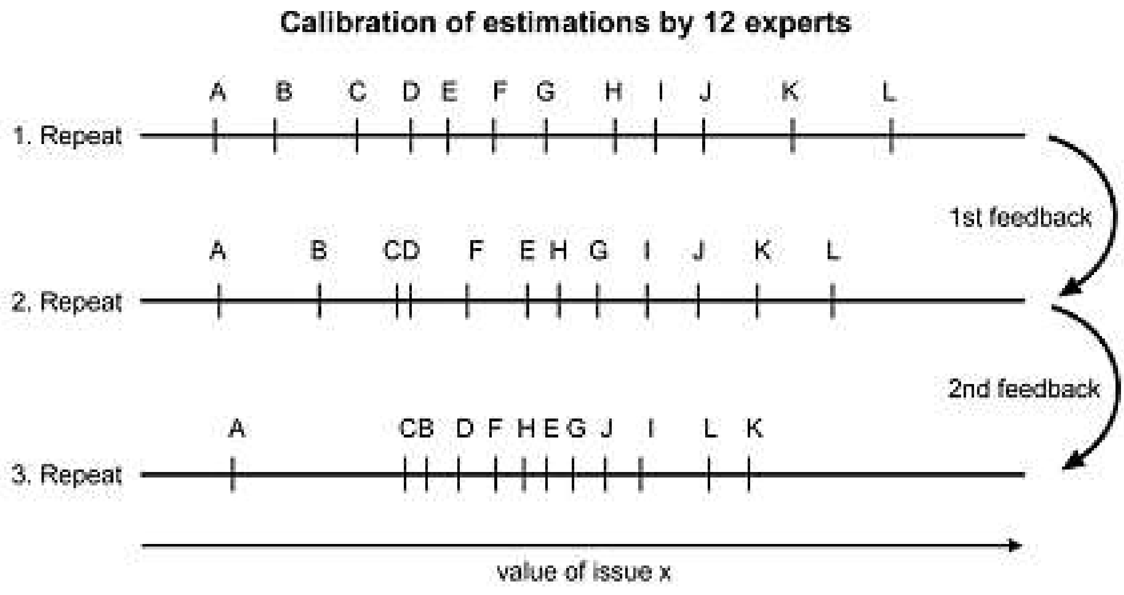

Fig. 1. Idealised process of calibration of individual estimations of experts (A-L) by use of the Delphi method (Hollenstein 1997, p. 83).

unsuitable issues (not uncertain or too complex), the integration of unqualified or over biased experts, mistakes in the implementation process (incomplete information, inappropriate feedback), or the over-interpretation of results. Thus, the application of the Delphi method should be undertaken with due awareness of these and other potential sources of distortion.

For weighting, the following procedure has been followed in the case studies:

1 Identification of the weighting question
2 Choice and definition of hazards and preparation of the analysis tool
3 Choice of experts
4 Carrying out the Delphi survey
5 Analysis of results and success control

Weighting results were used for the generation of a regional risk profile through the use of the simplified risk assessment method presented in chapter 1.4.

The matter of weighting is the expert's professional and personal view on the relative importance of the selected hazards in the region. The central question behind the weighting was:

How hazardous is one hazard compared with another in the region?

'Hazardous' means a hazard's potential to cause harm under average regional conditions. First, this question requests the expert's knowledge on multiple hazards. Second, it requires that experts set aside possible bias towards one certain hazard, but try to oversee the general situation in the region. Third, and most importantly, it appeals to the experts' perception of *hazardousness* of the hazards. Though attached to hazards, the question also appeals to personal perception of risk as connected to the hazard. Thus, the question is asked on the borderline between hazard and risk.

1.4 Method for inner-regional risk review

1.4.1 Background

Spatial planning, due to its notion of coordination (Faludi 2003), is an indispensable partner of risk management. In particular, management of spatially relevant risks is unthinkable without spatial planning (Greiving 2003). Nevertheless, the review of spatial planning reality has unveiled considerable deficits in spatial planning with regard to risks. While spatial planning is generally well established and applicable instruments already exist, there often remains a conceptual lack – if at all, risks are considered only selectively. Systematic consideration of hazards and risks in spatial planning virtually does not exist (cf. Heidland 2003). The reasons for this may be a certain unawareness of the relevance of hazards for spatial development, but also methodological deficits and the lack of data can both considerably constrict the integration of hazards in spatial planning.

Whatever the reasons may be, the enormous increase of losses (Munich Re 2004) even from average events urges action at all levels. Methodological advancement in the area of detailed risk assessment has been identified as an issue of major interest in research. However, efforts are needed to develop approaches ready for application in spatial and especially in regional planning, thus giving the stakeholders the capacity to act. The requirements for this are not only issues of regional risk management. Also, policy change at a European level may urge for action in near future, e.g. by coupling structure funds to issues of risk mitigation (cf. David 2004, p. 155).

As a solution for the review of regional risk distribution, the generation of a simple risk profile is proposed and tested in the case study areas. It is based on a multi-risk approach considering all potentially relevant (spatial) risks in an area and applies relative weighting factors derived by the use of the Delphi method (see above). By refining hazard information with regional vulnerability data, different levels of refinement are possible, indicating areas with different degrees of risk aggregation.

1.4.2 The method

The method for generating inner-regional risk profiles is based on the risk concept applied by ESPON Hazards, which sees risk as the coincidence of hazard and vulnerability (cf. Blaikie 1994, Helm 1996, Kron 2002). Both, hazard and vulnerability are represented by certain indicators (Figure 2). In the following, the method is described as a sequence of steps leading to a certain risk class.

1. *Selection of indicators representing factors of risk*
In this paper, 'hazard' is represented by the *haz-*

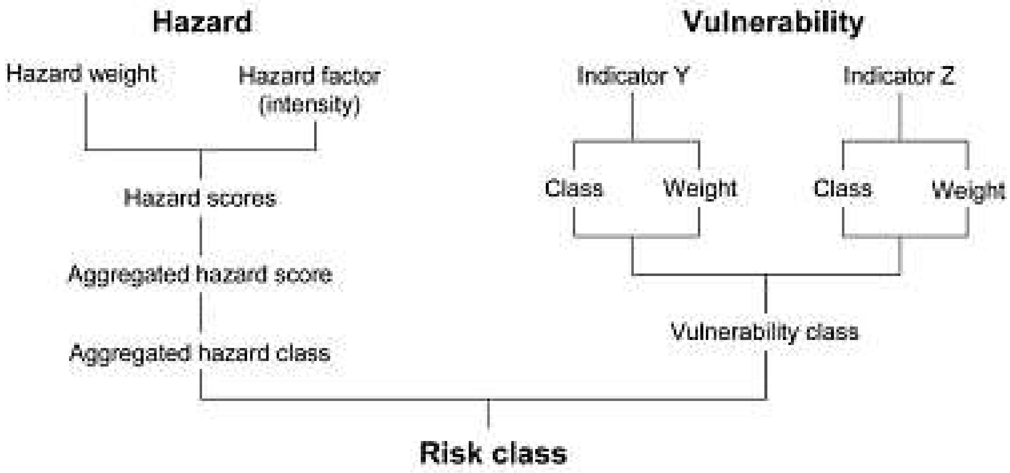

Fig. 2. Simplified procedure of derivation of risk classes.

ard frequency. 'Vulnerability' is represented by the indicators *GDP per capita* and *population density*. As indicated in the right column of Figure 2, vulnerability indicators can be manifold. They are also represented differently in the case studies. The approach is generally open to more indicators than used.

2. *Preparation of relative weights assigned by the panel of experts to each single hazard*

Hazards and vulnerability indicators are considered weighted. Hazard weights are derived through the use of the Delphi method. Vulnerability indicators were also partially weighted applying the Delphi method.

3. *Derivation of the hazard factor*

The *hazard factor* is used to substantiate weights assigned in the first step. It is derived from the regional intensity class of each hazard (Table 2). Different methods for hazard assessment exist in practice. In the ESPON Hazards project, hazard, intensity classes were established by combining the statistical frequency of the occurrence of the hazard and the magnitude of the events. The hazard factor is used as a multiplier for establishing the weighted hazard score.

Table 2. 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

4. *Derivation and aggregation of the weighted hazard scores*

The *weighted hazard score* is obtained through the combination of single hazard weights and the assumed hazard intensity in the reference area (e.g. NUTS level III). However, reliable hazard information may not be available for every hazard. Weighting factors for each hazard and hazard factors obtained from the potential hazard intensity are multiplied to obtain the individual *weighted hazard score* for each hazard (see also Table 3):

weighted hazard score
=
individual hazard weight * single hazard factor

By adding the individual hazard scores, the aggregated *weighted hazard score* of the region is obtained. The expected outcome (sum of all hazards scores) delivers a figure between 20% (in case that all hazard intensities are class 1) and 100% in case

Table 3. Establishing and aggregating weighted hazard scores.

Hazard (exp. from Dresden region)	**Weight**	**Hazard intensity class***	**Hazard factor**	**Weighted hazard score**
Volcanic eruptions	0.2	1	0.2	0.0
Floods	24.8	3	0.6	14.9
Landslides/Avalanches	2.8	1	0.2	0.6
Earthquakes	0.4	1	0.2	0.1
(…)	(…)	(…)	(…)	(23.0)
sum	**100**			**38.6**

that all hazards are in intensity class 5. As an example, in the Dresden region the scores sum up to 38,6 (Table 3).

5. *Classifying the aggregated hazard scores*
To obtain the aggregated hazard class, the calculated, aggregated weighted hazard score is classified on the basis of a 5 class scale (Table 4), starting with 20 as the lowest possible score.

6. *Derivation of the vulnerability class*
The differentiation between the sub-regions is based on vulnerability information at the sub-regional level and weighted as a result of the weighting procedure is important. Vulnerability is represented by the *vulnerability class* for each area of reference:

Vulnerability class
=
Indicator Y * indicator weight + Indicator Z * indicator weight …

Table 5 shows the calculation of the vulnerability class for two sub-units of the Dresden Region using the indicators 'GDP per capita' and 'Population density'. The result is a weighted vulnerability class for each NUTS 3 region within the case study area.

7. *Derivation of risk classes*
The derivation of risk classes is the final step, which is accomplished through the matrix-based combination of the aggregated hazard class with the obtained vulnerability class (Table 6).

Regional risk profiles are drawn for the chosen areas of reference. The presented procedure allows for further refinement down to levels beyond NUTS III. Due to the limitations of existing data, in the case study areas the NUTS level III was chosen as the level of reference. Cases study areas show different examples. While the Itä-Uusimaa case study is restricted to one NUTS level III area, the Dresden Region and Centre Region of Portugal are comprised of several NUTS III regions and thus allows differentiation of sub-regions. Due to good data availability, the Centre Region of Portugal offers an example of further refinement of results to NUTS level IV, unveiling more detailed spatial patterns of the spatial risk distribution.

Table 4. Classification of the aggregated hazard class.

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

Table 5. Derivation of vulnerability classes (example from Dresden Region).

NUTS level III Districts	**Population density** (55%)			**GDP per capita** (45%)			**Vulnerability class** pop. dens * GDP
	Value** (pers./km^2)	% (EU 15 average = 100)	**class**	value*	% (EU 15 average = 100)	**class**	Results (Weight 55 : 45)
Dresden Stadt	1.455	1.233	**V**	23.145	112	**III**	**IV**
Meißen	242	205	**IV**	16.149	78	**III**	**IV**

Table 6. Derivation of the regional risk profile through a combination of hazard and vulnerability.

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

2 THE DRESDEN REGION

2.1 Regional background

The Planning Region Oberes Elbtal / Osterzgebirge (Dresden Region) is one of five planning regions in Saxony. It is comprised of five sub-regions at the NUTS level III including the urban district of Dresden (City of Dresden), the District of Saxon Switzerland, the Weißeritz District, the District Meißen, and the District Riesa-Großenhain. The biggest share of the population (46%) and the highest population density (1455 persons/km^2) is in the City of Dresden (RPS 2004). In total, over 67% populate 'densely populated areas', a spatial category that is only assigned to 10 municipalities out of 87 in the region. The south of the region borders the Czech Republic.

Over the past 15 years, spatial patterns in the region have undergone considerable change, which is ongoing. The reason for the change is the transition from a centralised to a federal planning system with guaranteed self-government at the local level and major economic transitions, both induced by German Unification in 1990. Considerable economic transformation as well as loss and redistribution of population have taken place. Loss of population in the inner city and rural areas is accompanied by urban sprawl at the edge of urbanised areas.

The most important business branches in the region are information technology, engineering (including aviation, automotive industries), food processing, the glass and ceramics industry, paper industry as well as publishing and printing, which together make up about 80% of the employees in the manufacturing industries. Most industries are concentrated in and around the city of Dresden (Figure 3). As the capital of the Free State of Saxony, the City of Dresden also is an important centre of administrative employment.

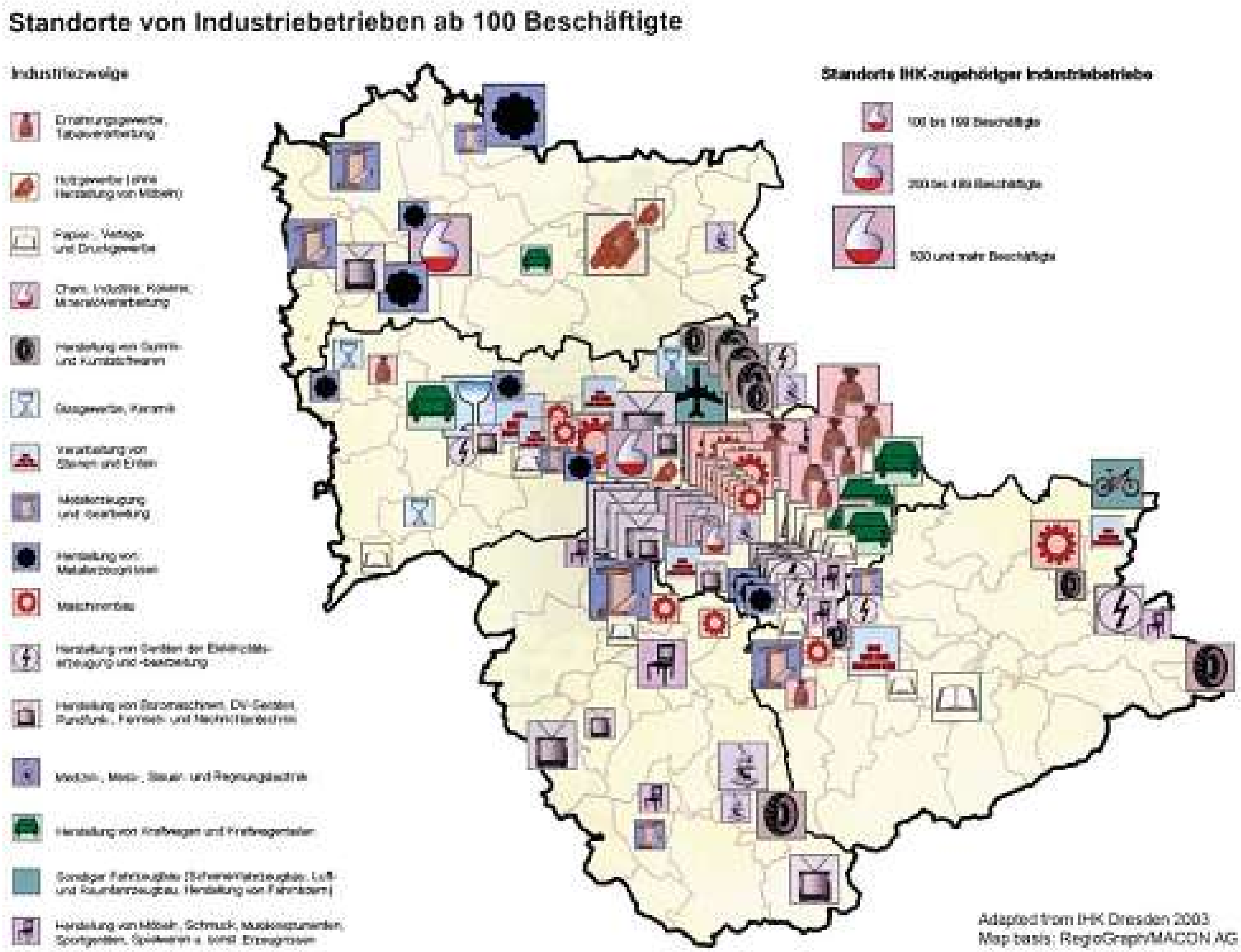

Fig. 3. Industrial plants in the Dresden Region with more than 100 employees (map: IHK Dresden 2003, p. 73).

Due to a polymorphic landscape, persisting industries, high population density in urban areas and the proximity of the region to other potential sources of hazards, various natural and technological hazards are evident in the Dresden region.

A special feature with relevance to hazards is the valley of the Elbe River, which, originating in the Czech Republic, flows through several towns of the region like Bad Schandau, Pirna, Dresden, Meißen, Riesa and Torgau. The discharge dynamic of the river Elbe is mainly influenced by precipitation and by the outlet from large dams in the Czech Republic.

Natural hazards

The most present natural hazards in the region are floods and windstorms. The region was hit heavily by the August 2002 flood that resulted from extreme precipitation in Saxony and the Czech Republic (Schanze 2002, DKKV 2003) and caused severe flash floods in the tributaries as well as an enormous slow rise flood along the Elbe River valley. Another known natural hazard refers to the special geological situation in the south of the planning region. Due to the steep relief in the sandstone area of Saxon Switzerland, collapses of rock formations and land slides occur regularly. However, while floods and windstorms affect large areas of the region, rock collapses and land slides are rather small events, which occur on a local level only. Therefore, these hazards have no significant relevance on a regional level.

Technological hazards

The Dresden Region is historically densely industrialised. Potential sources of technological hazards are single production plants of *chemical and manufacturing industries* that deal with hazardous substances and hazardous combinations of substances, the inland harbours along the Elbe river and the airport. In 1998, 344 industrial plants were registered under the German Emergency Ordinance (UBA 2000, p. 48).

In the past, coal and ore mining were also important in the region. Whereas most of the mining was completed decades ago, uranium mining had continued until early 1990s in two locations. Relicts of the mining activities are the not totally mapped and partly not totally known cavities (RPV 2001). From the past, no catastrophic collapses of cavities are known. Land subsidence hazards caused by past mining cavities have shown that these may have spatial importance but have not been sufficiently explored and documented. Only local subsidence areas in ancient mining locations are known. For the time being, no mapping of source areas or potentially exposed areas is available.

Other mining relicts are the countless waste heaps from non-ferrous metal mining (zinc, silver, bismuth, cobalt and nickel), mining and uranium mining as well as sites with deposits from uranium extraction plants (RPV 2001). The impacts of the uranium extraction plants have not yet been fully explored. However, conceivable hazard pathways such as direct radiation, excess radon exhalation, wind erosion of deposits and leachate into the ground water (SSK 1990) lead to the assumption that only creeping hazards can be expected which are not considered by the study.

There are no nuclear power plants in or close to the region. The nuclear physics department at the Research Centre Rossendorf is a single structure situated close to Dresden that deals with radioactive substances.

Taking into account the potential ‘hazard path’ along the Elbe river valley, chemical plants along the Elbe and Vltava rivers in Czech Republic are also relevant for the Dresden region. Several plants situated in the floodplains of the rivers have considerable amounts of hazardous substances potentially exposed to flood waters.

Small and large dams in the tributaries and the main valley of the Elbe River are a special technological feature in the mountainous part of the Dresden region. There are more than 3000 dams and weirs in the waters of Saxony, several hundreds of those in the planning region (LfL 2004). Several large dams create major impoundments of the Elbe and Vltava rivers in Czech Republic. The importance of this hazard was seen during the August 2002 flood when lives were endangered by the flood wave generated through the collapse of a retention basin, floods waves in virtually all rivers exceeded the storage capacities of dams and the operation of some large dams ran out of control.

2.2 Spatial planning and hazard mitigation

2.2.1 The spatial planning system and instruments

The German planning system is based on the *Constitution* (Basic Law 2002), which provides a general societal context as a framework for development and ensuring the so-called self governing right of municipalities (the lowest level is the administrative structure). Section 75 Nr. 4 of the constitution assigns the national level a so called 'framework competence' to set a framework for spatial planning in Germany. Nevertheless, spatial planning and development takes place at and is influenced by regulations from different administrative levels and is carried out by various institutions (Schmidt-Thomé 2005, Annex IIA). While municipalities physically implement the spatial planning and development, much regulation and coordination takes place at the regional levels.

A central feature of the planning system is the so-called subsidiarity principle. This means that decisions relevant to spatial development are passed "down" as far as sensibly possible to the subsequent levels. Based on this principle, spatial planning in Saxony takes place in a multiple-step approach:

– The federal government provides framework legislation and general spatial development guidelines and formulates aims and principles for spatial development.
– The Free State of Saxony (NUTS II) transmits federal requirements for spatial development into the Länder context, sets the larger spatial development framework legislation and provides statements on how the territory is to be developed. The Comprehensive Plan (CP) designates central places, main development and major transportation axes as well as areas of super-regional or federal interest.
– The actual regional planning in Saxony takes place at the planning regions level (covering several NUTS III areas). Here, the statements from the Länder level, especially those of the CP are specified in the Regional Plans (RP) and together serve as legally binding statements for municipal planning.
– Finally, municipalities (NUTS IV) are the operative level where planning and development activities are planned and implemented.

Various implementation strategies at the regional level and instruments of implementation at the local level support the materialisation of spatial planning (Table 7).

Table 7. Regional implementation strategies and local instruments.

Regional implementation strategies	Local instruments
– Regional (joint) land use plans – Regional Planning boards – Cooperation strategies – Public participation	– Landscape Plans – Preparatory land use plans – Preliminary binding land use plans – Priority areas – Reserve areas – Flood Zones

2.2.2 Hazard mitigation in regional planning practice

The German planning system at all planning levels requires the integration of various concerns. This is realised through the elaboration of sectoral plans. Whereas a large number of sectoral plans finally make up 'the spatial plan', no explicit 'risk' or 'hazard plan' exists. Rather, spatial planning integrates issues dealt with in different, often binding documents, such as (thematic) laws valid for various (potentially hazardous) issues like the Emissions Protection Law or the Federal Environment Law. These documents are usually not directly dedicated to risk mitigation, but often contain requirements on security issues and are to be considered in the course of approval procedures for spatially significant development projects. Due to the subsidiarity principle, most regulations are being implicitly integrated into spatial plans, and are thus not explicitly displayed.

Implicit hazard mitigation takes place, for instance, for droughts and storms or heavy precipitation by integrating these issues into spatial development recommendations. An example is the recommendation to change tree species combinations in certain forest areas to reduce the probability of drought, to increase the stability against wind storms and/or to reduce surface runoff. Permitting authorities also are bound to avoid new housing development in the very vicinity of a hazardous industrial plant and vice versa, but on a single case basis rather than a systematic risk reduction approach.

Therefore, the analysis of the regional planning documentation in Saxony may lead to the impression that very few elements of risk prevention are included. Indeed, in practice no systematic risk analysis, assessment or mitigation (cf. Plate 1999) is being performed by spatial planning authorities, which is also true for the Dresden Region. Consequently, no systematic information (like hazard maps, vulnerability maps, risk maps) about relevant risks is available. So far, selective hazard and risk identification takes place only in the field of environmental hazards (like soil erosion or deflation). While relevant for spatial planning action, these are also rather creeping hazards that do not show sudden or accidental appearance and are therefore not considered in this scope.

In practice, continuous cooperation exists between spatial planning authorities and sectoral authorities, which are in charge of phenomena related to hazards (like the State Institute for Environment and Geology). There are also instruments (see above) available for dealing with hazardous areas at different administrative levels. However, the issue largely relies on the initiative from spatial planning partners but lacks systematic basis.

For the case study region, the two relevant regional planning documents, the CP of Saxony and the Regional Plan of the Dresden Region, both hardly refer to hazards. If so, information is on a purely descriptive and qualitative basis.

The *Comprehensive Plan* traditionally contains only a few direct statements relating to hazard issues. Also, the aims of spatial development do not contain statements that could be interpreted as being related to risk prevention. The current CP (SMI 2003) recognises a particular call for action in the context of:

– Safe usability of former coal-mining areas (goals 3.3.7. – 3.3.9)
– Preventive protection of the drinking water resources (goal 4.3.1.)
– Preventive flood protection measures (principle 4.3.7, goals 4.3.8.–4.3.9.)
– Limitation of land use in ecologically sensitive areas (principle 4.1.3–4.1.4)
– Rehabilitation of former industrial areas for safe land use (principle 4.4.3.)
– Pronunciation of precautionary hazard prevention, especially flood protection, in terms of a sustainable development strategy (p. 108)

The current CP in this respect does not show considerable advancements compared to the previous CP (SMI 1994), which only referred to the following issues:

– Preventive protection of water resources usable for drinking water abstraction (so called Water Protection Areas, B-64)
– Hazard prevention in a location with a probability of landslides due to past surface coal mining (B-104)
– Hazard prevention in areas of past uranium mining where direct radiation may be exposed (B-104)
– Protection of the population against emission of noise, vibrations and air pollution (B-136)

Most of the statements are made from the perspective of the technical means of environmental protection rather than from a systematic risk management perspective. Also, the Regional Plan of the Dresden Region contains only scarce reference to spatially relevant hazards. Basically, these references are limited to general statements about flood protection as shown by Table 8.

The situation is starting to change with regard to the flood hazard. After the disastrous flood events in August 2002, the hazard maps are being prepared, sub-basin based flood protection plans are elaborated and legislature adapted. The new Environment Protection Law urges the delimitation of flood prone areas as a basis for spatial planning and development and defines restrictions on land uses (Hochwasser-

Table 8. Direct and indirect statements related to flood protection in the RP for the Dresden region.

Instrument	Cartographic display	Summary / aim or principle
Priority areas for flood protection	Map of spatial uses1:100000 Symbol (usual retention capacities smaller and larger than 1 Mio m^3)	*Aim 4.4.6*: Completion of the system of flood retention structures in the Eastern Ore Mountains and in the Müglitz river valley. *Requirement 4.4.6*: Environmentally sound flood protection
Flood zones (assigned and planned)	Map Maintenance, Development and Restoration of the landscape 1:100000	*Principle 4.2.2.6*: Clearing and reopening of natural paddles along the Elbe river, allowing for ground protection in case of floods, etc.

schutzgesetz 2005). The process is supported by the newly issued Flood Protection Program of Saxony. Sectoral documents usable for the purpose of risk mitigation such as ‘flood hazard maps’ and ‘flood source area maps’ are being prepared that will cover the whole territory of Saxony.

For other hazards, hardly any information is available and usually no responsibilities can be traced. Thus, systematic consideration of risk issues takes place as early as with disaster mitigation, which is out of the competences of spatial planning (Table 9).

Table 9. Levels and instruments of disaster mitigation in Germany (Grünewald and Sündermann 2001).

		General	Flood related
Foundation of disaster-protection in German laws.		Basic Law, Civil protection lawLaws of the states (i.e. Disaster protection law)	Water management law Specific laws of the states
Responsibilities in disaster protection		Duty of the states Supported by the federation Districts and districtless cities as the local disaster-protection authority	Ministry of the Interior as the supreme disaster-protection authority;
Instruments and actors of disaster-protection	Disaster prevention	Disaster protection plans (districts, main cities) Plans for management and maintenance of flood prevention constructions and flood prediction	Flood-prevention plans (cities, districts);
	Disaster management	Volunteers, Aid organisations, Units of extended disaster response, Fire-fighters, Technical Aid (THW), if required: border police, customs, army	Additionally State Environmental Agency, volunteers, private companies

2.3 Exemplary Risk Review for the Case Study Region

2.3.1 Introduction

The inventory of risk reduction by spatial planning in Saxony shows that in excess of an existing elaborate internal weighing procedure, which is integral to permission practices, systematic risk analysis at regional level should build the basis for a systematic spatial planning response to risks. The spatial overlapping of various risks especially calls for a multi-risk approach based on existing data and considering expert knowledge. In the following, the above presented methods for weighting of hazards and for the generation of inner-regional risk profiles are tested.

For this methodological test, the Dresden Region is particularly promising due to extensive social and economic disparities between the five NUTS III sub-regions. Whereas the City of Dresden is a densely populated economic centre with over-regional importance, the surrounding sub-regions are characterised by low population density and a peripheral economic situation. However, resolution of existing indicator data has the potential for further refinement of results.

2.3.2 Choice of experts for the Delphi survey

As systematic risk assessment is still not developed, only few practitioners have extensive knowledge of natural and technological hazards with a good overview of the case study area. However, due to the presence of past events (see above), experts showed particular interest to constructively participate in the Delphi panel.

The method is applied with two discrete groups of seven experts from four resp. five different institutions. For the first expert group mainly planners and administrative experts dealing with planning and plan approval issues are considered. In the second expert group, scientific expertise in regional and hazard related phenomena is emphasised. Lacking the ‘perfect expert’, specialists are chosen that combined as much expertise as possible on the case study area and spatial planning with respect to hazard related phenomena and risk assessment. Experts from the second group range from specialised research institutes and public authorities to state ministries. Special relationship of experts to single hazards is avoided. Though professional homogeneity is a particularly important criterion of choice, a certain degree of heterogeneity in terms of personal attitude towards the topic could not be totally excluded.

2.3.3 Choice of hazards and vulnerability indicators for the Delphi survey

The used set of hazards includes twelve hazards (Table 10), which not all are necessarily relevant for the region. Behind this stands the expectation that irrelevant hazards would be scored zero by the panel. Two main indicators are chosen as proxy for economic damage potential to represent the regional vulnerability: ‘Population density’ and ‘GDP per capita’.

2.3.4 Application of the Delphi Method

The Delphi inquiry in both expert groups is conducted through three rounds. Prior to the inquiry, the experts were informed about the background of the test and the attitude of the method used was explained. All experts were contacted personally by telephone to ensure that no questions remained open and to increase the personal commitment of the participants. The experts were asked to estimate (weight) the relevance of twelve hazards for the Dresden region as explained in chapter 1.3.2. A weighting has also been conducted for the vulnerability indicators. In the first round estimations are delivered uninfluenced. In round two and three, experts were acquainted with the mean result from the previous round.

2.3.5 Weighting the hazards

All proposed hazards received at least a very low consideration of relevance in both repeats (Table 10 and Table 11). The reason may be seen in the assumed relevance of distant events that may impact the region. However, it became apparent that most importance was attached to natural hazards (first/second repeat 79/75%) with floods (25/26%), extreme precipitation (16/16%) and storms (13/13%) at the top of the estimation (Table 11). Technological hazards in total received only 21/25% with industrial production plants (6/9%) on top.

Despite a purposefully different composition of expert groups, results derived from both expert groups are very close in terms of scores and dynamics of assessment through the rounds. Measuring the change in estimation from round 1 to round 3 in percent, the largest relative change was seen in the hazard estimations for volcanic eruptions and landslides/avalanches as well as for earthquakes and nuclear power plants (Table 10). These hazards, however, are at the same time the four lowest (absolutely) estimated hazards with given percentages be-

Table 10. Average estimations and their change in two expert groups.

Hazards		**Average estimation Expert group 1**			**Average estimation Expert group 2**			**Change in estimation** Round 3/ Round 1(%) Expert group 1	**Change in estimation** Round 3/ Round 1 (%) Expert group 2
		Round 1	**Round 2**	**Round 3**	**Round 1**	**Round 2**	**Round 3**		
Natural Hazards	Volcanic eruptions	0.3	0.2	**0.2**	0.0	0.0	**0.0**	**65.0**	–
	Floods	24.4	24.9	**24.8**	26.7	27.0	**26.0**	**101.5**	97.3
	Landslides/Avalanches	3.9	2.6	**2.8**	2.3	2.6	**2.2**	**72.0**	97.5
	Earthquakes	0.4	0.3	**0.4**	0.7	0.7	**0.7**	**83.1**	94.0
	Droughts	9.6	9.1	**9.1**	6.4	5.7	**6.1**	**95.1**	95.6
	Forest Fires	8.6	9.0	**9.2**	7.7	7.6	**7.7**	**106.6**	100.0
	Storms	12.9	13.6	**13.1**	11.3	11.4	**12.9**	**102.2**	113.9
	Extreme precipitation	14.6	14.9	**15.0**	14.3	14.6	**15.6**	**103.0**	109.0
	Extreme temperatures	4.0	4.0	**4.0**	4.0	4.1	**4.1**	**100.0**	103.6
Technological hazards	Nuclear power plants	1.7	2.0	**2.1**	2.1	1.3	**1.1**	**124.0**	53.3
	Production plants	5.8	5.7	**5.6**	8.9	9.7	**9.1**	**96.6**	102.7
	Waste deposits	4.1	3.9	**4.1**	5.3	5.8	**5.4**	**100.0**	102.7
	Marine/inland waterway transport	3.8	3.4	**3.5**	6.6	6.5	**6.3**	**92.6**	95.7
	Dams	6.0	6.5	**6.1**	3.7	3.0	**2.7**	**102.8**	73.1
	Sum	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**		

tween 0.2% and 2.8%. The relative changes in estimation for the other, higher ranked, natural and technological hazards changed only by a maximum of 6.6% (Forest fires) from Round 1 to Round 3.

The seemingly minor influence of several previous rounds on the final result, however, has to be seen in light of the *coordination process* induced by the use of the Delphi method. To evaluate the progress, the 'coefficient of variation' is used (Table 11). This measure relies on average estimations and the 'standard deviation' of single responses and shows a clear 'coordination effect' through the rounds. With the exception of the hazard 'extreme temperatures' in the first expert group, the coefficient constantly decreases through the rounds by 15% (volcanic eruptions) to over 50% (extreme precipitation).

2.3.6 Weighting vulnerability indicators

A widely agreed consensus is found among the experts in relation to the proposed vulnerability indicators 'Population density' and 'GDP per capita'. However, weighting results change more than in the case of hazards. Whereas the first expert group agrees on a weight distribution of 55% and 45%, the second expert group awards the indicators scores of 61% and 39% respectively (Table 12). It may be assumed, however, that the unexpected consensus in the first expert group was influenced by different pre-information. The first group was informed about the previously used weighting factors 50/50. Also, the variation of responses does not change through the inquiry. However, in the second expert group, the variation of responses began and ended about three times as high (Table 13).

Table 11. Measuring the coordination effect - the coefficient of variation.

Hazards		**Coefficient of variation Expert group 1**			**Coefficient of variation Expert group 2**		
		Round 1	**Round 2**	**Round 3**	**Round 1**	**Round 2**	**Round 3**
Natural Hazards	Volcanic eruptions	163.0	141.4	**139.6**	–	–	–
	Floods	62.1	52.5	**49.0**	65.6	36.7	**35.2**
	Landslides/Avalanches	97.6	64.0	**52.6**	86.5	38.0	**31.7**
	Earthquakes	100.3	122.2	**82.4**	105.8	68.3	**70.2**
	Droughts	38.0	27.8	**26.3**	112.1	89.1	**78.9**
	Forest Fires	39.1	30.8	**26.1**	50.6	46.3	**48.9**
	Storms	35.7	30.3	**27.4**	77.0	67.6	**55.1**
	Extreme precipitation	28.1	18.1	**13.3**	55.7	52.2	**45.4**
	Extreme temperatures	30.6	35.4	**35.4**	81.6	40.5	**38.0**
Technological hazards	Nuclear power plants	99.0	70.7	**62.1**	148.6	132.6	**128.1**
	Production plants	70.5	62.1	**51.4**	67.2	57.2	**54.4**
	Waste deposits	72.3	66.6	**57.2**	106.9	65.8	**48.6**
	Marine/inland waterway transport	48.0	45.4	**32.3**	79.0	54.9	**40.8**
	Dams	85.2	48.7	**53.1**	45.9	50.9	**46.2**

Table 12. Weighting of vulnerability indicators: average estimations and changes in estimation.

Indicators of vulnerability	**Average estimation Expert group 1**			**Average estimation Expert group 2**			**Change in estimation** Round 3/Round 1 (%) Expert group 1	**Change in estimation** Round 3/Round 1 (%) Expert group 2
	Round 1	**Round 2**	**Round 3**	**Round 1**	**Round 2**	**Round 3**		
Population density	54.3	54.7	55.3	59.3	61.9	61.1	**101.8**	**103.1**
GDP per capita	45.7	45.3	44.7	40.7	38.1	38.9	**97.8**	**95.4**
sum	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**		

Table 13. Weighting of vulnerability indicators: measuring the coordination effect, coefficient of variation.

Indicators of vulnerability	**Coefficient of variation Expert group 1**			**Coefficient of variation Expert group 2**		
	Round 1	**Round 2**	**Round 3**	**Round 1**	**Round 2**	**Round 3**
Population density	12.2	10.9	9.0	33.9	23.0	22.7
GDP per capita	14.5	13.1	11.2	49.3	37.3	35.7

In general, average estimations received from both groups did not substantially differentiate from each other. This may be taken as proof of the general suitability of the method.

2.3.7 Risk profile of the Dresden Region

By applying the ESPON Hazards approach, an aggregated hazard potential for the Dresden region is obtained that amounts to 38.6% (Table 14) of a potential maximum of 100%. This corresponds with aggregated hazard class II. Considering weighting factors of vulnerability indicators, the final vulnerability class is determined for each of the five subregions at NUTS level 3 (Table 15).

Weighting proportions of 55/45 (first expert group) resp. 61/39 (second expert group) lead to similar results and are therefore summarised in one column (Figure 4). Considering the weighting proportions from both expert groups on a differentiated ten class risk matrix (Greiving 2006, in the same volume), two of five sub-regions belong to risk class VI, three sub-regions are awarded risk class III. A significant difference in the risk only occurs, if the share of the vulnerability indicators changes beyond the mark of 50/50. This clearly indicates the stability of the results. However, in the case that changing risk perception would lead to a considerable change in the weighting of vulnerability indicators, a different risk map of the region may result. To illustrate this, fictional weights for the vulnerability indicators are assumed (45/55), representing the transposition of results from the first expert group. Figure 4 shows the results in an ascertained (4a) and fictional (4b) risk map. This underlines Delphi's specific applicability for the consideration of subjective issues of risk perception in more or less homogeneous regions.

Table 14. Aggregated hazard potential in the Dresden region.

Hazard		**Weight**	**Hazarrd intensity in the region***	**Hazard factor**	**Individual hazard score**
Natural Hazards	Volcanic eruptions	**0.2**	1	0.2	**0.0**
	Floods	**24.8**	3	0.6	**14.9**
	Landslides/Avalanches	**2.8**	1	0.2	**0.6**
	Earthquakes	**0.4**	1	0.2	**0.1**
	Droughts**	**9.1**	2	0.4	**3.7**
	Forest Fires	**9.2**	1	0.2	**1.8**
	Storms**	**13.1**	2	0.4	**5.3**
	Extreme precipitation**	**15.0**	2	0.4	**6.0**
	Extreme temperatures**	**4.0**	1	0.2	**0.8**
Technological hazards	Nuclear power plants**	**2.1**	1	0.2	**0.4**
	Production plants**	**5.6**	1	0.2	**1.1**
	Waste deposits**	**4.1**	1	0.2	**0.8**
	Oil spills**	**3.5**	1	0.2	**0.7**
	Dams**	**6.1**	2	0.4	**2.5**
	sum	**100**			**38.6**

* hazard intensities as used in the ESPON Hazards project
** comparative assumption lacking scientific data

Table 15. Derivation of vulnerability classes in the Dresden region (NUTS level III).

NUTS level III Districts (No NUTS V areas)**	**Population density**			**GDP per capita**			**Vulnerability class** Pop. Dens * GDP	
	Value** (pers./km^2)	% (EU 15 average = 100)	class	value*	% (EU 15 average = 100)	class	Results 55/45 and 61/39	Fictional weights 45/55
Dresden Stadt (1)	1.455	1.233	V	23.145	112	III	**IV**	IV
Meißen (17)	242	205	IV	16.149	78	III	**IV**	III
Riesa-Großenhain (23)	149	126	III	14.991	73	II	**III**	II
Sächsische Schweiz (26)	166	141	III	13.025	63	II	**III**	II
Weißeritzkreis (20)	164	139	III	12.012	58	II	**III**	II
EU 15 (100%)***	118	100		20.613	100			

* StLA 2000, except for ***; ** RPS 2004, except for ***; *** CEC 2000

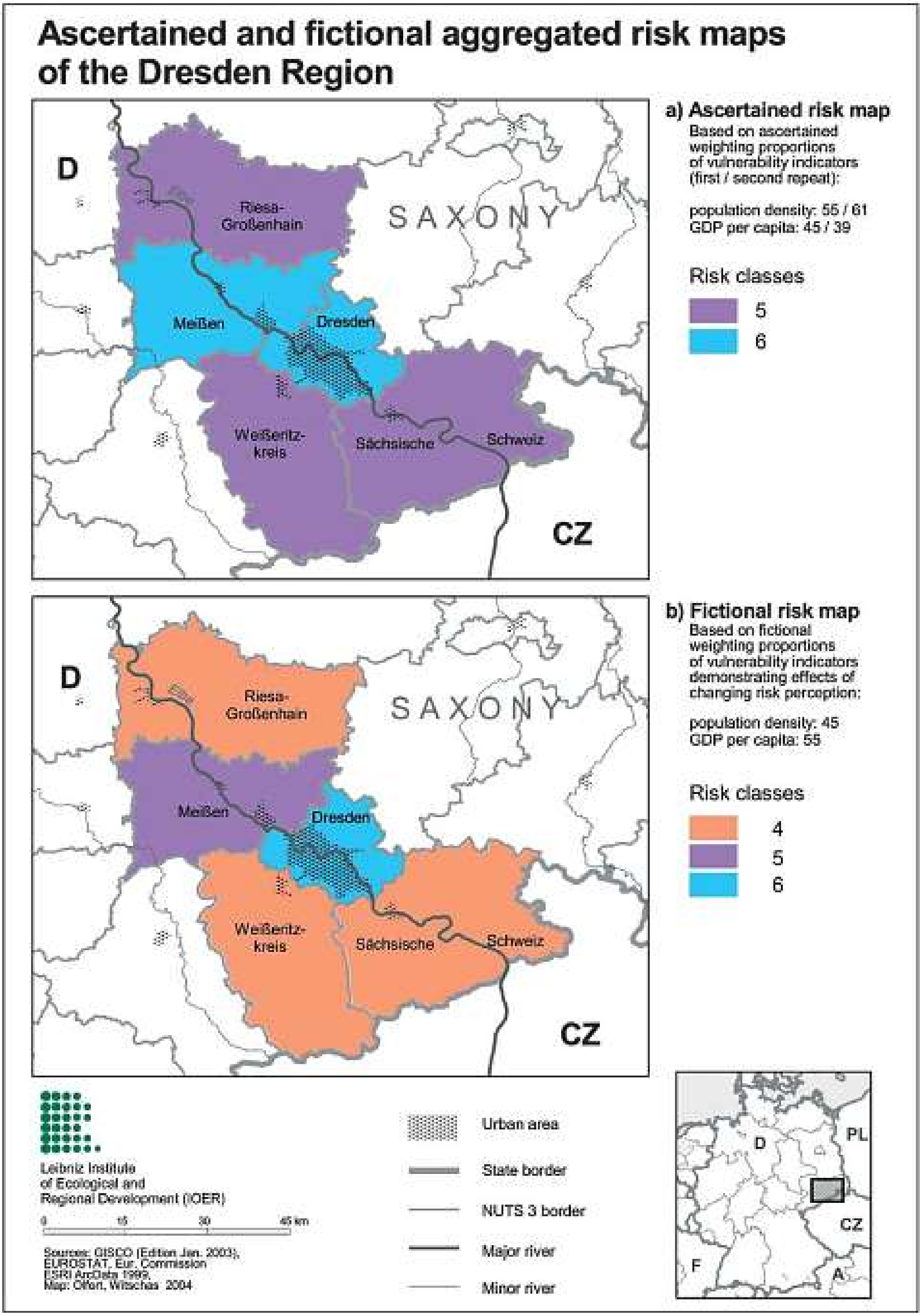

Fig. 4. Ascertained (a) and fictional (b) aggregated risk map of the Dresden region (IOER 2004).

3 THE CENTRE REGION OF PORTUGAL

3.1 Regional Background

The Centre Region of Portugal is one of the five planning and coordination regions in continental Portugal. It occupies an area of 23,668 km^2 (25.7% of the Portuguese land area) and includes 78 districts in 10 sub-regions at NUT III level.

Population: The population is almost 1.8 million inhabitants (17.2% of the national total), of which 65% is made up of population considered active.

Education: An increasing search for the valorisation and training of human resources through the established education system, with a special note for the three universities and six polytechnic institutes, which are spread evenly through the region. Today about 76,000 students attend higher education, of which 89% are public teaching establishments.

Agricultural and forestry: A strong heritage of small cattle and poultry farming and forestry that, despite the profound transformations, continues to play a role in the regional economy. Small farms dominate, are integrated and made viable within a family-based traditional economy.

Industry: The region has stood out due to its diversity, particularly in areas of the manufacturing industry, and moulds the growth that has been both quantitative and qualitative. The sectors with a relatively long tradition in the region are ceramics and glass, products, processes and ornamental rock. The chemical industry and metal mechanics are also important sectors, especially in Baixo Vouga sub-region where the population density is also the highest.

Tourism: Tourism, in its multiplicity of markets segments, is a field of the regional economy with excellent prospects, the qualitative and quantitative emergence of which is already evident, both in the Beira Litoral and in the Beira Interior sub-regions (NUTS III), in terms of supply and demand.

3.2 Natural and technological hazards

Natural hazards

a. Floods

The lower part of the Mondego valley downstream from Coimbra, until the 1980's was almost annually affected by flooding. Flood frequency was lowered with the construction of the Aguieira Dam, which was designed to mitigate flooding up to a 100-year event. In the Mondego River valley, there is a well-marked delimitation of an area, which is normally affected by the century flood and an emergency action plan was devised accordingly by the district civil protection services.

In contrast, the valleys of Vouga e Liz and especially its affluent Águeda River show an uncontrolled flood regime where harmful flooding almost annually occurs. Improper land use in floodplain areas, and forest fires upstream are the main identified reasons for frequent flooding.

b. Forest fires

Most of the Centre Region is classified high and very high risk of forest fire by LD n.º 1056/2004 (August 19th) and LD nº 1060/2004 (August 21). To prevent fire events, especially in the dry season, the Instituto Português de Meteorologia releases on a daily basis the Canadian Index on forest fires vulnerability, from which the national fire brigades draw indicators for their emergency plans for dealing with forest fire hazard. Nowadays it is questionable if forest fires are only a natural hazard or if it is the result of improper land use practices and improvident human behaviour, which makes forest fires much less predictable.

c. Landslides

Landslides could become problematic in case of high rainfall values in areas with severe relief. In the Centre Region, the problem of severe relief in mountainous regions combined with deforestation, usually caused by forest fires and bad planning of construction in the past, is now an important problem and there are no official prevention plans. Emergency plans are implemented by Serviço Nacional de Bombeiros e Protecção Civil (National Firemen and Civil Protection Service).

Technological hazards

a. Water contaminations

Industrialised areas such as the chemical industry and oil refinery in Estarreja city and gas storing in Ovar city, are industries that deal with hazardous substances, and were subject to national legislation published by article 16 of LD nº 164/2001 (Figure 5). Pulp paper mills (Aveiro e Figueira da Foz), manufacturing industries and animal breeding industries in Pinhal Litoral and Dão-Lafões are also hazardous to cause the death to fish in rivers when an accident happens. Measures to prevent or to punish these situations are not yet well implemented but these situations are now subject to enforcement of the law.

b. Radioactivity contamination

The region has no nuclear power plants, but near the border in Spain there is the Almaraz nuclear power station, which could affect the Centre Region in case of an accident. The area could be affected by the spread of radioactivity through the air. Also, the existence of 60 old uranium mine sites where the rupture of waste piles and tailings and radon exhalation can be considered a hazard of great importance with risks to water and dust spread of radionuclides and radon exhalation (Figure 5).

Fig. 5. Hazardous industrial plants (LD nº 164/2001, article 16) and uranium mines in the Centre Region (Schmidt-Thomé 2005 based on INETI 2000).

3.3 Spatial Planning and hazard mitigation

3.3.1 The spatial planning system

The Portuguese planning system is based on the Constitution of 1996, and on law n. 48/98, establishing the guidelines for spatial planning and urban policy. It was regulated through the law – decree n. 380/99, in which the legal system of spatial management planning instruments are drawn at national, regional and municipal levels.

The law – decree n. 555/99, which was altered by the law – decree n. 177/2001, establishes a new legal regime for urban operations at a municipality level (urban plans and detailed plans), a new legal regime for division of urban lands into parcels as well for building activities.

These three integrated (hierarchical) levels of planning aimed at ensuring the different public interests are able to express themselves spatially, in a conciliatory/ agreeable manner, to promote a sustainable economic and social development as well as territorial cohesion.

3.3.2 Instruments of spatial planning

Instruments of spatial management identify human, physical and natural resources, essential for sustainable use/management of the territory as well as setting up basic criteria and minimum levels of usage of those resources to insure that the natural heritage is able to continue renewing itself. Selected instruments are listed in Table 16. Only the municipal spatial plans are able to bind public and private bodies to comply with their rules. All the others solely bind public institutions.

3.3.3 Hazard mitigation in spatial planning practice

The National Council for Emergencies and Civil Protection (CNPCE) is the official board responsible for the coordination of all civil protection services. Within the CNPCE, there are sectoral committees that depend directly upon government even if, in operational terms, they depend on the president of CNPCE. Table 17 represents the levels and instruments of disaster mitigation and the responsible actors in each level.

Table 16. Administrative levels in the Portuguese planning system.

Administrative level	Relevant documentation
National level	*The national policy programme for spatial planning* *Sectorial plans* *Special plans*, inc. protected areas spatial plans, coastlands spatial plans, shallow lakes spatial plans and water protected groundwater plans.
Regional level	*Regional spatial plans* (NUTS level II) *Catchment basin plans* (Mondego, Vouga and Liz rivers) – Coordination and advise to municipalities plans In a sub-regional level, it is able to find the so called *Inter-municipalities plans.*
Municipal level	*Municipal spatial plans* (NUTS level IV) City councils strategic plans (PDMs) Urban plans (PU) Detailed plans (PP)

Table 17. Levels and instruments of disaster mitigation in Centre Region.

Levels / Institution		General Responsible	Disasters / Plan
1st Level - National Council for Emergencies and Civil Protection of Portugal		Portuguese 1st Minister Ministry of the Interior / (Administraçã Interna)	Floods, Forests fires / Water management law Specific laws
2nd Level County Centre for operations of emergency and Civil Protection		Mayor of County Council/ (Governador Civil) Coordenador Regional da Protecçã Civil	Floods, Forests fires Counties
3rd Level – District Centres of Emergences and Civil Protection		Mayor of City (Presidente da Câmara)	Several disasters/ Strategic Document: Municipal Plan for Emergencies and Civil Protection
Instruments and actors of disaster-protection	Disaster prevention	Disaster protection plans (districts, main cities)	Flood-prevention plans (cities, districts) Plans for management and maintenance of flood prevention constructions and flood prediction
	Disaster management	Volunteers, Aid organisations, Units of extended disaster response, Fire-fighters, Technical Aid (THW), in case of requirement: border police, custom, army	Additionally State Environmental Agency, volunteers, private companies

3.4 Exemplary risk review for the Centre Region of Portugal

To extract the importance of potential hazards for the Centre Region, the Delphi Method was applied as a coordination instrument. The goal of the Delphi application in the Centre Region is to depict an exemplary inter-regional risk profile as well as to produce a first aggregated risk map for the region.

As well, refinement was made to the NUTS level IV, adapting choices for NUTS IV level and transformation of results into a regional aggregated risk map for NUTS level IV.

3.4.1 Choice of experts

It was a challenging task to identify a sufficient number of experts with a good overview of the case study area and who are (or have until recently been) working in the area of spatial planning and/or hazards. Finally, ten experts from six different public and private organisations formed the expert group. However, the results were not successful due to the low receptivity of the inquiries by the specialists contacted. In a second phase, the method application was repeated with two different groups of ten experts from six different institutions. The former is made up of researchers and the latter by regional planning authorities, consulting companies and those from the environment and planning ministry. The special relationship of experts to single hazards is avoided.

3.4.2 Choice of hazards and indicators

For the investigation, hazards were chosen to form a representative set of European wide, relevant spatial hazards and accepting that some of those are not represented in the region and consequently would be scored 'zero' by the experts. The list of hazards is provided within the result tables below. Vulnerability indicators were refined due to the availability of additional and finer resolved data.

3.4.3 Application of the Delphi Method

The Delphi inquiry was to be applied with one expert group only. Later in the process, further inquiries were made to ensure highest possible representativeness of results. As a result, two expert groups were involved. In both expert groups, the inquiry was conducted over three rounds. Prior to the inquiry, the experts were informed of the background of the test and the attitude of the method used was emphasised. All experts were contacted personally or by post. Experts were instructed to consider feedback information provided after the first and second repeats.

3.4.4 Weighting the hazards

Both groups provided interesting remarks regarding floods, forest fires and landslides. Researchers (first group) tended to give less weighting to floods and forest fires while in the third round the tendency was to raise the weighting of these two hazards. The first group also gave more importance to landslides than the second group (planners and regional authorities). The reason may be the frequency (more emphasised in case of forest fires) and economic impact that forest fires and floods tend to have every year. Researchers tend to observe the probabilities of occurrence under certain circumstances more and not the event itself. However, it became apparent that the most importance was attached to natural hazards (first/second groups 77/80%), with forest fires (26/37%), floods (20/21%) and landslides (10/8%). Technological hazards in total received only 23/19% with major accident hazards in chemical plants in first (11/9%). In case of technological hazards, the results diverged between both groups (see Table 18).

Between Round 1 to Round 3 the largest relative change experienced were the estimations for droughts, earthquakes and storm surges with the smallest for volcanic eruptions, snow avalanches and hazards from nuclear power plants. At the same time, these hazards, however, are the four lowest estimated hazards although the changes estimated in case of droughts should be observed carefully and may be related to the drought definition between both groups.

The coordination process induced by the use of the Delphi method was more effective for the second group where all hazard results seems to converge, which was not the case in the first group where snow avalanches, droughts, forest fires and air traffic diverged from the first to the third repeat.

By observing the results of the two groups of Delphi inquiry in this stage, it is evident that both groups reach different results. However, it is possible to see that the second group of regional authorities, decision makers and consulting company people are more coherent between them and respect the efficiency of the rules of Delphi method more. There-

Table 18. Weighting of hazards, average estimations and their change in expert groups.

Hazards		Average estimation Expert group 1			Average estimation Expert group 2			Change in estimation Round 3/ Round 1 (%) Expert group 1	Change in estimation Round 3/ Round 1 (%) Expert group 2
		Round 1	**Round 2**	**Round 3**	**Round 1**	**Round 2**	**Round 3**		
Natural Hazards	Volcanic eruptions	0.0	0.0	**0.0**	0.0	0.0	**0.0**	100	100
	Large River Floods and Flash Floods	19.0	19.3	**20.9**	21.0	21.2	**20.4**	110.0	97.3
	Storm Surges	5.4	4.0	**4.1**	3.2	3.8	**3.7**	75.2	115.6
	Snow Avalanches	0.6	0.1	**0.1**	0.0	0.1	**0.0**	100.0	100.0
	Tsunamis	0.6	1.2	**0.9**	0.8	0.9	**1.1**	156.7	140.0
	Landslides	10.4	10.2	**9.4**	7.6	8.0	**8.4**	90.4	110.0
	Earthquakes	2.6	4.3	**3.6**	3.2	3.0	**3.0**	137.7	92.5
	Droughts	7.8	4.7	**4.1**	1.0	1.8	**2.3**	52.3	234.0
	Forest Fires	24.0	27.0	**28.4**	38.2	36.1	**35.4**	118.4	92.6
	Winter Storms	4.0	3.0	**2.3**	2.2	1.8	**2.0**	58.5	90.9
	Extreme temperatures	3.0	3.3	**3.2**	3.6	3.7	**4.3**	105.3	118.9
Technological hazards	Hazards from Nuclear Power Plants	3.6	2.9	**3.1**	3.7	3.5	**3.4**	87.2	93.0
	Major accident hazards	10.2	11.0	**11.4**	9.6	9.6	**9.1**	111.8	94.8
	Hazards from oil production. processing. storage and transportation. including major oil spills	7.4	7.4	**7.4**	4.6	5.2	**5.5**	100.0	119.6
	Air traffic hazards	1.4	1.5	**1.1**	1.3	1.4	**1.2**	77.1	92.3
	sum	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**99.8**		

fore, for further analysis, only the results of the second expert group were used.

3.4.5 Risk profile of the Centre Region of Portugal

By applying the ESPON Hazards approach, an aggregated hazard score for the Centre Region of Portugal was obtained that amounted to 51.7% of a potential maximum of 100%. This corresponds with aggregated hazard class III. Considering weighting factors of vulnerability indicators, the final vulnerability class was determined for each of the ten subregions at NUTS level III (see Table 19 and Table 20).

At NUTS level III, vulnerability is applied with the same weighting used by the ESPON Hazards project for the generation of European-wide maps. Vulnerability indicators are weighted using the Delphi Method. The indicators used for damage potential were population density and regional GDP per capita, and for coping capacity national GDP per capita was used (Table 19 and Table 20):

Vulnerability = Damage potential (25%+25%)
– Coping capacity (50%)

Considering general vulnerabilities as coping capacity and damage potential and using the same methodologies used in European maps, with the exception of fragmented natural areas not used in this case, the results show that NUTS III regions near the coastline with high development have higher risk.

In contrast to other case study areas, in the Centre Region data availability allows for the refinement of weighting results to NUTS level IV. For this reason, an alternative set of vulnerability indicators has been used:

Damage potential: Regional GDP referred to national data; Population density referred to national data; Population Lost referred to national data.

Coping capacity: Doctors/1000 inhabitants; number of firemen/area.

All vulnerability indicators were weighted 20% but coping capacity was calculated considering the lowest number of doctors per 1000 inhabitants as

Table 19. Damage potential indicators of NUTS level III in the Centre Region of Portugal.

Districts (NUTS 3)	**population density** (25%)			**GDP per capita** (25%)			
	value 1999 (pers./km^2)	**% with EU** 15 average = 100%	**class**	**value 2000(€)**	**% with EU** 15 average = 100%	**class**	**calculated vulnerability class**
Beira Interior Norte	27	23	II	7.311	35	I	**I**
Pinhal Litoral	131	111	III	10.104	49	I	**I**
Pinhal Interior Sul	13	11	I	7.680	37	I	**I**
Beira Interior Sul	20	17	I	8.618	42	I	**I**
Cova da Beira	64	54	II	7.321	36	I	**I**
Serra da Estrela	56	47	II	5.998	29	I	**I**
D„o Lafıes	142	120	II	7.246	35	I	**I**
Pinhal Interior Norte	50	42	II	6.578	32	I	**I**
Baixo Mondego	154	131	II	10.198	49	I	**I**
Baixo Vouga	196	166	II	10.568	51	II	**I**
reference (EU 15=100)	**118**	**100**		**0.613**	**2100**		

Table 20. Coping capacity indicator of NUTS level III in the Centre Region of Portugal.

Districts (NUTS 3)	**National GDP per capita*** (50%)				
	value 2003(€)	% with EU 15 average = 100%	**class**	**vulnerability class**	**DP+CC/2**
Beira Interior Norte	12.500	56	IV	**II**	**I**
Pinhal Litoral	12.500	56	IV	**II**	**II**
Pinhal Interior Sul	12.500	56	IV	**II**	**I**
Beira Interior Sul	12.500	56	IV	**II**	**I**
Cova da Beira	12.500	56	IV	**II**	**I**
Serra da Estrela	12.500	56	IV	**II**	**I**
D„o Lafıes	12.500	56	IV	**II**	**II**
Pinhal Interior Norte	12.500	56	IV	**II**	**I**
Baixo Mondego	12.500	56	IV	**II**	**II**
Baixo Vouga	12.500	56	IV	**II**	**II**
reference (EU 15 =100)	**22.432**	**100**			

* CCDRD 2001; DP-damage potential; CC-coping capacity

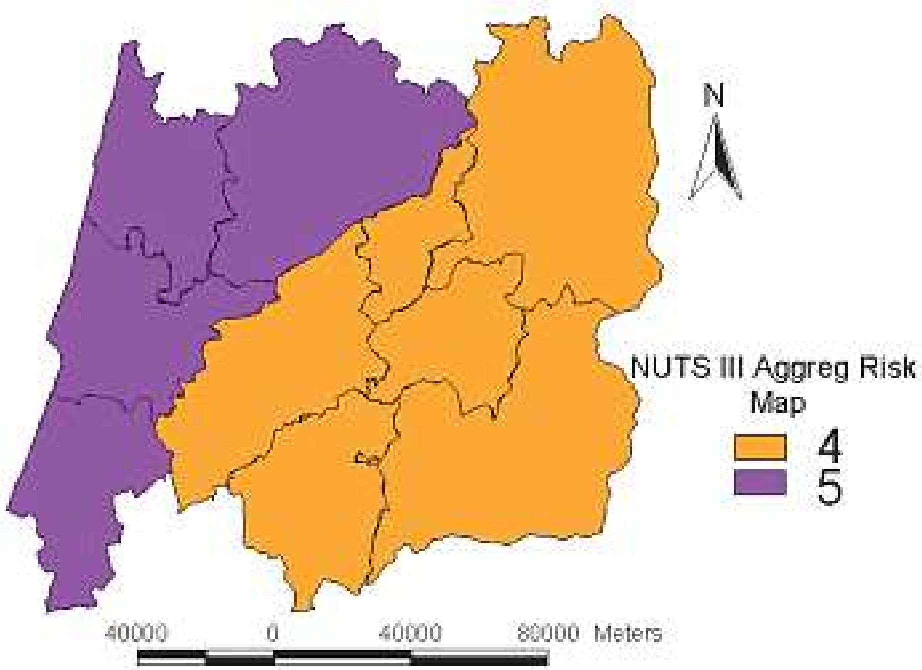

Fig. 6. Aggregated risk map of the Centre Region of Portugal for NUTS level III (Schmidt-Thomé 2005).

5 (the high vulnerability areas) and 1 the higher number of doctors per 1000 inhabitants as the low vulnerability areas. The same methodology was used for the number of fireman / areas.

These maps are based in ESPON Hazards methodology but may not reflect the real regional vulnerabilities. However, the damage potential and coping capacity indicators chosen were to be applied in all hazards of the study. In the future, more tests and new approaches should be tried (Figure 7).

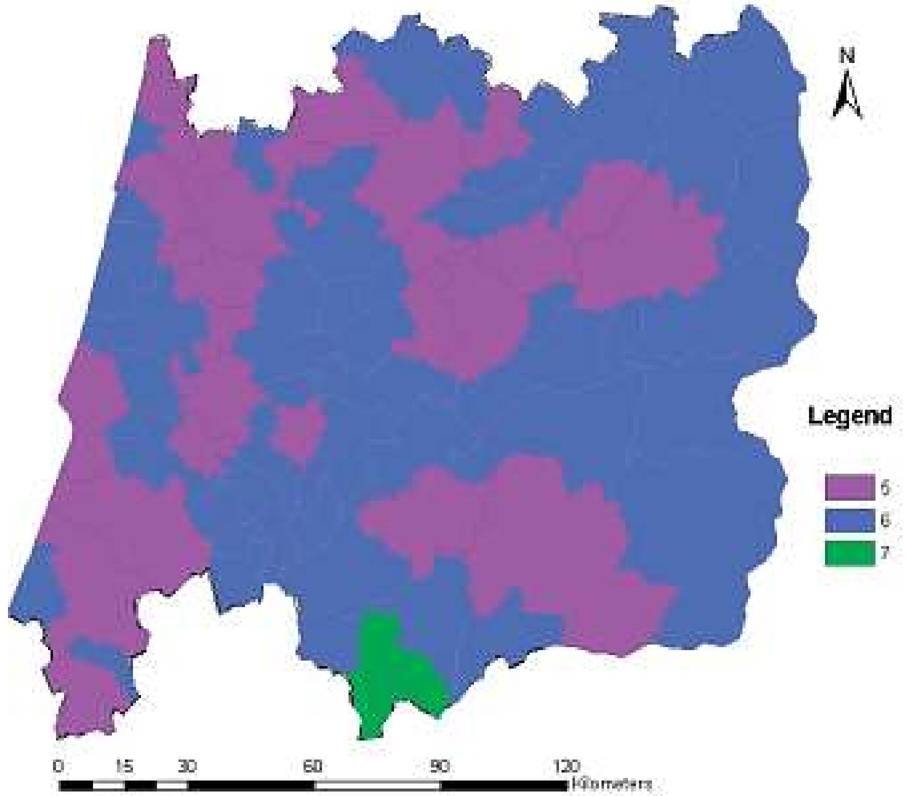

Fig. 7. Aggregated risk map of the Centre Region of Portugal for NUTS level IV (Schmidt-Thomé 2005).

4 CONCLUSIONS FROM CASE STUDIES

4.1 Conclusions regarding the application of the Delphi method

Applied to the weighting of hazards, the Delphi method offers indicative and subjective information. However, given that the question of weight is uncertain and partially subjective, the chosen approach to weighting appears to be useful. Critical for the quality of results is the careful selection of participants for the expert panel. The quality of results not only relies on the expert's knowledge of the issue, but also on the acquaintance with concepts used (e.g. risk concept) and the preparedness to fully accept the inquiry method. The clearness of the matter of weighting is decisive in relation to the comparativeness of replies. For example, certain hazards may be perceived as overlapping if not precisely defined and delimited against each other.

With respect to weighting, potential sources of distortion must be considered. One of those is the possible overestimation due to the presence of recent events. This seemed to be the case in the Dresden region where the first inquiry was done a few months after the August 2002 flood. Another source is underestimation due to unawareness of risk, like in the case of infrequent events. Also, missing knowledge of hazard propagation can lead to distortion in either direction. Furthermore, current events can considerably change results as remarkably proved in the case of the December 2004 tsunami that occurred during the European wide application of the method (Schmidt-Thomé 2005, chapter 3).

Appealing to subjective risk perception, the method assumes culturally homogenous areas. As a result, its applicability is limited to areas that indeed show a high cultural homogeneity, as can be expected in NUTS level II, III or even smaller.

1.4.3 Conclusions regarding the method for inner-regional risk review

The consensus based regional risk profile is useful as information for the regional planning practice. The consideration of relative weights of hazards is a valuable contribution to transparency in decision-making in spatial planning and could lead to better acceptance of measures and instruments for risk reduction (term see Olfert & Schanze 2005). As a result, the prevailing selective consideration of single hazards is put into perspective.

Regional risk profiles offer a fast and simple manner to accomplish an overview of the distribution of aggregated risk within the region. Results for each reference area of the region represent indicative information. The statement is generalised for the whole reference area and does not reflect the internal minima and maxima. Therefore, risk profiles are especially expressive, where risk aggregation can be accomplished for several sub-regions. The refinement in the Centre Region clearly shows that a sub-region of medium risk can be made up of areas with very low risk and some with very high risk.

In general, the obtained results are indicative and the level of detail is defined by data availability. The target users of this application are super-ordinate stakeholders for whom the profiles can be a basis for prioritisation or risk management activities. However, regional risk-profiles cannot aim at replacing the missing detailed risk assessment using more elaborate methods, such as the case specific modelling of hazards and vulnerability or the purposeful inquiry of required data.

The biggest challenge remains the provision of sufficiently resolved hazards data incl. hazard-specific exposure and vulnerability. The representativeness of applied information remains limited for uncertain hazard data. This especially applies with rising natural and societal heterogeneity of the reference area. Particularly, vulnerability methodology and indicators need further advancement to allow for comprehensive and representative consideration of multiple risks. The chosen reference level (NUTS III) used as a basis for the investigation offers only limited information needed for local level of spatial planning. However, the Ruhr District case offers some ideas for a more detailed regional risk assessment based on the analysis of given hazard intensities, including thematic information that leads to more detailed results.

Nevertheless, the applied procedure for deriving inner-regional risk profiles offers valuable indicative information for super-ordinate administrative levels even though there is a lot of potential for further development, especially in relation to the availability of impartial data. However, lacking the applicable tools of multi-risk assessment, the inner-regional risk profiles offer the first basic information that may allow regional planning stakeholders to approach systematic multi-risk response.

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