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ESPON CLIMATE - Climate Change and Territorial Effects on Regions and Local Economies

Applied Research Project 2013/1/4

Inception Report



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This report presents a more detailed overview of the analytical approach to be applied by the project. This Applied Research Project is conducted within the framework of the ESPON 2013 Programme, partly financed by the European Regional Development Fund.

The partnership behind the ESPON Programme consists of the EU Commission and the Member States of the EU27, plus Iceland, Liechtenstein, Norway and Switzerland. Each partner is represented in the ESPON Monitoring Committee.

This report does not necessarily reflect the opinion of the members of the Monitoring Committee.

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Inception Report Annex

Please also consult this Annex which contains further information, clarifying and complementing the information given in the Inception Report.

1. Research approach and co-ordination of actions

The research approach of the ESPON Climate project follows the rationale of the common research framework often used by the climate change and impact research community (see Fig. 1).

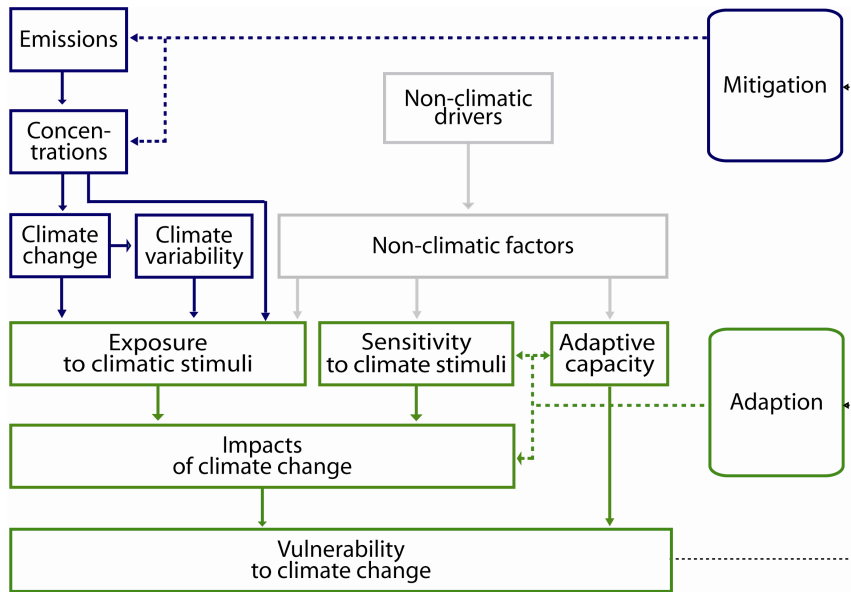


Figure 1: Research framework (adapted from Füssel & Klein, 2002, p. 54)

Rising anthropogenic greenhouse gas emissions contribute to global warming. This anthropogenic contribution to climate change runs parallel to the natural climate variability. The geographical representation of the effects of climate change, climate variability and greenhouse gas concentrations can be defined as the exposure to climatic stimuli. The impacts of climate change depend on the exposure to climatic stimuli on the one hand and the sensitivity to climate stimuli on the other hand. Thus, a strong impact can be either a result of high exposure or high sensitivity or both. The adaptive capacity of a society or social group or region is the ability to adapt to the impacts of a changing climate. The higher the adaptive capacity, the higher is the potential to reduce vulnerability, despite of climate change impacts. Non-climatic factors influence the adaptive capacity as well as the sensitivity and the exposure to climatic stimuli.

In the current discussion on climate change it must be understood that it is particularly the human vulnerability that has increased over the past decades. Climate change impacts are so far observed in trends, as manifested in changing of climate zones. Increases in extreme weather events are being expected but lack numerical traceability as yet (e.g. increase in storminess for frequency of extreme river floods). In other words, the rising costs caused by extreme events over the past decades can be mainly attributed to an

overall mal-adaptation, based on societal vulnerability (e.g. building in flood prone areas). Sensible climate change policies would consequently demand an understanding of vulnerabilities and an identification of appropriate counter measures. Once this is understood projections of future climatic changes can support the implementation of sustainable strategies, increasing societal resilience and supporting regional development.

Table 1: Definitions according to the concept of Füssel & Klein (2002) and IPCC (2007)

<p>Exposure: The nature and degree to which a system is exposed to significant climatic variations.</p> <p>Sensitivity: The degree to which a system is affected, either adversely or beneficially, by climate related stimuli. The effect may be direct or indirect.</p> <p>(Climate) Impacts: Consequences of climate change on natural and human systems. Depending on the consideration of adaptation, one can distinguish between potential and residual impacts.</p> <p>Adaptive capacity (or adaptability): The ability of a natural or human system to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences.</p> <p>Vulnerability: The degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity.</p>
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Sensitivity to climate change is a key factor in the climate change vulnerability assessment framework. Sensitivity describes the dose-response relationship between the exposure to climatic stimuli and the resulting effects: “Sensitivity is often assumed to remain constant over time. However, whilst this assumption may be correct for unmanaged natural systems, its appropriateness can be questioned for most human systems, which evolve continuously, even in the absence of climate change” (Füssel & Klein, 2002, p. 49). For the ESPON Climate project climate change sensitivity is understood to consist of six dimensions which will be combined for measuring the overall sensitivity of European regions:

- *Physical:* Physical sensitivity involves, for example, the degree of sensitivity of human settlements and infrastructure to climate change effects (long-term changes in temperature and precipitation, but also extreme weather events).
- *Social:* Social sensitivity will include the sensitivity of different social groups to climate change effects, in relation to the demographic, ethnic, cultural or physical composition of the groups and to the levels of marginality and social segregation or other weaknesses and restrictions in the access to social, economic or health-related assets.
- *Economic:* This dimension encompasses sensitivity of economic activities and structures to climate change induced or intensified hazards, but also to positive economic opportunities created by climate change.
- *Environmental:* Environmental sensitivity involves the fragility of ecosystems under the duress of changing climate conditions and hazardous events as well as the dependency of societies and specific economic activities on environmental structures (biogeographical regions).
- *Cultural:* This factor is related to natural and urban landscapes with their cultural

attributes and characteristics and their changing values and significance for individuals and communities.

- *Institutional/ Governance*: This aspect focuses on norms, formal rules, institutions and policies that constrain or facilitate human action and the involvement of relevant stakeholders in climate change related communication and decision-making processes.

Co-ordination of actions

The various elements of the research framework will be addressed by respective actions of the ESPON Climate project:

- Climate change effects and exposure of regions to climatic stimuli (action 2.1.)
- Sensitivity of regions to climate stimuli in regard to physical, social, environmental, cultural and institutional dimensions (action 2.1).
- Theoretical framework and review of sectoral economic sensitivity (action 2.2).
- Analysis of regional economic sensitivity (action 2.3)
- Adaptive capacity of regions including the role of non climatic drivers such as demographic and economic change (action 2.4.)
- Final analysis of vulnerability to climate change as a product of the given impact and existing adaptive capacities (action 2.5.)

Actions 2.2 and 2.3 form an integrated part of the research framework and focus mainly on the economic dimension of sensitivity, corresponding to the project title “Climate change and territorial effects on regions and local economies”. Here, a detailed assessment of the impacts on the different economic sectors will complement the integrative impact assessment (2.1). Moreover, action 2.2 will contribute to action 2.1 by providing high-level indicators for economic sensitivity.

Actions 2.2, 2.3 and 2.4 will take into account non-climatic drivers (e.g. economy, demography and others) of sensitivity and provide territorially distinguished indicators and data preferably on the NUTS-3 level.

The following figure shows the distribution of the work among the different sub-actions:

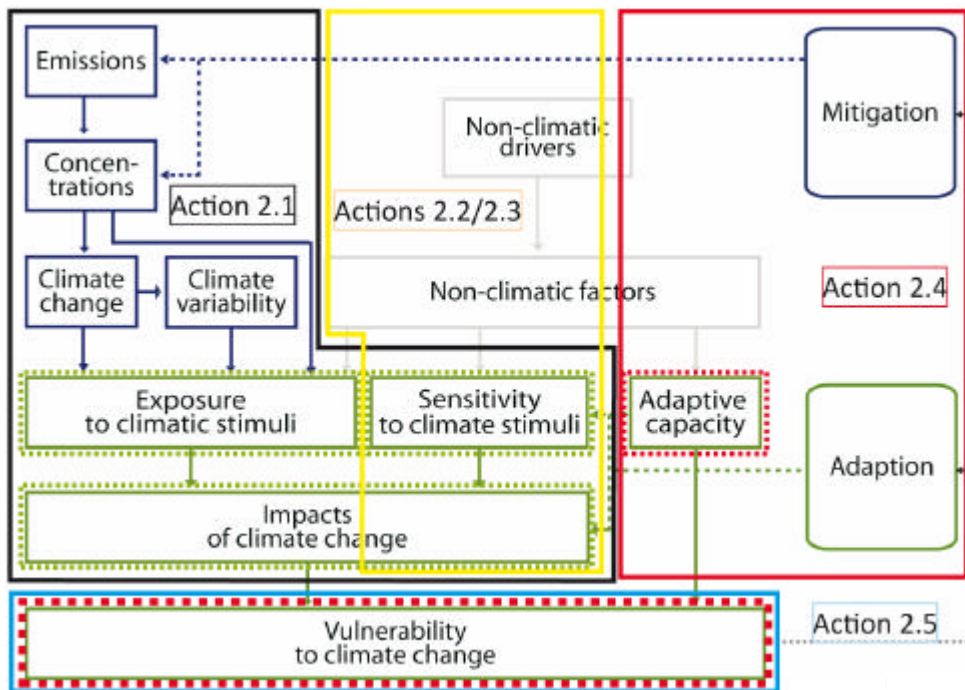


Figure 2: Co-ordination of actions within the methodological concept (based on Fussler & Klein, 2002, p. 54)

Indicators, typologies and maps

For each dimension of sensitivity, high-level indicators will be defined based on a literature and data availability review for both aspects: long-term/creeping changes (e. g. in temperature and precipitation) and extreme events (if possible one indicator per aspect).

Data will be generated for the six identified dimensions. Where no indicators exist, proxy variables will be used. The regional and local case studies will be used for producing indicators on the basis of local knowledge (from interviews, workshops).

Further, combined indicators will be produced such as climate change impact indicators (as a result of exposure and sensitivity) or climate change vulnerability indicators (as a result of climate change impact and adaptation). As there is a wide range of aggregation approaches discussed within the scientific community, a suitable approach has to be selected in action 2.1.

A factor analysis will be undertaken, seeking to optimise the analysis around 6-8 cluster points. For each of the 'cluster hearts' ideal regional types will be identified and from that the description of each cluster point will be determined. This will be linked back to the NUTS-3 level list to identify which regions correspond to which type of region. Finally the spatial and political distribution of these various regional classes will be explored and mapped.

Case studies

The case studies shed light on local or regional specificities in regard to climate change but also provide a cross-case analysis that will produce valuable input for the analysis at the European level. The specific input of the case studies will thus be:

- General appropriateness and feasibility for the selected indicators.
- Better understanding of effects/impacts on regions against the background of European diversity (culture, systems etc.).
- Exploration of the diversity of response approaches to climate change.
- Identification of transferability/applicability to different regions.
- Conclusions for the implementation of measures at the European level (European harmonisation).
- Opportunity to cover those dimensions of sensitivity with appropriate indicators and data where data for the whole ESPON area might not be available (especially cultural and institutional vulnerability).

The following Table 1 provides an overview showing the geographical as well as thematic balance of the case studies across European regions.

Table 2: Case studies and selection criteria

Case study area	ESPON three-level approach*	Geographic coverage			Planning systems covered (category)	Climate change relation		
		Macro-geographic regions	Geomorphological character	INTER-REG IVB cooperation areas		Climate change impacts	Climate change vulnerability	Adaptive/mitigation capacity
Coastal Zone Aquifer	transnational	Finland, the Netherlands, United Kingdom, Spain, Romania	coastal area, lowlands	Baltic Sea Region, North West Europe, Western Mediterranean, South East Europe	A, B, C	+	+	+
North Rhine-Westphalia	regional	Western Europe	river basin, hilly land	North West Europe	A	0	+	+
Bergen	local	Northern Europe	coastal area, mountain area	North Sea Region	A	+	+	+
Tisza river	trans-national	Central & Eastern Europe	river basin	Central Europe, South East Europe	A, B, C	++	+	-
Coastal Mediterranean Spain, Balearic Islands	regional	Southern Europe	coastal area	Western Mediterranean, South West Europe	A	++	+	0
The Netherlands	national	Western Europe	coastal area, river basin, lowlands	North Sea Region, North West Europe	A	++	++	+

Alpine space	trans-national	Central and southern Europe	mountain area	Alpine Space, Mediterranean, South Eastern Europe	A, B, C	++	++	0
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++ = very high, + = high, 0 = average, - = low, -- = very low

* The European level is not covered by case studies but by the whole project approach.

The case studies follow the same common approach by Füssel & Klein the whole project is in line with In order to achieve a common structure and comparability of the case studies they shall be structured along the following table of contents:

1. Introduction (characterisation of the region)
2. Vulnerability assessment
 - a. Main effects of climate change on case study region
 - b. Exposure
 - c. Sensitivity (with special attention to institutional and cultural sensitivity)
 - d. Impacts
 - e. Adaptive Capacity
 - f. Vulnerability
3. Response strategies and policy development (in regard to mitigation and adaptation)
4. Further aspects specific to the respective case study area
5. Discussion of validity of European-wide analysis from a regional perspective
6. Transferability of results to other regions
7. Sources.

Case study descriptions

Coastal Zone Aquifers, Finland, The Netherlands, United Kingdom, Spain, Romania

The ESPON Climate Change case study on potential problems of climate change to coastal aquifers will elaborate a systematic approach to assess the methodology developed by the project (action 2.1). The case study approach will be developed in south Finland, and subsequently applied to other case studies to perform similar and comparable analyses. The results of the study will certainly depend on the amount and quality of data from all case studies. Despite these limitations the study shall serve as a first approach and an example for future studies. In each case study two aquifers shall be selected according to the criteria: one coastal aquifer and a second aquifer located in a riverbank near the coastal discharge area. Following the example case study of southern Finland (Baltic Sea), examples from the other European Seas will be studied: The Netherlands (North Sea); United Kingdom (Atlantic Ocean); Spain (Mediterranean Sea); Romania (Black Sea). The sensitivity dimensions will be addressed in the case studies according to their potential relevance on groundwater:

- Physical: Effects on groundwater aquifers by sea level rise
- Social: Amount of people affected

- Economical: Costs related to potential impacts
- Environmental: Effects on groundwater quality and quantity
- Cultural: Are the aquifers related to cultural assets?
- Institutional: The current potential of relevant institutions to assess and mitigate potential problems (coping capacity)

North-Rhine Westphalia, Germany

With around 18 million residents North-Rhine Westphalia is the most populous state of Germany and includes Europe's largest conurbation (the Ruhr district). The state comprises 396 municipalities ranging from rural to urban characteristics, with different climate conditions. While in summer it can become very hot in the Rhine-Ruhr Basin, the temperature in the highlands and mountainous regions is more moderate. The latter are recreational regions for the densely populated Rhine-Ruhr area. Climate scenarios imply that temperature increase, shifting seasonality and changes in the amount of precipitation might have tremendous impacts in different regions of the state. A sectorally and spatially highly resolved vulnerability analysis (on NUTS 3 or LAU2- level whenever possible) is planned showing hot spots of necessary action and regional climate impacts. Among relevant sectors, winter tourism, forestry, energy and health could be considered by on model or indicator-based approaches.

Bergen, Norway

Bergen is the second largest city in Norway with approximately 250,000 inhabitants. The city region consists of 14 municipalities with about 360,000 inhabitants. Bergen city is situated at the West coast, in Hordaland County. It is a city in close proximity to the sea and the mountains, with large quantities of precipitation. The case study will first focus on relevant vulnerability dimensions (cf. action 2.1) for Bergen related to sea level rise, flooding, wind, precipitation and extreme weather. Secondly, there will be a statistical mapping of selected sectors which may be affected by climate change. This part of the study will be based on regional and local statistical sectoral analyses with data on LAU 2 level but it will also draw on an ongoing scenario project for Bergen which is focusing on climate impacts for the following industries: marine industries, maritime sector, tourism, energy and energy-intensive industries. Thirdly, the case study will also look into mitigation and adaptation measures taken on local/regional level in order to see what plans have been adapted and what actions have been taken. One should bear in mind that the adaptive or institutional capacity of the municipality or region is very decisive for the possible actions that will/can be carried out.

Tisza River

The case study area is a river basin in a highly sensitive location in regard to climatic aspects. The Tisza river basin comprises territory of five countries. It covers 157,186 km² and is home to approximately 14 million people. The Tisza river basin is among the most affected regions in Europe in terms of the expected decrease of precipitation, and accelerated warming. According to recent climate modelling results the temporal distribution of both warming and precipitation will change too. Dry periods will be followed by sudden, heavy rains and floods will be devastating. Extreme (and more

severe) meteorological and hydrological events (such as flash floods, heavy precipitation, droughts etc.) will significantly increase by the middle of this century in the case study area. Based on the main features of the case study area the vulnerability assessment will focus on the following areas: flood and inundation in the built-up areas, drought in the rural areas, increasing erosion, decreasing biodiversity. The evaluation of vulnerability in the case study area – as in the European analysis - will be based on a complex analysis of sensitivity, exposure and adaptation capacity. The most important indicators in light of the research of exposure are the change of precipitation and temperature and also the increase of run-off. The indicators of sensitivity will be the relevant environmental, economic, and social variables. Regarding adaptation capacity, land use regulation, land use change and flood protection measures are especially important in the Tisza region.

Coastal Mediterranean Spain and Balearic Islands

The Mediterranean coast, together with the Balearic Islands is the most important tourist area of Spain and a key pillar of the Spanish economy. According to the latest IPCC report (2007), precipitation in the Mediterranean may diminish in the next decades due to global warming thus limiting the amount of water available for tourism. Moreover, tourism may be affected also by heat waves and flood episodes as well as by storm surges that damage beaches and force the construction of costly defence infrastructures. The study will analyse different models that attempt to develop regional scenarios of climate change and will look especially at precipitation patterns. It is also important for the case study to provide some information on the likely impacts of climate change for the Spanish economy and especially for the tourist sector. This necessitates a characterisation of tourist land uses and the distribution of tourist infrastructure (hotels, apartments, campsites, etc.) in recent years as well as prospects for the future. Subsequently an assessment of existing and potential water resources in the study area will be conducted, classified according to their origin and corrected to introduce the impacts of climate change, and also of existing and potential water demands by the tourist sector according to different types of tourism. Finally, adaptation and mitigation strategies to cope with dwindling water supplies will be examined also for the different types of tourism. It would be very relevant to assess the role of water desalination as a tool to become “climate independent” as well as the costs of pursuing this action for each type of tourism.

The Netherlands

The Netherlands form a delta where four European rivers meet (the Rhine, Meuse, Scheldt and the Ems). It is a low lying country and ca. 60-70% of its area is prone to flooding either from the sea or from the rivers (Ligtvoet et al., 2008). As many other countries the Netherlands are exposed to a wide range of effects due to climate change (MNP, 2005). Assessing the vulnerability of the Netherlands, PBL (2009) identify four spearheads for a long term spatial strategy aiming at reducing the vulnerability of the Netherlands: i) long term safety against flooding; ii) the long term freshwater availability in relation to agricultural land use and nature development; iii) the integrated development of urban areas addressing the mitigation challenges, adaptation challenges and quality of the living environment and iv) climate proofing transport and energy networks. In the

case study costs and benefits (reduced economic losses and victims) will be investigated for different long term strategies (policy options) that aim to reduce the vulnerability for flooding. This will incorporate the uncertainties about future climate change and different sea level rise scenarios. A European typology of coastal areas vulnerable for flooding will be developed and mapped and the policy options for different types will be discussed and evaluated in workshops.

Alpine Space

Already today the climate in the Alps has changed significantly and affected regions and local economies. Future climate change, especially the increase of temperature, a higher variability of precipitation and an increasing occurrence of hazards, will reinforce this development and modify today's living and working conditions (Beniston 2005, ClimChAlp 2008). Therefore, the Alpine space as rural area with relative densely populated valleys and several Metropolitan European Growth Areas (MEGAS) in the surrounding lowlands needs a transnational strategy how to foster climate change mitigation and adaptation. In the case study the analysis of vulnerability and response strategies to climate change impacts focuses on two economic sectors specific to the Alpine space: alpine tourism (esp. winter tourism) and hydro power production. Within the last 200 years both sectors emerged as core economic sectors within the alpine countries and will be highly influenced by climate change impacts (EEA 2009, OECD 2007). In addition hydro power production becomes also relevant as mitigation strategy. The vulnerability assessment will be based on existing data and studies on the Alpine Space (literature review) as well as on data provided by actions 2.1-2.5. Specific focus will be put on cultural and institutional sensitivities, impacts and adaptive capacities within the selected sectors. For the analysis of the response strategies standardised interviews will be conducted with representatives of public authorities (spatial planning authorities and environmental agencies) and organisations for regional tourism and energy supply in all alpine regions (NUTS 3).

N. N.

This additional case study will be selected in the course of the project according to specific research needs that may occur in order to complement the criteria of the other case studies. Depending on the first results, possibly a thematic oriented, but European wide case study could also be useful to complement the work by a very special focus on a potential hot spot which is not identified yet.

The final decision will be made on the next project meeting in September 2009, as the different case studies start in month 9 according to the work plan.

2. Review of the main literature and data sources

2.1 Research studies and policy documents

A broad analysis of the current climate change related literature carried out in 2008 (Rannow et al. 2008) has shown common elements but also missing aspects concerning climate change mitigation and adaptation indicators and strategies as well as aspects of vulnerability, e. g. its institutional dimension. Most of the studies, strategies and approaches to adapting to climate change show a main focus on sectoral elements. Some studies concentrate only on one sector (e.g. BRANCH partnership 2007; LUBW & LfU 2006) while other studies compile several sectoral strategies into one report. The distribution of varying effects of climate change is in focus of many studies, but it is not possible to determine "losers" or "winners" of climate change because positive and negative effects often overlap considerably. As highly differentiated impacts of climate change on the different economic sectors exist, the positive effects in one region are countered by losses due to negative effects in another region. Further, economic and health related climate impacts are very often addressed in the literature – as these are aspects that can be quite easily analysed by statistics such as mortality rates. In contrast, the effects on the biosphere are not as prominent (e.g. KLARA-Net 2007; LCCP 2006).

Only few approaches choose an integrated or territorially oriented approach, as vulnerability assessments are so far typically sectoral oriented. Thus, strategies are often only understood as a compilation of single, sectoral measures. One of the few approaches that systematically lists strategic options is an example from Canada where the basic reaction to climate change impacts can be summarised as follows: Business as usual; prevent the loss; spread or share the loss; change the location; change the activity; enhance adaptive capacity (C-CIARN 2006). Thus, it is not surprising that the largest deficits of the approaches exist in relation to interactions, both horizontally (co-ordination of actions across sectoral disciplines) and vertically (diffusion of information through the spatial levels).

Furthermore, the question of how measures can be successfully implemented is in general not answered. Only indirectly a lack of implementation of national objectives at the regional and local level and a lack of control (monitoring) is mentioned. Finally, the question on how to define and how to assess vulnerability (in the meaning of "climate change vulnerability" and "sensitivity") is answered differently in scientific studies. Research on this is an ongoing process (i. e. FP7 projects MOVE and ENSURE, but also by the EEA, see EEA 2008). Results from various vulnerability assessment approaches will be taken into consideration and possibly adapted to the needs of the ESPON Climate project.

A complete and structured list of the growing body of literature reviewed above is included in Annex II.

2.2 Data sources

The analyses within the different project actions as well as for the case studies require different types of data. At the current working stage three main blocks of data can be delineated: data on climate stimuli (a), data on sensitivity indicators (b) and data on adaptive and mitigation capacities (c).

While data on indicators on sensitivity to climate stimuli and adaptive and mitigation capacity will be collected from various sources data on climate change will be derived from a single source – the CCLM data. The processing and analysis of selected climate data will be conducted by the project team members with particular climate-related expertise, the Potsdam Institute for Climate Impact Research (PIK). The impacts of climate change will be analysed based on the latest outputs of the COSMO-CLM model (or CCLM), a non-hydrostatic unified weather forecast and regional climate model developed by the COntortium for SMOll scale MOdelling (COSMO) and the Climate Limited-area Modelling Community (CLM). The COSMO model is a well-established weather prediction model. The climate version of the COSMO model extended its predecessor towards enabling for climate simulations. COSMO model and CLM model were merged in 2007 into a unified model and are since then maintained and developed as COSMO-CLM (or CCLM) in a community process in which among others also PIK has been involved. The Max-Planck-Institute for Meteorology in Hamburg adopted the model for climate change runs with three realisations for the time period 1960-2000 and two realisations for each scenario for the time frame 2001 – 2100 based on two of the IPCC climate scenarios (A1B and B1). The results have been adopted into the 4th IPCC assessment report on climate change. For European-wide data the spatial resolution available is approximately 20x20 km. The outputs have been made available for use by the scientific community through the CERA database provided by World Data Center for Climate (WDCC), Hamburg.

Data on indicators within the fields of sensitivity towards climate stimuli resulting from climate change as well as on adaptive and mitigation capacities will be collected from various data sources. Within the six dimensions to be considered (physical, societal, environmental, economic, cultural and institutional sensitivity) data derived from remote sensing, existing GIS-databases as well as statistical, socio-economic data will be used. Data sources include the existing ESPON database, Eurostat's Regio database, CORINE land cover data provided by the European Environmental Agency (EEA) as well as IRPUD European transport networks database. Further data might be derived from sources as for instance proposed by the Tyndall report 2004, the latest EEA/JRC report on the impact of climate change in Europe 2008 or the ATEAM project. A set of desired indicators will be developed by the project consortium in due time and subsequently data availability will have to be checked with respect to the interim report.

2.3 Data availability

Since the analysis focuses on regional level data collection is preferably undertaken on NUTS3 level. A further requirement is imposed by the territorial coverage of the data.

Ideally, data to be used for indicator calculation shall cover the territory of the 27 EU Member States as well as Iceland, Liechtenstein, Norway and Switzerland, Turkey and parts of the Western Balkans. According to the experience within past and present ESPON projects as well as other European research this approach imposes two major issues. The first one relates to data availability and coverage in general and the second one to the use of administrative boundaries which have been subject to change over time or cannot be applied offhand within comparative analysis which seems to be the case particularly for the candidate countries.

Indicators on climate stimuli derived from CCLM data are available for the whole of Europe and can thus be used for comprehensive analysis. Corine Land Cover covers almost all countries except Turkey and Kosovo. While the current ESPON database does not cover any of the candidate countries (nor Iceland and Liechtenstein). Eurostat Regio Database offers at least some basic data for these countries although coverage is still extremely fragmentary and in most cases just available on national level. A screening for feasibility has to be carried out once a preliminary set of indicators has been established.

Concerning the issue of administrative boundaries within candidate countries reviews in recent ESPON2013 projects FOCI, ReRisk and Edora report that some countries (Croatia, Former Yugoslav Republic of Macedonia (FYROM), Turkey) have already adopted EU NUTS classifications while for others (Albania, Kosovo, Montenegro, Serbia) existing administrative boundaries could probably be assimilated to NUTS classification. For Bosnia and Herzegovina no NUTS classification exists and administrative units can not be associated with corresponding NUTS levels. Since all mentioned reports state rather fragmented availability even concerning basic socio-economic data in many cases analysis may be restricted to national level or may not be possible at all.

3 Use of existing ESPON results for this project

Due to the cross-cutting nature of both drivers and effects of climate change the project will utilize the results of a number of completed and ongoing ESPON projects:

Spatial Effects of Natural and Technological Hazards (ESPON 2006 1.3.1): Among others the project dealt with extreme natural events and their potential impact on the population, environment and material assets. It also included a rough assessment of the influence of climate change on the probability of occurrence of some natural hazards. Thus a number of indicators, projections and methodological experiences can be transferred to the ESPON Climate project.

Territorial Trends of the Management of the Natural Heritage (ESPON 2006 1.3.2): Among others the project analysed Europe's most valuable landscapes and natural habitats and how they are threatened by various (mostly anthropogenic) factors. Thus the project yielded data that can be used by ESPON Climate in regard to the exposure and sensitivity of regions to climate change as well as possible mitigation strategies.

Territorial Trends and Impacts of EU Environmental Policy (ESPON 2006 2.4.1): The project analysed various EU policies in regard to their environmental impact. The results can be used for ESPON Climate for gauging mitigation and adaptation capacities and possibly also for the project's scenarios.

Transport Services and Networks: Territorial Trends and Supply (ESPON 2006 1.2.1): This project investigated transport infrastructure expansion in Europe and calculated the changing transport accessibility of Europe's regions. While transport's emissions are a crucial driver for climate change it is not clear yet exactly how this project's results can be used to gauge transport related emission changes and potential impacts at a regional level.

Governance of territorial and urban policies (ESPON 2006 2.3.2): This project analysed institutional and instrumental aspects of implementing territorial policies in Europe. The identified strategies, planning and implementation styles and their respective effectiveness differed significantly between countries. These results will feed into ESPON Climate's assessment of climate change related mitigation and adaptation capacities across Europe.

Demographic and Migratory Flows Affecting European Regions and Cities (ESPON 2013 DEMIFER) and *Spatial Effects of Demographic Trends and Migration* (ESPON 2006 1.1.4): Both projects are concerned with natural population and migration trends in Europe with ageing and demographically shrinking regions identified as most important trends. The results of these projects provide valuable input for scenarios of changing sensitivity of regions to climate change and their changing adaptive capacity.

Spatial Scenarios in Relation to the ESDP and EU Cohesion Policy (ESPON 2006 3.2). Among others this project developed scenarios on the future development of Europe's demography, economy, transport, energy, rural development, governance and lastly climate change – all of which can possibly be used for the scenario-building within ESPON Climate.

European Development Opportunities in Rural Areas (ESPON 2013 EDORA): This project analyses a host of development trends relevant for the development of Europe's rural regions. Of particular interest for ESPON Climate will be the data that will be generated on the demography, economy (especially agriculture) and the institutional capacity of rural regions. There is also a theme on the effects of climate change on rural regions on which the two projects can cooperate.

Territorial Diversity in Europe (ESPON 2013 TeDi): This project will focus on the development of insular, mountainous, sparsely populated and peripheral regions of Europe. The ESPON Climate project could use the results of this project in order to analyse the vulnerability of these particular types of regions to climate change.

Typology Compilation (ESPON 2013): This project will compile regional typologies that are of particular interest to policy makers. The foreseen types are: urban/metropolitan regions, rural regions, sparsely populated regions, regions in industrial transition, cross-border regions, mountainous regions, islands and coastal regions. This typology will be used by ESPON Climate in various activities, not least when it will be used for developing a new, climate change related typology of regions.

In sum, the ESPON Climate project will build on a wide range of ESPON projects that will provide data, assessments, scenarios and strategies related mainly to the non-climatic factors of climate change vulnerability.

4 Distribution of work packages among partners

Work package	Partner involved
WP 1 Coordination	<i>LP</i>
WP 2 Actions and subactions <i>LP, all</i>	
2.1. Climate Change and Sensitivity	<i>LP, 2, 5</i>
2.1.1 Climate change effects analysis	<i>LP, 2, 5</i>
2.1.2 Climate change exposure analysis	<i>LP, 2, 5</i>
2.1.3 Climate change sensitivity analysis	<i>LP, 2, 5</i>
2.1.4 Potential climate change impact analysis	<i>LP, 2, 5</i>
2.2 Theoretical framework and review of sectoral economic sensitivity	<i>3, 4, 5</i>
2.2.1 Cost-benefit analysis	<i>3, 4, 5</i>
2.2.2 Qualitative overview	<i>3, 4, 5</i>
2.3 Analysis of regional economic sensitivity	<i>4, 3, 2, LP, 7, 5</i>
2.3.1 Economic sensitivity indicators	<i>2, 3, 6</i>
2.3.2 Maps of impacts and typologies	<i>LP</i>
2.4 Territorial Potentials for Mitigation and Adaptation	<i>6, LP, 2, 4</i>
2.4.1 Review of mitigation and adaptation policies	<i>2, 4, 6</i>
2.4.2 Analysis of mitigation and adaptation capacity	<i>4, 2, 6</i>
2.5 Typology of Climate Change Vulnerability Regions	<i>LP, 2, 4, 3</i>
2.5.1 Development of climate change vulnerability typology	<i>LP, 2, 4, 3</i>
2.5.2 Scenarios of regional climate change vulnerabilities	<i>LP, 2, 4, 3</i>
2.5.3 Cluster analysis of climate change vulnerability regions	<i>LP, 2, 4, 3</i>
2.6 Case Studies	<i>LP, 2, 3, 5, 7-13</i>
2.6.1 Coastal zone aquifer	<i>2</i>
2.6.2 North-Rhine Westphalia	<i>5</i>
2.6.3 Bergen	<i>3</i>
2.6.4 Tisza River	<i>7, 8, 9, 10</i>
2.6.5 Coastal Mediterranean Spain and Balearic Islands	<i>11</i>
2.6.6 The Netherlands	<i>12</i>
2.6.7 Alpine space	<i>13</i>
2.6.8 N.N.	<i>LP</i>

(The Project Partners names and the corresponding numbers are listed in Annex IV)

WP 3 Dissemination *LP, all*

5 Further project specific aspects

Based on feedback from the expert group the following aspects of the project will be explained in more detail. Note that other aspects mentioned by the expert group (complexity of indicators, selection of case studies, missing elements) are already dealt with in Chapter 1 and linkages with other ESPON projects are pointed out in Chapter 3.

5.1 Degree of added value

The IPCC reports and other studies have laid important foundations regarding the drivers, mechanisms and likely consequences of climate change, albeit on a global or national level. There are only few studies that analyse climate change impacts on a sub-national scale.

The novel approach of the ESPON Climate project is its aim to conduct fine-grained geographic analysis of climate change impacts on a NUTS 3 level coupled with a complete coverage of the European territory. While data availability may impose restrictions, the identification of data gaps is also relevant for climate-related policy development. The project will also analyse the different degrees of mitigation and adaptation capacities of the respective regions in order to arrive at a more realistic assessment of regional vulnerabilities - and possibilities for policy-making and spatial planning.

This policy focus is also what sets the case studies of this project apart from case studies in other research projects which typically only focus on climatic, biological and geological processes and outcomes, neglecting political, administrative, socio-cultural and institutional conditions and potentials. The case studies will thus combine existing and new 'hard data' with 'soft data' on the outlook and commitment of local and regional stakeholders. Furthermore the case studies will follow a systematic comparative approach across countries and thus enable cross-checking and cross-fertilization with the pan-European statistical analyses of the other actions of the project.

5.2 Territorial focus

The explicit territorial focus is a distinguishing characteristic of the ESPON Climate project. Following the stipulations of the ESPON programme and the tender for this project the territorial focus is the *raison d'être* and methodological core of the project as a whole and its various research actions: The outcomes of each action will be focused on what impacts global climate change will have for the different European regions and how the regions can cope with the projected impacts in order to become less vulnerable to climate change.

The linkage with various spatial typologies to be developed by ESPON project 'Typology Compilation', different types of territories (e. g. highly or sparsely populated regions, cross-border regions, mountainous regions) as well as territorial developments (e.g. urban sprawl, rural-urban migration) that have been identified in previous ESPON projects will form an important part of action 2.5 of the ESPON Climate project. After developing a strictly climate change related typology of regions, this typology will be overlaid with the

aforementioned typologies and maps in order to arrive at a more policy and planning oriented characterisation of climate change vulnerabilities. The same will be done with typologies explicitly derived from or related to EU policy (e.g. INTERREG IIIb and IV regions). These overlays lend themselves to communicating or mainstreaming climate change related findings into the various sectoral policies and programmes of the European Commission.

5.3 Dissemination plans

The project consortium is going to use a wide range of dissemination and information channels. Therefore the dissemination work package is subdivided into the following actions:

Action 3.1 Publications and Reports

The project reports are sent to a large network the contributing research institutes are embedded in, both in Europe and overseas. The involved scientists in fact depend on publishing project results in scientific papers and articles. It is envisaged to compile a book dedicated to the results of the project. Contacts have already been established to Wiley – Blackwell which has confirmed its interest to publish a scientific book with the project results.

Action 3.2 Conferences, Seminars and Networking

At least one representative of the project is going to participate in all events organized by *the ECP network and ESPON Coordination Unit* and will use this opportunity to disseminate the results in the ESPON community.

Presentation of the project results at international events and conferences. Depending on the event a large range of target groups will be addressed, including local practitioners, representatives of regional, national and European authorities as well as scientists of various disciplines.

Action 3.3 Project Homepage

Set up of a regularly updated webpage: The webpage is installed and will stay online after the termination of the project to keep data available online (see www.espon-climate.eu).

6. Overview of more detailed deliveries and outputs envisaged by the project

Deliverable	Outputs presented
Intermediate report	<ul style="list-style-type: none"> • First Results from action 2.1: <ul style="list-style-type: none"> - Results from climate change effect analysis - Results from climate change exposure analysis • Results from action 2.2: <ul style="list-style-type: none"> - Results from cost benefit analysis - Results from qualitative overview • Updates on action 2.3: <ul style="list-style-type: none"> - More detailed conceptual approach - List of possible indicators • Updates on action 2.4: <ul style="list-style-type: none"> - Preliminary results from policy review • Updates on action 2.5: <ul style="list-style-type: none"> - Update on methodology • Updates on case studies: <ul style="list-style-type: none"> - More detailed description of case studies - Update on methodology • Preliminary set of indicators (actions 2.1 – 2.4) • Detailed review on data availability • Update on dissemination concept
Draft final report	<ul style="list-style-type: none"> • Results from action 2.1: <ul style="list-style-type: none"> - Results from climate change sensitivity analysis - Results from climate change impact analysis • Results from action 2.3: <ul style="list-style-type: none"> - Regional impact indicators - Maps of impacts and typologies • Results from action 2.4: <ul style="list-style-type: none"> - Review of mitigation and adaptation policies - Analysis of mitigation and adaptation capacity

	<ul style="list-style-type: none"> • First Results from action 2.5: <ul style="list-style-type: none"> - Climate change vulnerability typology - Draft scenarios of climate change and vulnerabilities - Draft results from cluster analysis of climate change vulnerability regions • Results from case studies
Final report	<ul style="list-style-type: none"> • Final results from all actions and case studies: <ul style="list-style-type: none"> - Scenarios of climate change and vulnerabilities - Results from cluster analysis of climate change vulnerability regions

7 Barriers for project implementation

Data availability will be a main obstacle in the ESPON Climate project. Ideally the project would have detailed geographically disaggregated time series data on the various climate and non-climate related indicators. For many indicators such detailed disaggregated data will not be available or not be available across Europe: The new Candidate Countries pose special problems in this regard. For a more detailed description of these data related problems see Chapter 2.3.

Another barrier is the comprehensive coverage of the project. Given the complex and trans-disciplinary nature of climate change the research needs to tackle a wide range of topics. Especially in regard to non-climatic drivers of climate change and related response capacities the project has to integrate the results of a large number of other ESPON projects (both completed and ongoing) – in addition to more specifically climate change oriented scientific studies. The challenge will be to integrate these cross-cutting findings into one coherent framework. This calls for a very systematic and tailor-made overall methodology for the project

The methodology development itself is a critical and complex challenge for the project. While methodologies for various sub-topics exist, there exists no accepted methodology for an integrated climate change vulnerability assessment. However, the lead partner (TUDO) and PIK are involved in the two FP 7 projects (MOVE, ENSURE) that are currently dealing with this methodological challenge. Moreover, the already established contacts with the EEA, which is currently doing an indicator based vulnerability assessment, are quite relevant (see EEA 2008). Representatives of TUDO, and PIK will attend the next technical workshop on vulnerability and disaster risk mapping which will take place in Copenhagen on the 2 July. Nevertheless, it needs to be noted at this stage that the project is exploring largely ‘uncharted waters’ and cannot rely on tested and accepted methodologies and standards.

This pioneering status and the expected preliminary and final results may, lastly, make the project vulnerable to strong political criticism. After all, climate change is currently a sensitive political topic and no country or region likes e.g. to be identified as poorly prepared for likely climate change impacts. On the other hand other regions or countries may nevertheless like to be identified as climate change hot spots as this might attract policy attention and extra funding. Thus, the project might receive ambiguous feedback to even its preliminary results.

8 Preview of activities towards the Interim Report

The deliverables and their contents that are to be produced until 21 December 2009 are indicated in Chapter 6.

The timing of the respective activities is shown in Annex I (detailed work plan).

ANNEX I: Detailed Workplan

Project: ESPON Climate

Work Programme and Schedule

Code	Work Packages	Responsible	Schedule																																			
			2009												2010												2011											
			1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
1.	Coordination		[Gantt chart for Coordination: A long red bar spans from month 1 of 2009 to month 7 of 2010. Below it, 'Financial reporting' (LP) has icons at months 3, 8, 13, 18, 23, 28, 33, 38. 'Project meetings' (LP) has stars at months 3, 8, 13, 18, 23, 28, 33, 38. 'Reports' (LP) has blue bars at months 6-7, 11-12, 18-19, 23-24, 28-29, 33-34, 38-39.]																																			
2.	Research Activities		[Gantt chart for Research Activities: Multiple bars with green, red, and blue segments. 2.1 Climate Change and Sensitivity (LP, P2, P5) spans from month 1 of 2009 to month 7 of 2010. 2.1.1 Climate change effects analysis (LP, P2, P5) spans from month 1 to 12 of 2009. 2.1.2 Climate change exposure analysis (LP, P2, P5) spans from month 1 to 12 of 2009. 2.1.3 Climate change sensitivity analysis (LP, P2, P5) spans from month 9 to 12 of 2009 and month 1 to 7 of 2010. 2.1.4 Potential climate change impact analysis (LP, P2, P5) spans from month 9 to 12 of 2009 and month 1 to 7 of 2010. 2.2 Theoretical framework and review of sectoral economic sensitivity (P3, P4, P5) spans from month 4 to 12 of 2009. 2.2.1 Cost-benefit analysis (P3, P4, P5) spans from month 4 to 12 of 2009. 2.2.2 Qualitative overview (P3, P4, P5) spans from month 4 to 12 of 2009. 2.3 Analysis of regional economic sensitivity (P4, P3, P2, LP, P7, P5) spans from month 9 to 12 of 2009 and month 1 to 7 of 2010. 2.3.1 Economic sensitivity indicators (P2, P3, P6) spans from month 9 to 12 of 2009 and month 1 to 7 of 2010. 2.3.2 Maps of impacts and typologies (LP) spans from month 10 to 12 of 2009 and month 1 to 7 of 2010. 2.4 Territorial potentials for mitigation and adaptation (P6, LP, P2, P4) spans from month 9 to 12 of 2009 and month 1 to 7 of 2010. 2.4.1 Review of mitigation and adaptation policies (P2, P4, P6) spans from month 9 to 12 of 2009 and month 1 to 7 of 2010. 2.4.2 Analysis of mitigation and adaptation capacity (P4, P2, P6) spans from month 10 to 12 of 2009 and month 1 to 7 of 2010. 2.5 Typology of climate change vulnerability regions (LP, P2, P3, P4) spans from month 4 to 7 of 2010. 2.5.1 Development of climate change vulnerability typology (LP, P2, P3, P4) spans from month 4 to 7 of 2010. 2.5.2 Scenarios of regional climate change vulnerabilities (LP, P2, P3, P4) spans from month 6 to 9 of 2010. 2.5.3 Cluster analysis of climate change vulnerability regions (LP, P2, P3, P4) spans from month 6 to 9 of 2010. 2.6 Case studies (LP, P2, P3, P5, P7-13) spans from month 9 to 12 of 2009 and month 1 to 7 of 2010.]																																			
4.	Dissemination		[Gantt chart for Dissemination: 4.1 Conference papers (LP, P1-13) spans from month 1 of 2009 to month 12 of 2010. 4.2 Book publication (LP, P1-13) spans from month 4 of 2010 to month 12 of 2011.]																																			

Annex II: Literature on climate change indicators, strategies and vulnerability

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Annex IV: Partner number and names

No.	English name of the Partner	Country
1	TU Dortmund University	Germany
2	Geological Survey of Finland	Finland
3	Norwegian Institute for Urban and Regional Research	Norway
4	Newcastle University	United Kingdom
5	Potsdam Institute for Climate Impact Research	Germany
6	Helsinki University of Technology	Finland
7	Budapest University of Technology and Economics, Department of Environmental Economics	Hungary
8	VÀTI Hungarian Public Nonprofit Company for Regional Development and Town Planning	Hungary
9	National Institute for Territorial and Urban Research Urbanproject	Romania
10	Agency for the Support of Regional Development Kosice, n.o.	Slovakia
11	Autonomous University of Barcelona	Spain
12	The Netherlands Environmental Assessment Agency	Netherlands
13	Swiss Federal Institute WSL	Switzerland

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The ESPON 2013 Programme

ESPON CLIMATE - Climate Change and Territorial Effects on Regions and Local Economies

Applied Research Project 2013/1/4

Inception Report

Annex



EUROPEAN UNION
Part-financed by the European Regional Development Fund
INVESTING IN YOUR FUTURE

This report presents a more detailed overview of the analytical approach to be applied by the project. This Applied Research Project is conducted within the framework of the ESPON 2013 Programme, partly financed by the European Regional Development Fund.

The partnership behind the ESPON Programme consists of the EU Commission and the Member States of the EU27, plus Iceland, Liechtenstein, Norway and Switzerland. Each partner is represented in the ESPON Monitoring Committee.

This report does not necessarily reflect the opinion of the members of the Monitoring Committee.

Information on the ESPON Programme and projects can be found on www.espon.eu

The web site provides the possibility to download and examine the most recent documents produced by finalised and ongoing ESPON projects.

This basic report exists only in an electronic version.

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0. Introduction

This annex is attached to the Inception Report of the ESPON Climate Change project. The aim of this annex is to elaborate in more detail some aspects of the Inception Report which due to the report's page restrictions (maximum 20 pages) could only be outlined in the main report. In particular the annex will deal with the following issues: overall methodology, use of indicators, research activities towards the Interim Report and the project's ongoing and planned dissemination activities.

1. Overall methodology

1. 1 Towards an integrated approach to climate change research

The study of climate change is highly interdisciplinary. It involves scientific fields like climatology, meteorology, oceanography, solar physics, biology and geology – just for assessing climatic effects. Estimating impacts on societies calls in addition for different disciplines of social sciences. The foci and research methodologies of these fields differ significantly, yielding diverse and sometimes contradictory results. Even within each discipline there are research groups that have developed and employed competing methodologies for ever smaller aspects of the overall phenomenon of climate change. Therefore, specialisation and diversity are hallmarks of the international study on climate change.

This scientific diversity is a challenge but also necessary for advancing knowledge on climate change. Climate change is such a complex phenomenon that it can not be explored by one scientific field alone. However, diversity and specialisation also pose serious problems for understanding climate change and its impacts. Each field and each research group use different concepts, assumptions and methodologies which may not be compatible with each other. This constrains putting all the pieces of scientific evidence together and looking at the overall results and trends of climate change - which is a serious handicap especially vis-a-vis politicians and the general public. It is partly because of the sectoral specialisation that it took so long to establish an institution like the International Panel on Climate Change as an international and interdisciplinary body of scientists dealing with climate change.

Studies on the *impacts* of climate change have been equally specialised. Some studies deal with impacts on different types of regions, e.g. coastal areas, islands, river basins or cities. Actually, it is more common to find studies focusing on impacts on particular countries, regions or cities which are, however internally still sectoral oriented which means that they aim to measure the effects of climate change on different economic sectors, e.g. agriculture, forestry or different types of tourism for a certain area. For this

the studies needed to develop tailor-made methodologies that would allow them to capture and analyse the respective sectoral or region-specific effects: For example, the methodology of a study on the impacts of climate change on arctic regions in northern Finland needs to address different issues and mechanisms compared to a study on the Algarve in southern Portugal. Specialised research is sensible and necessary but the findings of specialised studies are not easily transferable between regions or sectors. Findings may not even be comparable due to methodological differences.

This is particularly troublesome in an international policy context like the European Union, when it needs to be determined, for example, how much support Northern Finland vis-a-vis the Algarve may require to cope with or prepare for climate change impacts. Thus one must go beyond mere local, regional, national and sectoral analyses and adopt a territorially comprehensive and thematically integrated approach – not as a substitute, but as a complement to specialised studies which are somehow still part of the ESPON climate project since it aims to assess the sensitivity of economic sectors as the project is asked to respond to question like “How and to which degree are the different sectors of regional and local economies as well as regional and local infrastructures going to be affected by climate change?”

Nonetheless, an integrated mainly territorially oriented sensitivity assessment seems indispensable for answering other main research questions raised by the tender and interpreted as hypothesis for further investigations, such as:

- Different types of European regions are differently vulnerable to climate change
- Different types of European regions need different, tailor-made mitigation and adaptation measures to cope with climate change
- There are potentially new development opportunities for European regions in the wake of climate change
- Different types of European regions are characterised by different territorial potentials for the mitigation of climate change
- There are new types of regions emerging, revealing the same characteristics regarding both, their adaptation and mitigation capacities

For that purpose, a new typology of regions has to be developed, characterised by similarities regarding climatic stimuli and their sensitivity.

However, there are several methodological challenges such as availability of indicators for dimensions like cultural and institutional, but also weighting problems when integrating the different dimensions to an index. As research is not legitimised to put weight to factors which are mainly determined by political values, this weighting will be based on a Delphi survey asking a couple of stakeholders among Europe for their opinion.

When looking at key literature, existing studies have not focused on such a comprehensive methodological approach so far.¹ Furthermore, these other studies lacked of a clear territorial European wide focus which² makes this approach sensible and somehow indispensable, too. This hypothesis will be further investigated towards the interim report.

Actions 2.2 and 2.3 form an integrated part of the research framework and focus mainly on the economic dimension of sensitivity, i.e. territorial effects of climate change on regional and local economies. Thus, while the project as a whole assesses the *comprehensive* territorial effects of climate change, actions 2.2 and 2.3 add a detailed assessment of the impacts on different economic sectors.

The impacts of climate change will often be specific to individual economic sectors or regions, making some sectors and regions more vulnerable than others. A wide range of economic effects will result from climate change in Europe: They include impact associated with the natural environment (including forest and fisheries), coastal zones, agriculture, tourism, energy, human health and the built environment. However, key economic sectors that will be particularly sensitive to climate change impacts include: energy supply; agriculture, forestry and fisheries; tourism; and transport infrastructure and water supply. The results of this assessment will be displayed in sectoral economic sensitivity maps, which are important outputs in their own right. In the end, however, the detailed results of actions 2.2 and 2.3 will be aggregated and provide high-level indicators for the overall economic sensitivity being part of comprehensive sensitivity assessment of action 2.1.

1. 2 From climate change to regional impacts and vulnerabilities

The conceptual core of the ESPON Climate Change project is depicted in Figure 1.

¹ See e.g. the German or Finnish climate change vulnerability/adaptation assessments (but also other national studies) which focus on certain sectors without taking an integrative perspective (Zebisch et al. 2005; Carter 2007). Further, the EEA report on an indicator-based assessment looks at sectors and thus cannot provide an integrated (regional) view (EEA 2008). Other studies like the Stern Review focus only on a limited group of sectors (Stern 2006).

² See e.g. the adaptation strategy for North Rhine Westphalia (Kropp et al. 2009) which provides – apart from the sectoral analysis – an integrated (sub-regional) view. So do other climate change impact and adaptation studies; however, they cover a regional perspective and are not able to give an overall European perspective. Due to different methodological approaches in the regional studies these cannot be compiled to an EU-wide assessment; thus, a new European-wide integrated approach is needed.

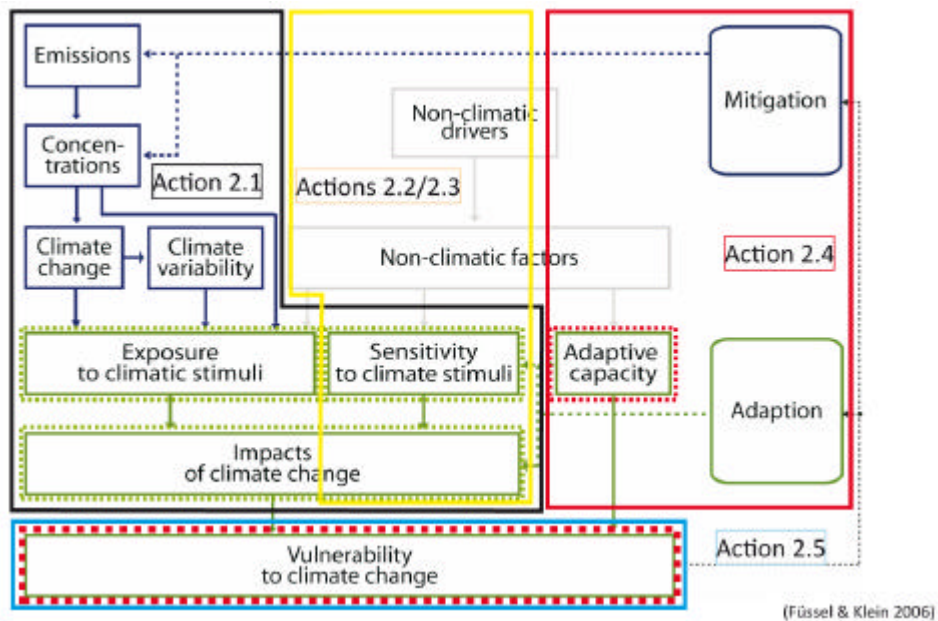
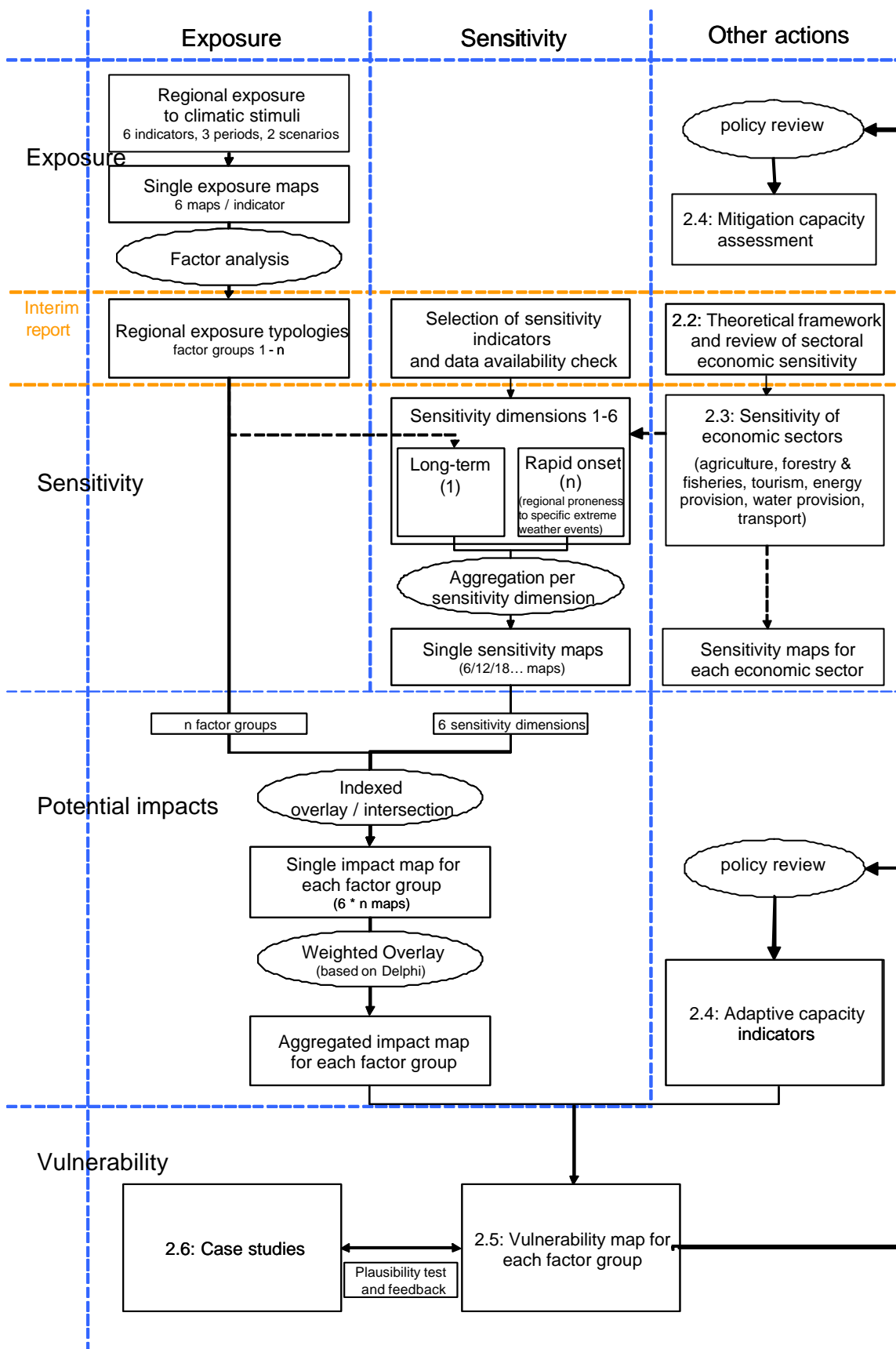


Figure 1: ESPON Climate Change research framework (adapted from Füssel & Klein, 2002, p. 54)

The following figure 2 describes the work on the application of this methodological core more in detail. It indicates which steps will be finalised for the interim report.



ESF Figure 2: Methodology step by step

In the following the various parts and analytical steps that are based on the methodology displayed in figure 2 shall be explained more in detail.

The analysis of **exposure to climate stimuli** will make use of existing projections on climate change and climate variability from the CCLM model, which is a non-hydrostatic unified weather forecast and regional climate model whose results have been used, among others, by the 4th IPCC assessment report on climate change (for more information on the CCLM model see section 2.2 of the Annex). More specifically CCLM data on the central aspects of climate change for three realisations of the IPCC climate scenarios A1B and B1 for the simulated period 1960-2000 and two realisations for the scenario period 2001-2100 will be used in the ESPON Climate Change project. Obviously this is a major component of the research framework as it provides the *raison d'être* for the project and the main driving forces for all subsequent components. Modelling climate change as such is not, however, the task of this project.

These climate data (which come in a spatial resolution of 20x20 km) will then be recalculated and transposed to relate to the NUTS 3 regions of the 27 EU Member States as well as Liechtenstein, Norway and Switzerland, Turkey and parts of the Western Balkans.³ These regionalised climate data are then categorised according to their magnitude of change for the respective region. This would finally yield the regional **exposure to climatic stimuli**. This regional exposure will also be depicted in various maps, addressing each stimulus separately.

A matrix will be used to undertake a factor analysis, seeking to optimise the analysis of the region's exposure to the six different climatic stimuli as shown by the following figure 3. In doing so, the complexity of information derived from the analysis can be considerably reduced by grouping those climate stimuli which are strongly correlated with each other. This leads to a first typology of regions which are similarly exposed to climatic stimuli addressing the research questions, mentioned by chapter 1.1.

Thus, a unique approach is chosen for the ESPON Climate project that differs from the existing approaches. This approach and especially the role and use of indicators are explained in the following chapters.

³ Iceland is not included in the CCLM datastream 3. Iceland can therefore not be covered in the exposure analysis.

Assessment of climate change effects through factor analysis

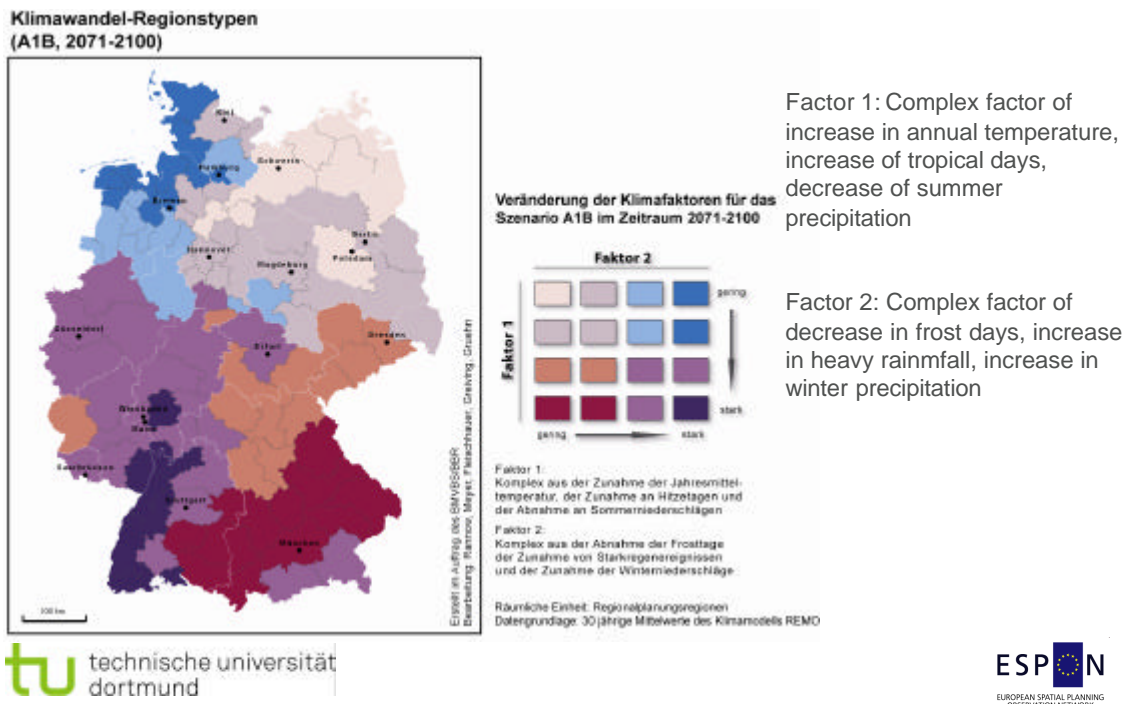


Figure 3: Example for a factor analysis

In addition to the region's exposure to climate stimuli, their **sensitivity to these stimuli** will be determined, based on the selected sensitivity indicators. Studies have shown, for example, that heat days are more serious for the health of residents in urban areas (with its high percentage of sealed surface area) than for rural areas where other environmental conditions mitigate the effects of heat. Likewise elderly people are more likely to suffer from heat days than younger residents. Therefore these two indicators can be used to determine the social sensitivity (i.e. the sensitivity of a particular social group of a region's population) to the different factor groups.

As already discussed in section 1.1 the aim of this project is not to conduct yet another specialised climate change impact assessment, i.e. a study that produces highly differentiated and detailed results for only individual indicators or as many exposure and sensitivity indicators as possible. This would also require, e.g. to identify and relate different climate indicators for every sensitivity indicator used. While not discounting the merits of such an approach (which is the foundation for all subsequent research), the ESPON Climate project is not operating primarily at the level of individual indicators,

but at a more aggregated level of sensitivity dimensions, which will then allow further aggregation and an integrated comparison of all ESPON regions.

Wherever possible sensitivity will however be differentiated into sensitivity to long-term climate changes and sensitivity to a rapid onset of climate changes (see also section 2 on indicators) in order to integrate the predisposition of a certain region into the assessment: wherever a region is already prone to e. g. floods, more precipitation would seriously increase the existing problem. On the contrary, more precipitation probably does not cause major problems in other regions. This concept makes the use of a limited group of exposure indicators justifiable.

However, the sensitivity analysis cannot be completed without having the results of the exposure analysis at hand. Based on the identified factor groups, those extreme weather events will be identified which are triggered by the represented climate stimuli (see figure 3). The results serve as input for the sensitivity analysis which is therefore different for the identified factor groups as specific groups of extreme weather events are taken into consideration (see also chapter 2.3).

For every factor group such sensitivity analyses for each of the six main dimensions of sensitivity (physical, social, economic, environmental, cultural and institutional) will be carried out which were defined in section 1 of the Inception Report. For each sensitivity indicator the appropriate thresholds for the data categorisation need to be determined based on existing studies and plausibility assessments.

In the next step regional exposure and sensitivity are combined to explore the **impacts of climate change** for each factor group. The procedure is quite similar to combining several sensitivity indicators to one indicator, i.e. juxtaposing categorised indicator data in a matrix that will yield various impact categories. Accordingly, a high impact can be the result of either a high exposure or a high sensitivity to a particular climatic stimulus.

A third major component of the project's research design (Figure 1) is the **adaptive capacity to climate change**, i.e. the economic, socio-cultural, institutional and technological ability of a region to adapt to the impacts of a changing regional climate. High adaptive capacity counterbalances sensitivity, thus reducing vulnerability. Indicators for the various aspects of adaptive capacity will be assessed and combined in a similar procedure as for climate change sensitivity. A combined adaptive capacity measure is developed, as a generic determinant for each region. Since the capacity for policy development and implementation are crucial determinants of adaptive capacity, a policy review feeds into the development of adaptive capacity indicators.

Mitigation is also highly relevant for territorial development and cohesion since climate policy implementation and the transition to a low-carbon society will have differential effects on sectors and regions. However,

mitigation mainly has effects on greenhouse gas emissions and concentrations and thus contributes to a reduction of climate change. Mitigation policies are fed by research on climate change as well as anticipated and observed vulnerability to climate change. Mitigation and adaptation are two options a society can choose in order to deal with the challenge of climate change. However, only adaptation has direct regional effects, while mitigation measures – even implemented at the regional level – will not have significant effects on *regional* climate but only contribute to an overall reduction of *global* climate change. Since the ESPON Climate Change project is about differentiating territorial effects, the focus of the project will therefore be primarily on adaptation.

The project will furthermore explore possibilities of linking the sensitivity analysis of different economic sectors to regional mitigation capacity, because in practice there is always a strong link between adaptation and mitigation policies at regional and local levels as well as in the common understanding of stakeholders. This needs to be further elaborated (e.g. within the case studies) since the sensitivity of various economic sectors in relation to adaptation is qualitatively different from sensitivity in relation to mitigation policy. The policy review to be conducted in action 2.4 will also include aspects of mitigation policy. The results of this policy analysis will later be juxtaposed with the results of the vulnerability assessment and lead to differentiated policy recommendations. The project will not, however, develop any indicators or maps that attempt to estimate the impact of mitigation policies on regional or global greenhouse gas emissions. This would be far beyond the project's scope and mitigation effects would also be seen primarily in a global but not European or even regional context.

Finally, climate change impacts and adaptive capacity can be combined to determine the overall ***vulnerability to climate change***, again for each factor group separately. Hence a region with a high climate change impact may still be moderately vulnerable if it is well adapted to the anticipated climate changes. On the other hand, anticipated high impacts would result in high vulnerability to climate change if combined with low regional adaptive capacities. The procedure for this determination and corresponding map display is illustrated in Figure 2.

Based on projections for relevant indicators (actions 2.1 -2.4) the regional vulnerability typology will be varied to create low, medium and high vulnerability scenarios. The CC vulnerability typology map will be overlaid with regional typologies of other ESPON projects (e.g. urban/rural, FUAs, MEGAs etc.) A factor analysis will be performed integrating indicators of these ESPON projects to identify new types of CC regions with similar characteristics. This will be linked back to the NUTS-3 level list to identify which regions correspond to which type of region. Finally the spatial and political distribution of these various regional classes will be explored and mapped.

The **case studies** will serve - among others - as plausibility test of the proposed methodology and providing feedback for the previous actions.

The procedure described above constitutes the methodological core of the ESPON Climate Change project. As far as data availability allows, they will be implemented for all NUTS 3 regions of the study area. Obviously, sensitivity and adaptive capacity parameters will also have to utilise projections (drawing e.g. on available projections of previous and ongoing ESPON projects) or alternatively scenarios where no projections are available.

As regards methodology, the Interim Report will identify, discuss and assess the suitability of possible indicators for the various analytical tasks and thus come up with a first comprehensive list of indicators to be used in the project. The report will also discuss and elaborate on the specific aggregation procedures to be used for combining different indicators (including possible weighting of indicators and determining categorical thresholds). Lastly, while the overall methodology described above will also be employed in the case studies, the Interim Report will explain in detail how the case studies will utilise more fine-grained and region-specific data, especially in regard to local/regional adaptive capacity depending on the scale of the respective case study.

1. 3 Work towards the interim report

To summarise the various methodological components described above, the following overview shows the work to be undertaken until the interim report:

Action 2.1:

- Exposure analysis. Will be finished until the interim report. Final products: exposure indicators, exposure maps, regional exposure typology
- Sensitivity analysis: First results: Selection of sensitivity indicators and data availability check

Action 2.2:

- Economic impact analysis.
- Draft cost-benefit analysis as a guideline for evaluating economic effects of climate change.
- Draft literature-based overview of climate change impacts on the overall economy and specific sectors.
- Selection of economic and sectoral indicators (in co-operation with Action 2.3).

Action 2.3:

- Analysis of regional economic sensitivity
- Draft literature review for the development of economic sensitivity indicators
- Selection of economic and sectoral indicators (in cooperation with Action 2.2)

Action 2.4:

- Policy review: Preliminary results of the policy review with respect to both mitigation and adaptation capacities
- Adaptive capacity and mitigation capacity indicators: screening and selection, review of data availability

Action 2.5:

- Update on methodology and work plan

Action 2.6:

- Update on case study methodology and work plan
- More detailed description of the case studies

2. Complexity of indicators

2. 1 General comments on the role and meaning of indicators

In the following, some general comments and explanations concerning the role and meaning of indicators will be presented. This mainly relates to the Annex III to the Subsidy Contract where some of these questions have already been raised.

Indicators that are linked to different dimensions and different processes

One of the open questions was how indicators interrelate with each other that are linked to different dimensions and different processes. This was mainly questioned concerning the fact that GDP is proposed to be used for measuring the economic sensitivity to climate change but also the territorial potential for mitigation. In this specific case two spatial relations of the GDP have to be distinguished: National level GDP is used as one indicator (or indicator component in the case of an integrated/composed indicator, respectively) for climate change mitigation potential and adaptive capacity whereas the regional GDP indicates the regional climate change impact potential. Thus, although the indicator seems to be the same, there are in fact slight differences between the two uses of GDP as an indicator. The appropriateness of GDP or income, respectively to show both, economic sensitivity as well as adaptation, but also coping capacity potential is also stated by other authors (e.g. Cutter, Boruff & Shirley, 2003).

Dealing with indicator and data gaps

Another question is raised concerning indicators that are not available (e.g. on policy development). The consortium is aware of the fact that some indicators will not be available for the whole ESPON area (especially for the cultural and institutional dimension). In these cases dummy indicators will be used for the overall calculation at the European level (probably referring to NUTS 0 or 1 level) whereas these indicators will be developed in the case studies in more detail (e.g. by interviews, workshops, literature and document analysis etc.).

2. 2 Exposure indicators

Research context

Exposure to climatic stimuli represents the nature and degree to which a system is exposed to climatic variations. The exposure of a system to climatic stimuli depends on the level of global climate change and, due to spatial heterogeneity of anthropogenic climate change, on the system's location (cp. Füssel and Klein 2006, p. 313). Thus, exposure to climatic stimuli is directly influenced by general trends in climate change as well as climate variability (variations on various spatiotemporal scales) and also concentrations of greenhouse gases (see figure 1). Non-climatic factors influence exposure as well. In other words, exposure refers to the geographical representation of the effects of climate change, climate variability and greenhouse gas concentrations and non-climatic factors. Taken together with sensitivity to climate change as well as adaptive capacity, exposure becomes a component of impacts of climate change (potential as well as residual).

Burton (1997) suggests a hierarchy of weather and climate phenomena (denoted as type 1,2, and 3 variables) to distinguish between single climatic variables (such as local temperature), specific weather events (such as convective storm), and long-term processes (such as anthropogenic climate change) (cp. Füssel and Klein 2006, p. 313). According to the project research framework exposure will focus rather on long-term trends which are immediately available from climate model predictions since discrete extreme events or rapid onset hazards are rather hard to localise considering their specific spatial extent. However, according to existing records of such events and a combination with future exposure to climate stimuli, reasonable assumptions on increase or decrease of the frequency and intensity of extreme events can be made.

Climatic stimuli

Within the current research framework climatic stimuli and the resulting exposure to climatic stimuli are understood to result from climate change and climate variability as well as from direct impacts of concentrations of greenhouse gases. Thus it is necessary to gain evidence on the spatiotemporal distribution and variability of projected developments. For the ESPON climate project these projections are based on the Intergovernmental Panel on Climate Change (IPCC) scenarios published in 2000 and i.a. employed within the fourth IPCC assessment report in 2007. Based on these scenarios the CCLM model has been run simulating future climate change for almost the whole European territory.

CCLM projections

Exposure to climate stimuli will be analysed based on the latest outputs of the COSMO-CLM model (or CCLM). CCLM is a non-hydrostatic unified weather forecast and regional climate model developed by the Consortium for Small

scale MOdelling (COSMO) and the Climate Limited-area Modelling Community (CLM). The CCLM model has been adopted for climate change runs with three realisations for the time period 1960-2000 and two realisations for each scenario for the time frame 2001 – 2100 based on two IPCC scenarios (A1B and B1). These model runs have been conducted in conjunction with the global coupled atmosphere ocean model ECHAM5/MPI-OM. For European-wide data the spatial resolution available is approximately 18 km. Based on these model projections different climate-change indicators have been calculated by PIK constituting the basis for the current analysis of exposure to climate stimuli.

Exposure indicators

In principle, the CCLM model delivers a wide range of climate-related output parameters (cp. Wunram 2007). These parameters relate to many different fields relevant within meteorology and climate research. For almost all output parameters, data is provided on an hourly to daily basis. Thus, for the purpose of this research, selected parameters have been aggregated by PIK for the time frames 1961-1990 and 2011-2040, 2041-2700, 2071-2100 for both scenarios (A1B and B1) in order to attain mean values from which projected mean changes for the European territory can be derived (see figure 2 as example).

The focus on central climate parameters is crucial since the CCLM model delivers a broad range of parameters (also varying by datastream) which is hardly useful for applied research outside the meteorological domain. The derived exposure indicators will be discussed in more detail within the subsequent paragraphs. Generally, the change indicators always related the reference time frame (1961-1990) to the climate conditions within the projected periods as calculated by the CCLM model (e.g. 2071-2100). The difference between these two periods constitutes the projected climate change.

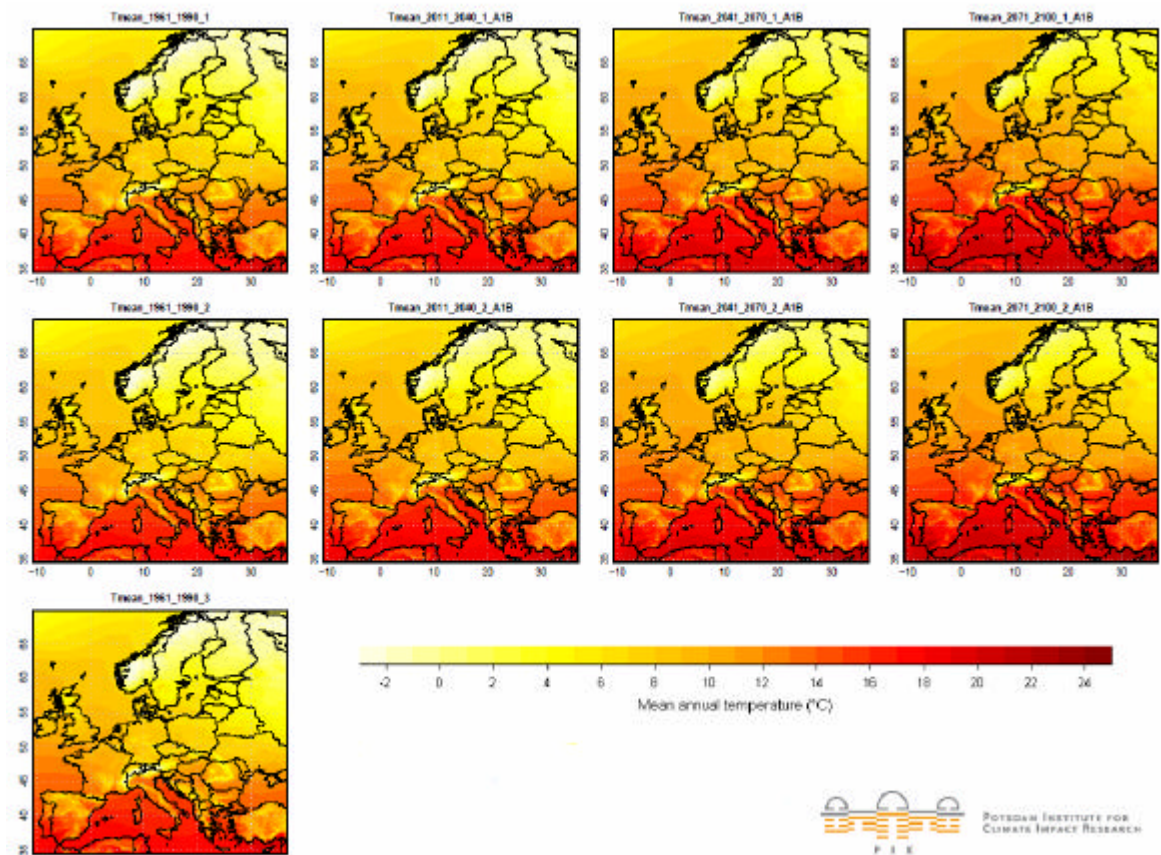


Figure 4: CCLM output on mean annual temperature (T_{2M_AV}), averaged for different timeframes (1961-1990, 2011-2040, 2041-2070, 2071-2100), for different model runs and scenario A1B.

Source: Lautenschlager et al. 2009, preparation by PIK

Change in annual mean temperature

Based on the CCLM parameter 'air temperature in 2 metres above surface' (T_{2M_AV}) average annual temperatures in degrees Celsius for the selected time frames have been calculated. This indicator shall serve to indicate regional variation of changes in temperature. Changes in temperature may lead to various impacts taken together with respective regional sensitivities.

Change in annual number of frost days

Based on the CCLM parameter 'frost days' (FD) average annual number of frost days (days with temperatures below 0°C) for the selected time frames has been calculated. This indicator shall serve to indicate changes in regional climate extremes with respect to cold temperatures. Taken together with

respective regional sensitivities increase or decrease in frost days may lead to impacts considering natural hazard exposure on the regional level.

Change in annual number of summer days

Based on the CCLM parameter 'summer days' (SU) average annual number of summer days (days with temperatures above 25°C) for the selected time frames has been calculated. This indicator shall serve to indicate changes in regional climate extremes with respect to summer temperatures. Changes in summer temperatures taken together with respective regional sensitivities may have direct and indirect impacts for example on the population or species/ecosystems.

Change in annual mean precipitation in winter months

Based on the CCLM parameter 'total precipitation' (PRECIP_TOT) average annual precipitation in kg/sqm for the selected time frames has been calculated for the meteorological winter months (December, January and February). This indicator accounts for changes in winter precipitation which taken together with changes in temperature may impact directly on regions with respective sensitivities. Moreover also indirect impacts may occur.

Change in annual mean precipitation in summer months

Based on the CCLM parameter 'total precipitation' (PRECIP_TOT) average annual precipitation in kg/sqm for the selected time frames has been calculated for the meteorological summer months (June, July and August). This indicator will be used to indicate regional exposure of changes in summer precipitation which may have direct as well as indirect impacts on sensitive regions.

Change in annual number of days with heavy rainfall

Based on the CCLM parameter 'number of days with total precipitation at least 20 kg/m²' (R20MM) average annual number of days with heavy rainfall for the selected time frames has been calculated. This indicator will illustrate regional exposure to changes in heavy rainfall events which may impact directly and indirectly on regions with respective sensitivity.

2. 3 Sensitivity indicators

General comments

Sensitivity to climate change is a key factor in the climate change vulnerability assessment framework. Sensitivity describes the dose-response relationship between the exposure to climatic stimuli and the resulting effects: "Sensitivity is often assumed to remain constant over time. However, whilst this assumption may be correct for unmanaged natural systems, its appropriateness can be questioned for most human systems, which evolve continuously, even in the absence of climate change" (Füssel & Klein, 2002, p. 49).

For the ESPON Climate project climate change sensitivity is understood to consist of six dimensions which will be combined for measuring the overall sensitivity of European regions. Here, an integrated – and not sectoral – approach is chosen that allows identifying certain regional typologies of sensitivity (sensitivity typologies). This represents an interdisciplinary and spatial perspective that is required for spatial planning and territorial development.

Reducing complexity

In order to reduce the complexity of the potentially high number of indicators, two high level indicators (the most relevant or an integrated/composed indicator) will be developed for each dimension of sensitivity.

Character of changes

Sensitivity can be represented in two ways: First there is a sensitivity towards long-term changes like changes in temperature, precipitation but also sea level rise. These long-term changes that are related to the gradual changes of climatic parameters over time however do not represent those climate change effects that are triggered by a changing climate and result in a higher frequency and magnitude of certain climate related extreme events like floods, forest fires or mass movements (so called rapid onset hazards).

Moreover, rapid onset indicators are needed to take into account the predisposition of regions towards certain extreme events. For example, a region that has already strongly been affected by forest fires in the past (e.g. regions in Spain, Portugal) will suffer more under an increase of dry weather periods than a region where low forest fire hazards (e.g. Norway).

This predisposition however is not equally distributed over all existing extreme weather events but depends on typical factor groups (or clusters) of climate changes (results from the factor analysis of climate change exposition). E.g., a “summer related cluster” (increase in mean temperatures, decrease in precipitation) is relevant for forest fire hazard but a “winter related cluster” would not be relevant. This means that for every factor group (cluster) it has to be defined which climate related extreme weather events are relevant in this case. Thus, it is important to define indicators for rapid onset that are tailored to the specific sensitivity dimension. On the other hand, indicators showing long-term changes in sensitivity are general and independent of particular extreme weather events.

Indicators shall be selected in a way that long-term climate changes as well as rapid onset changes can be described.

Future changes as a challenge

Climate change assessments use climate projections based on climate change models and scenarios on greenhouse gas emission. In order to assess climate change vulnerability it is – from a methodological point of view – questionable to combine data from climate change projections (e.g. until 2070 or 2100) with present or even past socio-economic data for assessing society's sensitivity towards the projected climate change.

However, this means a methodological challenge from another point of view because projections and estimations for future changes of the society or the economy are difficult to make, especially for the long term. Concerning population development there are quite reliable projections maybe until 2050. For other socio-economic parameters rapid changes and upheavals that are not predictable are very likely to happen, making any kind of projection is rather plain guessing. A methodological way out of this problem is to work with scenarios that can help defining (and analysing) possible future developments whenever information about the future development is low, not at all available or highly uncertain.

The IPCC developed a range of greenhouse gas emission scenarios that describe in storylines the underlying socio-economic development. As a pragmatic way which is at the same time in line with global climate change projections we suggest to use the emissions scenarios also for the future European socio-economic development in the ESPON Climate project. The storylines of the IPCC A1B and B1 will be used as a general framework to design these scenarios (IPCC, 2000):

- The *A1 storyline and scenario family* describes a future world of very rapid economic growth, global population that peaks in mid-century and declines thereafter, and the rapid introduction of new and more efficient technologies. Major underlying themes are convergence among regions, capacity building, and increased cultural and social interactions, with a substantial reduction in regional differences in per capita income. The A1 scenario family develops into three groups that describe alternative directions of technological change in the energy system. The three A1 groups are distinguished by their technological emphasis: fossil intensive (A1FI), non-fossil energy sources (A1T), or a *balance across all sources (A1B)*.
- The *B1 storyline and scenario family* describes a convergent world with the same global population that peaks in mid-century and declines thereafter, as in the A1 storyline, but with rapid changes in economic structures towards a service and information economy, with reductions in material intensity, and the introduction of clean and resource-efficient technologies. The emphasis is on global solutions to economic,

social, and environmental sustainability, including improved equity, but without additional climate initiatives.

The EEA also uses IPCC scenarios as basic information in their report "Impacts of Europe's changing climate". However, the EEA also discusses the problems related to these scenarios as the global IPCC scenarios contain spatially detailed European information for only few indicators. They are also incomplete and differ between indicators. The EEA argues that regular interaction is needed between the climate modelling community and the user community that is analysing impacts, vulnerability and adaptation in order to develop high-resolution, tailor-made climate change scenarios for the regional and local level (EEA, 2008).

Methodologically the adaptation of the IPCC storylines to the situation in the ESPON area will be done in a qualitative way in order to define the socio-economic situation in the future. From there, change factors will be derived by a heuristic estimation based on expert knowledge that will be assigned to the selected sensitivity indicators.

Therefore, it is intended to make use of the ESPON community for going ahead in this respect. Particularly, the ESPON seminars could serve as a discussion platform for that purpose. Moreover, existing ESPON results will be analysed with respect to their relevance for that question.

Integration of sensitivities

A further question to be solved is how sensitivity dimensions shall be integrated – irrespectively if this integration is done to create an overall sensitivity index or if it is done at the level of climate change impacts (integration of sensitivity dimension related impacts).

The weighting of indicators can be done by experts using the Delphi method – an approach that has already been applied successfully in the ESPON Hazards project (Greiving 2006). The Delphi method was used in the ESPON Hazards project as a tool to weight hazards on regional and European levels, as well as to weigh vulnerability components on the regional level.

The Delphi Method is based on a structured process for collecting and synthesizing knowledge from a group of experts through iterative and anonymous investigation of opinions by means of questionnaires accompanied by controlled opinion feedback (Helmer, 1966; Turoff & Linstone, 1975; Cooke 1991). After several rounds of assigning weights, the individual scores are finally aggregated to achieve collective weights for all sensitivities. On this basis, the integration of all extreme weather events and the production of an integrated sensitivity map can easily be performed. For that purpose, the single range of extreme weather event intensity (1-5) will be multiplied with the Delphi weighting of a certain sensitivity.

Indicators

The following indicator section presents work in progress, as the final identification and discussion of relevant indicators is part of the Interim Report. Therefore only the main sensitivity categories are characterised in short and what the respective indicators would indicate.

Physical sensitivity

Physical sensitivity involves, for example, the degree of sensitivity of human settlements and infrastructure to climate change effects (long-term changes in temperature and precipitation, but also extreme weather events).

The term “physical” is used here to include all human artefacts that have a specifically spatial planning or territorial development related character, e.g. as they are on a specific site or form a network that has a certain spatial extent. Thus, indicators are needed that are able to show this spatial relation in context with long term and rapid onset impacts of climate change.

Long-term changes affect physical structures comprehensively and over a longer time. Damages are not that much of physical character but affect mainly the use and functionality of settlement areas and infrastructures (urban heat island, dimension of waste water system).

- Settlement area: The percentage of settlement area within a region indicates the degree of physical structures that is potentially affected by long term changes. The higher the share is, the more likely it is that a region will suffer from these changes.

Rapid onset changes indeed lead to damages to physical structures such as housing, streets, supply and disposal infrastructure etc.

- Infrastructure: The share of infrastructure in hazard prone areas could be a good indicator for the physical sensitivity. However, it will be difficult to obtain data for all hazard prone areas in Europe. Maybe this is possible at least for river floods which could lead to an approximate estimation of the infrastructure related physical sensitivity.
- Settlement area: Settlement area and its overlapping with hazard-prone areas could be also – similarly to infrastructure – an indicator to show the physical sensitivity.
- Density of the built environment: This factor highlights those areas where significant structural losses might be expected from a rapid onset event.
- Housing stock: The nature/quality of the housing stock (e.g. mobile homes, camp grounds) and the nature of ownership (renters) and the location (urban) combine to produce the social sensitivity depicted in this factor.

Social sensitivity

Characterisation and indicators needed: Social sensitivity will include the sensitivity of different social groups to climate change effects, in relation to the demographic, ethnic, cultural or physical composition of the groups and to the levels of marginality and social segregation or other weaknesses and restrictions in the access to social, economic or health-related assets.

Social sensitivity also comprises the aspect of environmental justice which can be defined as the fair treatment and meaningful involvement of all people – regardless of race, ethnicity, income or education level – in environmental decision making (USDE 2009). Thus, indicators shall be able to show the social sensitivity by relating to environmental justice related characteristics.

As societies change permanently a more general indicator seems to be more appropriate to show the long term effect of climate change on the society than an indicator that specifically describes a society but only is a snap shot view.

- Population: The total number of people within a certain region can generally show the share of society that is potentially affected by climate change impacts. This, however, is only a quantitative indication that provides no information about discerning qualitative characteristics.

The linkage between rapid onset changes and the society is better portrayed by looking at more qualitative aspects within society. In their study on social vulnerability to environmental hazards Cutter, Boruff & Shirley (2003) have identified eleven composite underlying factors for a social vulnerability index. These can be redefined as social sensitivity indicators in the context of rapid onset changes triggered by climate change. In the following, those factors that exclusively have a social context are listed and composed to a new Social Sensitivity Index.

- Personal Wealth: Wealth enables communities to quickly absorb and recover from losses. Lack of wealth is a primary contributor to social vulnerability as fewer individual and community resources for recovery are available, thereby making the community less resilient to the hazard impacts. On the other hand, however, wealth also means that there may be more material goods at risk.
- Age: The two demographic groups that are most affected by climatic impacts are children and the elderly.
- Migration background: The migration background often contributes to social sensitivity through the lack of access to resources, cultural differences, and the social, economic, and political marginalisation that is often associated with migration related disparities.
- Lower wage service occupations: It is expected that counties heavily dependent on a lower wage service occupations employment base

might suffer greater impacts from natural hazards and face slower recovery from disasters (Cutter, Boruff & Shirley, 2003).

- Dependency: This is a composite indicator that comprises e.g. dependency ratio, low income, illiteracy ratio, ethnic minorities/refugees/tourists.

Environmental sensitivity

Characterisation and indicators needed: Environmental sensitivity involves the fragility of ecosystems under the duress of changing climate conditions and hazardous events (biodiversity and ecosystem services of different biogeographical regions).

The environmental dimension of sensitivity acknowledges ecosystem or environmental fragility. In the case of environmental sensitivity, it is important to find out how different kinds of natural environments cope with long-term climate changes or rapid onset of extreme weather events.

Long term impacts of climate change affect mainly those regions that have a high percentage of unfragmented natural areas.

- Natural areas: The higher the percentage of unfragmented natural areas is the higher is the potential loss due to climate change impacts. However, at the same time, large unfragmented areas have larger adaptation capacities because they allow a better migration of species in case climate parameters change in the long term. Thus, the higher the percentage of unfragmented areas is the lower is the environmental sensitivity. This indicator nevertheless is quite ambivalent due to the fact that it is also a question of the species "quality" within a certain area.

Certain subjects of protection such as fauna, flora, soil, water or air can be potentially affected by extreme events (due to rapid onset hazards) as a consequence of climate change. However, there are diverging opinions on this question because it is often argued that nature itself cannot be affected by natural disasters because these are normal processes of the earth's dynamics. But nowadays all natural events always have a certain element of anthropogenic influence and there are often interdependencies with technological hazards at the same time. Thus, it can be justified that subjects of environmental protection can be affected by rapid onset hazards due to climate change.

- Subjects of protection: Number of river floods, flash floods, land slides etc. with significant impacts on the environment.

Economic sensitivity

Characterisation and indicators needed: This dimension encompasses sensitivity of economic activities and structures to climate change induced or

intensified hazards, but also to positive (economic) opportunities created by climate change.

The following examples of indicators can be used for long-term as well as rapid onset impacts of climate change.

- Single-sector economic dependence: A singular reliance on one economic sector for income generation creates a form of economic sensitivity for regions. Economies like oil development, fishing, or tourism are good examples – in the heyday of prosperity, income levels are high, but when the industry sees hard times or is affected by climate change, the recovery may take longer. The agricultural sector is no exception and is, perhaps, even more vulnerable given its dependence on climate (Cutter, Boruff & Shirley, 2003).
- Arable land: As agriculture is the sector that is most directly affected by climate change, an indicator is proposed that portrays this circumstance. The percentage of arable land indicates how intensively a certain region depends on agricultural production. This could also be integrated with the number of jobs in the agricultural sector.
- Income/jobs in climate sensitive sectors: Income is an indicator for the economic potential in a region and thus also for the general regional damage potential because it can be argued that the higher the income is the higher are the cumulated values of private and public property in a region. This could be integrated with the number of jobs in a region because the general damage potential is also a quantitative question.
- Type of jobs: The type of jobs is an indicator for the more qualitative impacts on the regional economy. Here the thesis is that certain economic sectors (types of jobs) will be more affected by climate change than others, e.g. jobs in winter tourism, jobs in summer tourism, agriculture, transportation etc. Regions that have a high share of these jobs will thus have a larger impact on their local economy.

Cultural sensitivity

Characterisation and indicators needed: This factor is related to natural and urban landscapes with their cultural attributes and characteristics and their changing values and significance for individuals and communities.

- Cultural heritage: This could be one indicator for measuring cultural sensitivity to climate change. Data could be taken from the inventory of world heritage sites although these represent only a very limited section of the overall cultural heritage. Another data source could be the highest rated touristic sites in international travel guides like Michelin or Baedeker.

Institutional sensitivity

Characterisation and indicators needed: This aspect focuses on norms, formal rules, institutions and policies that constrain or facilitate human action and the involvement of relevant stakeholders in climate change related communication and decision-making processes.

The identification of indicators that can show institutional sensitivity at a European level is a challenging task and might not be solved within the project. Instead, indicators have to be found that might indirectly show institutional sensitivity:

- Political concern: Voter participation in local elections; the idea behind is the assumption that political actors (and their administrations) are less vulnerable if there is a high participation in local decision making and thus trust in political decisions.
- Institutional effectiveness: For example, share of illegally built houses as an indicator of the effectiveness and respect towards the political-administrative system.

Institutional sensitivity is understood to consist of two dimensions: (1) between institutions (misfits in interplay) and (2) between institutions and the public. For both dimensions indicators are needed, that can as well be differentiated between long term changes and rapid onset hazards. Theoretically or academically the distinction between rapid onset and long-term changes might be important; however in practice a distinction into measures to reduce institutional vulnerability for rapid onset or long term changes is most likely not needed.

2.4 Adaptive capacity indicators

Characterisation and indicators needed: Adaptive capacity consists of various determinants. Three distinctions should guide indicator development of adaptive capacity: 1) generic vs. specific capacity; 2) autonomous vs. planned adaptation; 3) short term (emergency response) vs. long term adaptive potential.

In general terms, adaptive capacity refers to the characteristics contributing to adjustments in natural or human systems in response to actual or expected environmental change and external stress. Adaptive capacity can also be understood as a particular factor, specific to a location and/or a particular hazard (Metzger & Schröter 2006, 209; Adger et al. 2004). In this project, a combined adaptive capacity index will be developed for the regions within ESPON space, based on a selection of available indicators that measure the generic adaptive capacity of each region. Specific qualitative analysis of adaptive capacity (pertaining to particular hazards) will be conducted in the case studies.

First, a set of socio-economic indicators for generic capacity will be used. Such an approach indicates generic capacity for adjustment and thus refers to *autonomous adaptation*.

Second, *planned adaptation* needs to be addressed through indicators pointing to conscious political action taken at different levels of governance. For instance, the development of national adaptation strategies in Europe has seen rapid progress over the past few years (See Zwart et al. 2009). National policy development for adaptation clearly adds to long term adaptive capacity, and should be factored in the adaptive capacity of a region. The policy review in action 2.4. precedes and feeds into adaptive capacity indicator development, thus addressing the dimension of planned adaptation.

Third, the distinction between long- and short term adaptive capacity will be addressed in developing the indicators. Emergency response capacity (or: coping capacity directly to hazardous events) can be differentiated from a longer term adaptive capacity and specific indicators (e.g. ratio of doctors and hospital beds per capita) can be used to reflect emergency response.

The following five categories can be used to describe adaptive capacity to climate change or its lack, respectively (Haanpää & Peltonen, 2007):

- Capacity to conceptualize and formulate policies, legislations, strategies, and programmes: Analyzing conditions that may affect country needs and performance in climate change related (adaptation) policies, developing a vision, long-term strategizing, and setting of objectives, conceptualizing broader sectoral and cross sectoral policy, legislative and regulatory frameworks, prioritization, planning and formulation of climate change adaptation related guidance in planning.
- Capacity to implement policies, legislations, strategies, and programmes: Process management capacities that are essential in the implementation of any type of policy, legislation, strategy and programme; execution aspects of programme and policy implementation; mobilizing and managing human, material and financial resources, focusing on the capabilities of local actors in spatial planning.
- Capacity to engage and build consensus among all stakeholders: Mobilization and motivation of stakeholders, awareness raising and developing an enabling environment for spatial planning processes and the civil society to address climate change and discussion on the issue.
- Capacity to mobilize information and knowledge: Mobilization, access and use of information and knowledge; effectively gathering, analyzing and synthesizing information, identifying problems and potential solutions; cooperation issues between different actors, including planners, politicians and scientists.
- Capacity to monitor, evaluate, report and learn: Monitoring of progress, measuring of results and learning and feedback. It naturally links back to policy dialogue, planning and improved management of implementation on international and national levels.

It should be noted, finally, that indicators for adaptive capacity are usually used for national-level comparisons, based on national data (IPCC 2001, Adger et al. 2004). Therefore, the identification and utilisation of sub-national level indicators requires a thorough screening of available indicators, which will be conducted for the Interim Report.

3. Dissemination strategy

The following dissemination activities have already been undertaken or are planned for the coming month (presentations at conferences, meetings, seminars, workshops, etc. within the climate change scientific community). Due to the fact that the ESPON Climate Change project is still in its early phase, most past presentations listed below did not focus exclusively or primarily on the project, but addressed or introduced it in a broader scientific context .

IRPUD

- Greiving; S. (2009): The Espon climate Project. EEA workshop on 'Vulnerability and Disaster Risks Mapping', Kopenhagen, 2. July 2009.
- Greiving; S. (2009): "Linking civil protection and spatial planning though agreement on objectives. 7th open Meeting on social dimension of global environmental change". Bonn. 29. April 2009.
- Greiving; S. (2009): "Spatial Planning and adaptation. Strength and weaknesses. Vortrag auf der Konferenz Evaluating the Climate Change Fitness of Spatial Planning. Bern, 25. March 2009.
- Fleischhauer, M. (2009): Regionaler Handlungsrahmen Klimaanpassung. 2.MORO-Fachkonferenz "Raumentwicklungsstrategien zum Klimawandel". Berlin, 3. July 2009.
- Fleischhauer, M. (2009): An Overview of Climate Change Activities in Europe. Trans-Atlantic Collaboration Workshop "Changing Land Use to Mitigate Climate Change". Dubrovnik/Kroatien, 7. May 2009.
- Fleischhauer, M. (2009): Möglichkeiten des Klimaschutzes und der Klimaanpassung auf der Ebene der Regionalplanung. 32. Sitzung des Planungsausschusses, Bezirksregierung Düsseldorf. Düsseldorf, 26. March 2009.
- Fleischhauer, M. (2009): Klimawandel zukunftsfähig gestalten! Risiken im Bereich der kommunalen Infrastruktur. Informationsveranstaltung zum Klimawandel in der Bezirksregierung Arnsberg. Arnsberg, 9. February 2009.

GTK

- Schmidt-Thomé, Philipp (2009): Presentation ESPON Climate project at the ESPON seminar in Prague, Czech Republic, June 3 2009
- Schmidt-Thomé, Philipp (2009): PhD course on natural hazards, climate change and planning, University of Alicante, Spain, 29.06-02.07.2009
- Schmidt-Thomé, Philipp (2009): UN Habitat. Natural hazards, risks and climate change in planning. UN Habitat Course on sustainable cities, Nairobi, Kenya, August 2009
- Schmidt-Thomé, Philipp (2009): lecture 05.10.2009 TTK Sustainable Global Technologies programme: Environmental risks and adaptation to the climate change? (Impacts of climate change on human settlements, natural hazards and development, vulnerability mapping)
- Schmidt-Thomé, Philipp (2009): invited speaker in panel: Open days 2009 European week of regions and cities : 08B03 Territorial Cohesion, Integrated Coastal Zone Management, islands and maritime policy European Commission, DG ENV 08.10.2009; 09:15 - 11:00, European Commission, Centre Borschette
- Schmidt-Thomé, Philipp (2009): CCOP annual meeting thematic session on environmental geosciences, Vung tau, Vietnam, October 2009.
- Schmidt-Thomé, Philipp (2009): invited panel speaker: "Structural and Cohesion Funds", November 17th, 2009 in the European Parliament in Brussels.
- Schmidt-Thomé, Philipp (2009): Lectures on natural hazards, climate change and planning at the University of Helsinki (02-30.11.09)
- Schmidt-Thomé, Philipp (2009): lecture 19.11.2009 TTK: Sustainable Urbanization, : Urban risks and climate change
- Schmidt-Thomé, Philipp (2009): A workshop and lectures on the climate change adaptation in Putrajaya, Malaysia, December 2009
- Schmidt-Thomé, Philipp (2010): Lectures on climate change adaptation for planning at the University of Luxembourg (March 2010)
- Schmidt-Thomé, Philipp (2010): Lectures on natural hazards and climate change adaptation for regional development (Alicante, Spain (April 2010)
- Schmidt-Thomé, Philipp (2010): Workshop in conjunction with the annual GEM meeting to be held in SE Asia (October 2010)

PIK

- KROPP JP (2009): The 2+1 challenges of Climate Change: is it possible to reconcile climate protection, adaptation, and development? Keynote lecture, International Conference on Sustainability Science 2009, 5.2.2009, University of Tokyo, Japan
- KROPP JP (2009): Estado das artes: Experiências práticas e pesquisa sobre vulnerabilidade e adaptação aos impactos da mudança climática em nível mundial. Diálogo de Expertos Adaptação às Mudanças Climáticas e Combate à Desertificação no Semiárido, 13.03. de 2009 – Recife; Cooperação República do Brasil e República Federal da Alemanha.
- Kropp JP (2009): Climate Impacts - Global and Regional Adaptation support Platform. Environmental Ministry Brazil, Brasilia, 12.3.2009
- Kropp JP (2009): Mainstreaming Adaptation: how and why. High Level Meeting with Ministries and associates of the Royaume du Maroc, Rabat, 12.7.2009
- Kropp JP (2009): Climate impact and other environmental stressors in cities. International Summer School: Megacities: "Health, Geomatics and Climate Change", University of Bielefeld, September 07-11, 2009
- Kropp JP (2009, Sept.): Building Adaptive Capacity of Local and Regional Authorities INTERNATIONAL SUMMER SCHOOL Humboldt University and University of Copenhagen on European Studies in the Baltic Sea Region Studies, Berlin
- Kropp JP (2009, Oct.): Regional responses to climate change. Open Days 2009, European Commission, Brussels
- Kropp JP (2009, Nov.): How reconcile adaptation, mitigation and sustainable development on the regional scale. Conference on Climate Change and its Impact, Prague, Greenpeace
- Kropp JP (2009, Oct. 7): How to assess regional impacts of climate change and the challenge to assess their effects. Cambia Climatico Un destino para el Desarrollo Regional, Concepcion, Chile
- Kropp JP (2009): The need for a new era of information sharing (side event on the COP 15 together with the Deutsche Gesellschaft für Technische Zusammenarbeit). United Nations Climate Change Conference, Copenhagen COP15
- Kropp JP (2009): Ci: grasp and the potentials to leave the information trap. International Conference on Climate Change and Developing Countries, Kerala, India, 19.-22.2.2010
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NIBR

- NIBR have had two meetings with representatives from the City of Bergen this spring. One meeting with the Department of Climate, Environmental Affairs and Urban Development in the City of Bergen, March 12th, and one meeting June 17th where people from the Water Department, and the Bjerknes Centre for Climate Research attended in addition to Department of Climate, Environmental Affairs and Urban Development. In these meetings we discussed problems and solution to climate change in Bergen city region, and availability of data related both to BaltCICA and to ESPON Climate.
- NIBR has also had a meeting with The Ministry of Local Government and Regional Development discussing ESPON projects, including ESPON Climate.
- In November NIBR plans to arrange a seminar at Oslo Centre for Interdisciplinary Environmental and Social research (CIENS), in which NIBR is a member. The seminar will discuss climate change, impacts and adaptation strategies. Both BaltCICA and ESPON Climate will be presented there, and scientists, bureaucrats and politicians will be invited to this seminar.

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