ESPON Climate

Climate Change and Territorial Effects on Regions and Local Economies

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Executive Summary

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This report presents the final results of an Applied Research Project 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.

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Problem setting

Territorial development is generally considered as very important for dealing with climate change. For instance, territorial development is regarded to be responsible for and capable of reducing regional vulnerability to climate change and developing climate mitigation and adaptation capacities against the impacts of climate change. The EU White Paper „Adapting to climate change: Towards a European framework for action" explicitly relates to spatial planning and territorial development, respectively. In the EU Territorial Agenda it is stipulated under Priority 5 that further work is required to develop and intensify territorial cohesion policy, particularly with respect to the consequences of territorially differentiated adaptation strategies.

However, territorially differentiated adaptation strategies call for an evidence basis. This is what the ESPON Climate project is mainly about; a pan-European vulnerability assessment as a basis for identifying regional typologies of climate change exposure, sensitivity, impact and vulnerability. On this basis, tailor-made adaptation options can be derived which are able to cope with regionally specific patterns of climate change. In the ESPON Climate project this regional specificity is addressed by seven case studies from the transnational to the very local level.

The territorial perspective on climate change is somehow unique, because most of the existing vulnerability studies have a clear sectoral focus, addressing very specific potential impacts of climate change on single elements of a particular sector. The leading existing studies have so far not employed such a comprehensive methodological approach. Furthermore, most studies lack a clear territorial pan-European focus. Specialised research is sensible and necessary but the findings of specialised studies are not easily transferable between sectors or between regions. 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, what are the consequences of climate change on the competiveness of Europe as a whole or the territorial cohesion of European regions.

Therefore, the ESPON Climate project developed a new comprehensive vulnerability assessment methodology and applied it to all regions across Europe in order to create the evidence base needed for a climate change responsive European territorial development policy. However, any vulnerability assessment is confronted with uncertainty which is based in the models (the project made use of CCLM[1]), the emission scenario (A1B[2]) and of course, the future trends in socio-economic development. Thus, the results of ESPON Climate may be seen as a possible vulnerability scenario which shows what Europe's future in the wake of climate change may look like and not as a clear-cut forecast. Nonetheless, it gives some hints what adaptation should be about in view of the identified regional typologies of climate change.

[1] 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).

[2] The IPCC developed six scenarios on the development of greenhouse gas emissions (GHG) from 2000 to 2100 (SRES scenarios). A1B is used for almost all vulnerability assessments as a moderate scenario.

Methodology

The ESPON Climate project's conceptual framework is widely used in the climate change and impact research community. According to this framework rising anthropogenic greenhouse gas emissions contribute to global warming and thus to climate change, which run in parallel to natural climate variability. The potential impacts of these changes differ greatly between regions. Not only are some regions more exposed than others, but the specific configuration of the climatic changes also vary significantly. In addition, each region already has distinct environmental, social and economic characteristics and is therefore more or less sensitive to climatic changes. Together *exposure* and *sensitivity* determine the possible *impact* that climate change may have on a region. The potential of a region or country to deal with these impacts is described by its *adaptive capacity*. The combination of all factors above determines the *climate change vulnerability*.

The change indicators relate the reference time frame (1961-1990) to the climate conditions within the projected periods, as calculated by the CCLM model (e.g. 2071-2100) and the A1B scenario. The absolute or relative difference between these two periods constitutes the projected change for each climate parameter. Certainly, with more financial resources and time it would have been more scientifically exact to use more climate models, more emission scenarios and more climate variables.

Climate change typologies

The typology of climate change regions in Europe shows that a strong increase in annual mean temperature is observable for three clusters, namely 'Northern Europe', 'Southern central Europe and 'Mediterranean region'. Strong decreases in number of frost days predominantly characterise the clusters of 'Northern central Europe, 'Northern Europe' and 'Southern central Europe' whereas strong increases in annual mean number of summer days is projected for the clusters of 'Southern central Europe' and 'Mediterranean region'. Change in precipitation in winter months in the 'Northern Europe' cluster shows particularly strong increases while for summer months most significant changes in terms of strong decrease can be observed in 'Southern central Europe' and 'Mediterranean region' clusters. The variables heavy rainfall and evaporation do not show very strong changes for any of the clusters while days with snow cover are projected to decrease strongly in the 'Northern central Europe' cluster.

Europe's regions and their different sensitivities to climatic changes

According to the IPCC, sensitivity is defined as "the degree to which a system is affected, either adversely or beneficially, by climate-related stimuli. The effect may be direct (e.g., a change in crop yield in response to a change in the mean, range, or variability of temperature) or indirect (e.g., damages caused by an increase in the frequency of coastal flooding due to sea-level rise)." ESPON Climate defined five dimensions of sensitivity:

Physical sensitivity relates to all human artefacts that are important for territorial development and which are potentially affected by climate change. The assessment shows that in Europe the physical assets that are sensitive to these extreme weather events are mainly concentrated along the coastline.

Social sensitivity relates to human populations that may be adversely or positively affected by climate change. According to the assessment, these populations are mainly concentrated in Southern European agglomerations and along the coastline. In fact, the most sensitive regions are coastal agglomerations in the Mediterranean.

Economic sensitivity is related to economic activities or sectors that are especially sensitive to climatic changes. The results of the assessment highlight particularly those local economies which are dependent on tourism, agriculture and forestry: the Mediterranean region, the Alps, large parts of Eastern Europe, but also Scandinavia (energy demand for heating!).

Environmental sensitivity focuses on natural entities that are highly sensitive (like protected natural areas or especially fire prone forests) and relatively stable entities like soils, that have only limited capacities to adapt and at the same constitute the basis for animal and plant ecosystems. The results indicate that especially mountain and river delta regions have protected natural areas and/or possess sensitive soils and forests.

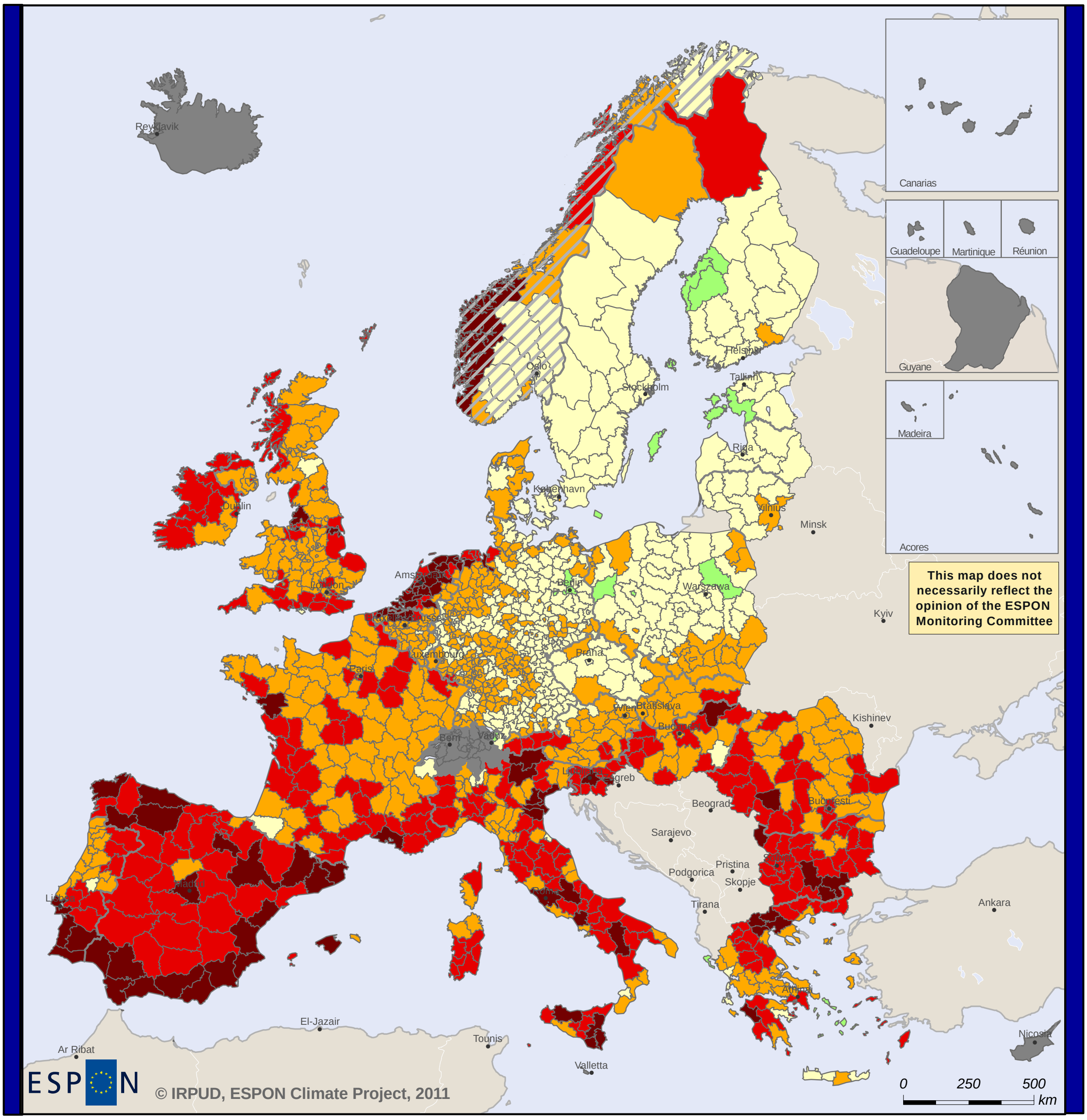
Cultural sensitivity encompasses cultural assets like museums and internationally recognised historic sites that may potentially be damaged or destroyed due to climate change. The assessment shows concentrations of sensitive cultural assets in regions along the coasts and along major rivers. Coastal cities like Barcelona, Rome or Venice with their outstanding cultural heritage can easily be distinguished.

The impacts of climate change on Europe's regions

Map 1 shows the overall spatial distribution of climate change impacts in Europe. Accordingly the *aggregate potential impacts* vary considerably: Hot spots are mostly in the South of Europe – i.e. the big agglomeration areas and summer tourist resorts at the coasts. However, other specific types of regions (mountains) are particularly impacted, but partly for other reasons (e.g. economic dependency on summer and/or winter tourism). There seems to be medium negative impacts in some areas in northern Scandinavia. This results mainly from the sensitivity of the environment and flood prone infrastructure. All in all, two of the five climate change regions that the project identified in a cluster analysis of climate change variables are clearly discernible in this map: North-western Europe and the Mediterranean region.

The *potential physical impact* of climate change is remarkably high in north-western European coastal regions, which border the Atlantic Ocean. This pattern results from sea level rise and a projected increase in river floods. Other small hot spots in Northern Italy (Po river valley, Venice) are caused by similar factors. However, large parts of Europe may not expect relevant impacts on their infrastructure resulting from climate change.

The *potential social impact* map shows that the population of Southern Europe's agglomeration areas have a high impact. A similar impact, but for different reasons, is projected for large parts of North-West Europe and northern Scandinavia. Here the causing factors are the projected



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Origin of data: see data sources of the individual impact dimensions

Aggregate potential impact of climate change

- highest negative impact (0.5 - 1.0)
- medium negative impact (0.3 - <0.5)
- low negative impact (0.1 - <0.3)
- no/marginal impact (>-0.1 - <0.1)
- low positive impact (-0.1 - >-0.27)
- no data*
- reduced data*

Weighted combination of physical (weight 0.19), environmental (0.31), social (0.16), economic (0.24) and cultural (0.1) potential impacts of climate change. Weights are based on a Delphi survey of the ESPON Monitoring Committee.

Impact calculated as combination of regional exposure to climatic changes and recent data on regional sensitivity. Climatic changes derived from comparison of 1961-1990 and 2071-2100 climate projections from the CCLM model for the IPCC SRES A1B scenario.

*For details on reduced or no data availability see Annex 9.

Map 1: Aggregate potential impact of climate change on Europe’s regions increase in river flooding and the consequences of sea level rise. In contrast, the population of large parts of the core of Europe is potentially not or only marginally affected by climate change.

The *potential economic impact* follows a south-north gradient: many economically important countries like Germany and the U.K. may expect only a low to marginal economic impact. The main reason for the gradient is the economic dependency of large parts of Southern Europe on (summer) tourism. However, the Alps as a premier tourist depended region are also identified as hotspot which mainly results from the projected decrease in snow cover. The economic impact in South Eastern Europe is a consequence of the impact on agriculture – which is still important there.

The *potential environmental impact* map shows the highest environmental impacts in the south and north of Europe – in particular in mountainous regions. Important factors are the high slopes and specific soil characteristics that facilitate soil erosion there. In the Mediterranean the drier and hotter climate also increase the likelihood of forest fire occurrence. Soils in river deltas or along coasts seem to also be negatively impacted by climate change. The severe impacts in northern Scandinavia are in part also due to their very large protected areas where any climatic change is considered as negatively affecting the specific ecosystems under protection.

The *potential cultural impact* is obviously an issue for a minority of European regions while most regions may expect no or just a marginal impact. This result mainly comes from the change of frequency and magnitude of extreme events, to which cultural heritage sites and museums are sensitive. Thus, the hotspots in Italy are a consequence of the projected increase of flood hazard on the one hand and the density of cultural heritage sites in this country. Other remarkably impacted regions in the north of Europe are those which encompass some cultural sites and museums, and are most affected by an extreme increase in flooding.

Adaptive and mitigative capacities

In general terms, the Nordic countries have higher capacity to adapt to climate change than most of the Southern European countries. Also, in comparison, Eastern European countries, on the whole, have lower adaptive capacity than Western or Northern European countries. Overall, most countries around the Mediterranean appear to have lower adaptive capacity than the countries around the Baltic Sea region. Given these differences in adaptive capacity and the regional differences in climate change impacts it is difficult to give pan-European recommend-dations regarding adaptation policies. The project did, however, relate the results of its vulnerability assessment to different typologies of European regions and then identified recommendations for these types of regions, namely for metropolitan and urban regions, rural regions, mountain regions, coastal regions, sparsely populated regions, islands and border regions.

Furthermore, possible regional contributions to climate change mitigation were analysed. Regions that have low emissions and high mitigative capacity are mostly located in Northern parts of Europe, and parts of France and the Iberian Peninsula. Regions that have high emissions and high mitigative capacity can be found in Western Europe as well as in parts of Scandinavia. Regions that have low emissions and low mitigative capacity can mostly be found in Eastern Europe as well as in Scotland and Portugal. Regions that have high emissions and low mitigative capacity are of course the most crucial in terms of reduction of greenhouse gas emissions. These regions can be found in Eastern Europe, and in the UK Isles and Ireland. Also, some regions in Southern Italy fall into this category. There are regions which have high or low potentials in both adaptive and mitigative capacity, but there are also regions where either mitigative or adaptive capacity is lower than the other. The differences between the types of regions have also implications for policy in terms of mitigation and adaptation. Building of mitigative and adaptive capacity is equally important, and can be complementary.

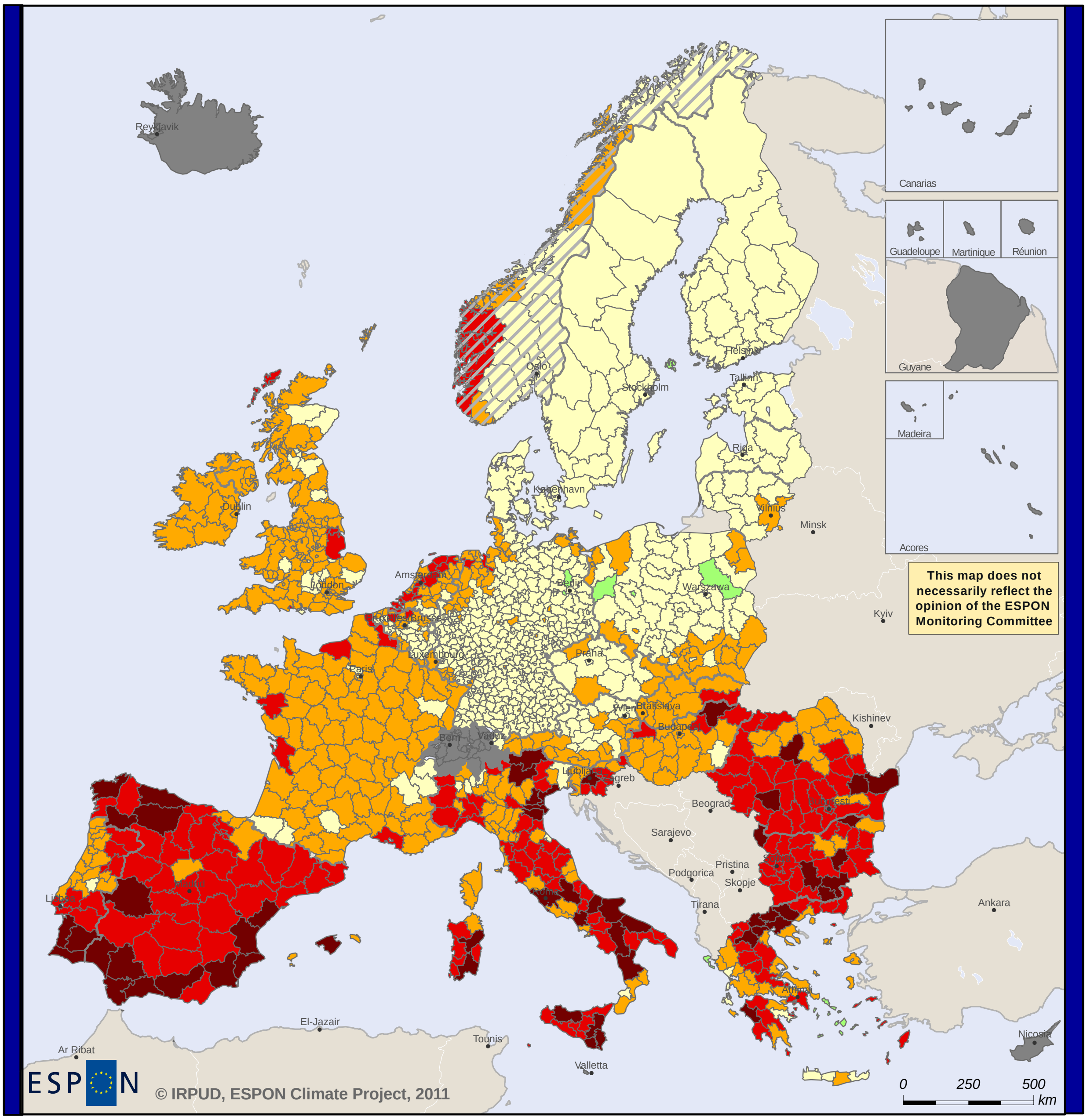
A regional typology of climate change vulnerability

The regional impacts of climate change and a region's capacity to adapt to climate change can be combined to determine a region's vulnerability to climate change. Due to the uncertainty of climate projections and all subsequent analyses one may only speak of 'potential vulnerability'. The potential vulnerability of Europe's regions to climate change is depicted in Map 2. It looks slightly different compared with the map on aggregate impact: The south-north gradient which was already visible on the aggregate impact map is now even more obvious. This is due to the considerable adaptive capacity of Scandinavia and Western European countries which lowers the potential impact projected for these regions. However, this is somehow astonishing: particularly those countries for which a medium to high negative impact is projected seem to be less able to adapt than others for which the severity of the problem is less visible. In consequence, a medium to high vulnerability may be expected in the Mediterranean region, but also in South-East Europe.

This scenario for the future runs counter to territorial cohesion. Climate change would trigger a deepening of the existing socio-economic imbalances between the core of Europe and its Southern and South-eastern periphery. Particularly the East of Europe is also affected by demographic changes (in particular outmigration and ageing; see the following section), which may lead to an additional increase in sensitivity and therefore impact. At the same time these demographic changes would also decrease Eastern Europe's adaptive capacity, since an ageing of population makes the population more sensitive (i.e. to heat) and less capable to adapt.

However, these problematic patterns of vulnerability call for additional efforts in balancing and harmonising differences to ensure a balanced and sustainable territorial development of the EU as whole, strengthening its economic competitiveness and capacity for growth while respecting the need to preserve its natural assets and ensuring social cohesion as stated by the Green Paper on Territorial Cohesion (EC 2008).

Apart from this remarkable result, territorially differentiated adaptation strategies seem to be important primarily for tourist resorts in the Mediterranean region, but also in the Alps, because both types of regions are identified as particularly vulnerable. Such differentiated strategies are discussed by two ESPON Climate case studies. Moreover, agglomerations - mainly in the South - have to be mentioned. They are vulnerable for several reasons, of which urban heat might be the most relevant one from a long-term perspective as this poses not only risk for human health, but also leads to additional energy demand for cooling and as a second order effect possibly to frequent power failures.



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Origin of data: see data sources of the individual impact and adaptive capacity dimensions

Potential vulnerability to climate change

- highest negative impact (0.5 - 1.0)
- medium negative impact (0.3 - <0.5)
- low negative impact (0.1 - <0.3)
- no/marginal impact (>-0.1 - <0.1)
- low positive impact (-0.1 - -0.25)
- no data*
- reduced data*

Vulnerability calculated as the combination of regional potential impacts of climate change and regional capacity to adapt to climate change.

The potential impacts were calculated as a combination of regional exposure to climate change (difference between 1961-1990 and 2071-2100 climate projections of eight climatic variables of the CCLM model for the IPCC SRES A1B scenario as well as resulting inundation depth changes for a 100 year return flood event based on river flooding projections of the LISFLOOD model and coastal storm surge height projections of the DIVA model adjusted with a 1 m sea level rise) and most recent data on the weighted dimensions of physical, economic, social, environmental and cultural sensitivity to climate change. Adaptive capacity was calculated as a weighted combination of most recent data on economic, infrastructural, technological and institutional capacity as well as knowledge and awareness of climate change.

* For details on reduced or no data availability see Annex 9.

Map 2: Vulnerability to climate change of European regions

Case studies

The seven case studies of the ESPON Climate project serve to cross-check and deepen the findings of the pan-European assessment of the other research actions. They provide in-depth regional analyses of climate change vulnerability (exposure, sensitivity, impact, adaptation). The studies cross-check the indicators and findings of the European-wide analysis with the results of the case study areas, but explore also the diversity of response approaches to climate change. Finally, they develop conclusions for the implementation of measures at the European level. The case studies proved the applicability of the generic vulnerability assessment framework. It was shown that this framework is flexible in terms of spatial scales and indicators for exposure, sensitivity and adaptive capacity. The seven case studies are very good examples that the new comprehensive, cross-sectoral ESPON approach meets the demands of spatial planning: all of them were able to identify a new, more complex picture of the patterns of vulnerability and can therefore be seen as a step forward from pure sector-based studies. In conclusion, a more qualitative approach is needed in order to understand the driving forces for institutional settings and related response strategies. All the case studies pointed out that adaptation has to be addressed in a more comprehensive way by spatial planning on the different spatial scales.

However, particularly the more fine-grained case study on North Rhine-Westphalia, The Netherlands, but also the Tisa river case study show a more differentiated picture in terms of impact, adaptive capacity and vulnerability as the results of the pan-European assessment for these areas. This is mainly due to the normalisation of data which clearly underlines the scale-dependency of any vulnerability assessment.

Policy implications

At the level of the EU as whole, compared with other major economic regions in the world, Europe will be less affected by climate change (e.g. IPCC 2007 report). This is particularly the case for the economic core of Europe which also has, as shown in the ESPON Climate project, a high level of mitigative and adaptive capacity. If this capacity is capitalized, it will certainly enhance the competitiveness of the EU in the global market. Another important point is that the diversity of climatic regions in Europe allows for a degree of economic adjustment. For example the economic sensitivity analysis of the ESPON Climate project suggests that while the impact of climate change on summer tourism is negative in the Mediterranean regions, it is positive in the colder regions of the north which will enjoy a more favourable Tourist Comfort Index. For the competitiveness of the EU as a whole, this implies that a potential loss of tourism in one part of Europe may be compensated by a potential gain in another part. Furthermore, climate mitigation and energy efficiency policies are one of the four key priorities of the renewed Lisbon Strategy. This means that through the development of knowledge base and support for research and innovation, EU action on climate change can converge with the Lisbon Strategy. Nevertheless, without effective adaptation measures, such transformations may lead to increased disparities in Europe.

While climate change will affect Europe as a whole, the severity of its impacts varies in different regions and for different economic sectors and social groups. The assumption of the EU White paper on climate Change Adaptation that “more adverse impacts may be expected in some regions with lower economic development” was clearly supported by the ESPON Climate project: particularly large parts of Eastern Europe, but also the Mediterranean region are characterised by a low adaptive capacity. Considering the fact that these regions are from today’s perspective mostly less developed than the centre of Europe, the existing imbalance between the centre and the periphery of the European Union might deepen due to the projected impact of climate change.

The results of the ESPON Climate project shows that the following sectors of the economy are directly affected: the primary sector (agriculture, forestry), tourism (winter and summer) and the energy sector (supply and demand). The severity and nature of impact on these sectors vary in different parts of Europe resulting in negative impacts in some places and positive impacts in others. Also, depending on the share of these sectors in the overall economy of different regions, the expected impacts can be more or less damaging economically (in terms of GVA) and socially (in terms of employment). It is evident from the economic impact analysis that the primary sector in the peripheral regions is particularly vulnerable to climate change. This plus a low level of adaptive capacity may exacerbate regional disparities in Europe and reduce European cohesion. Hence, there needs to be a mainstreaming of climate issues into the rural development policy in the interest of a balanced territorial development of European rural areas. Such mainstreaming is also required under the Renewed Social Agenda[3] which is based on a holistic approach to social policy. On the other hand, some climate change impacts can provide opportunities which, if capitalized, can reduce such disparities in Europe. Overall, there is need for a degree of oversight and responsibility at the EU level to complement the actions at the national level to ensure cohesion.

The ESPON Climate project shows that a significant driver of potential future disparities is the degree of adaptive capacity for tackling climate change. This is highly differentiated across Europe with peripheral regions in the east and south of Europe showing a low level of adaptive capacity. Attention, therefore, should be paid to the different level of efforts and investments needed to mitigate and adapt to climate change in different parts of Europe. Although the 5th Cohesion Report dedicates a chapter on ‘Enhancing environmental sustainability’ which acknowledges that climate change will hit southern and eastern Europe hardest, it says little about how these varied climate change impacts will be reflected in future cohesion policy. In fact, it continues to put the emphasis on economic indicators for providing financial support for the regions. The findings from the ESPON Climate Project provide a robust basis for identifying the expected social and economic impacts of climate change on different regions and their adaptive capacity to cope with these. These should inform the allocation of EU funds so that regions that are expected to be hit severely and have low mitigative and adaptive capacity are provided with targeted financial assistance to enhance their capacities. The evidence provided by this project could be used to develop criteria for ERDF-funded projects. For example, it could be a requirement that EU-funded infrastructures should demonstrate a high level of energy efficiency as well as adaptability to future climate change. In current ERDF programmes climate change impacts are indirectly addressed as they appear as an intervention in the interest of achieving other priority goals. As a rule unfavourable impacts are addressed by the development

[3] Aadopted by the European Commission on 2 July 2008.

of water management and the use of various means of risk prevention. As far as recommendations for concrete projects are concerned, tasks requiring international co-operation have been mentioned most frequently in, for example, the development of models, development of forecast systems, transfer of knowledge, new methods of planning, development of the spatial and regional planning practice, and its preparation for coping with the impact of climate change, forecasting of and coping with the potential impacts of climate change and natural risks, and coping with trans-boundary risks. The emphasis is on the theme of water management. The results of the ESPON Climate project may support planning for the next programme period (2014-2020). Potential future cross border cooperation (INTERREG IVA) could enhance climate change mitigation and adaptation capacities. Especially in climate change adaptation competition or contradicting adaptation in cross border areas can be avoided. Due to the manifold INTERREG IVA areas the project has identified here only those border regions with strong differences in adaptive capacity and would especially recommend future strong cooperation in the border regions of: Germany and Poland, Germany and Czech Republic, Hungary and Austria, Austria and Czech Republic, Austria and Slovakia, Switzerland and Italy, France and Italy. The projects should be used as sources for direct support of further policy development. The overall structure of regional development projects could be enhanced towards delivery of policy recommendations, derived from practical examples of regional cooperation.

Policy options for climate change mitigation and adaptation

Adaptation measures can target four different objectives, building of adaptive capacity, reduction of risk and sensitivity, increase of coping capacity or capitalisation on climate change. For the most part, adaptation measures that reduce risk and increase coping capacity across the five impact dimensions relate to planning, and supporting the emergency services. Measures to build adaptive capacity relate to the production of knowledge that can enable adaptation in the longer term. Finally, policies to capitalise on climate change are important but only few examples exist.

The territorial potentials for mitigation are determined by the underlying mitigative capacity of a society. Firstly, there are regions which have high mitigative capacity and low greenhouse gas emissions. Secondly, there are regions which both high mitigative capacity and also high levels of greenhouse gas emissions. Thirdly, there are regions which have low mitigative capacity and low greenhouse gas emissions and finally there are regions which have high emissions and low mitigative capacity. The two types regions, which are specifically important, are regions, which have high emissions and high adaptive capacity, and regions, which have high emissions and low mitigative capacity. In areas with low mitigative capacity and high emissions, the emphasis can be placed on both increasing mitigative capacity in order to facilitate the development and uptake of cleaner technologies as well as implementation of policies to mitigate emissions.

It is likely that new development opportunities emerge for the European regions in the wake of climate through adaptation and mitigation. As uncertainty is still relatively high in terms of the expected climate change impacts, it is difficult to estimate the kinds of development opportunities that can emerge across different sectors. Adaptation, as means of capitalising on climate change, is yet relatively rare in Europe, as the focus of adaptation policy has centred on risk management and the avoidance of damages as a result of the changing climate. Tourism and agriculture are sectors that are most likely to be impacted by climate change, and adaptation measures within these sectors need to focus on new development opportunities, whilst avoiding maladaptation. Adaptation policy plays an important part in the realisation of opportunities that climate change can bring about. Currently, the main focus in adaptation policy in Europe has been on identification of vulnerabilities and management of risk.

Issues for further research and data collection

The ESPON Climate project was a first attempt of a pan-European cross-sectoral climate change vulnerability assessment. The project succeeded in developing and implementing a comprehensive methodology that integrates data and interrelations across a vast range of relevant fields. Nevertheless, for each indicator a detailed methodology had to be developed that built on existing research findings, established causal relations to other indicators and utilised the most appropriate and up-to-date data. In this course the project developed several advanced methods for assessing climate change impacts for the pan-European study on a very fine-grained scale. The assessment of many indicators was performed on a 100 x 100 metre grid cell basis, e.g. to identify exactly those parts of a region's population which are sensitive to river flooding inundation or which live in urban heat islands and are especially sensitive to heat events in the summer.

Further research is needed in just about every aspect of climate change that the project touched upon. This includes research on second-order, indirect effects of climatic changes. Such further analysis would allow a more complete assessment of e.g. the wider economic impacts of climate change. But besides a deeper understanding of detailed mechanisms of climate change, what is needed are pan-European methodologies and comparative research. There are many studies that have been conducted at the national or regional level, which deserve and need to be upscaled to the European level.

It is also well known that current climate models differ greatly in their projections of future climatic conditions. It would be important, that in the future research projects on climate change vulnerability are resourceful enough to be able to make use of all or the major climate model data – both for comparing their results and implications for a vulnerability assessment like ESPON climate and for combining them to a more robust database upon which to perform sensitivity, impact and vulnerability analyses.

Last, but perhaps most importantly, further research is urgently needed with respect to projecting sensitivity indicators into the future. ESPON's DEMIFER project broke new ground in projecting demographic trends up to the year 2100. But what about other social and economic trends? Of course it is difficult, some may say impossible, to make such long-term projections for issues and variables that are volatile and constantly shaped by human intervention. However, the challenge of climate change and the advances made in modelling future climates puts pressure on other disciplines to also develop sophisticated models or scenarios. Without such research, any climate change impact or vulnerability assessment is fraught with the great weakness that one can only relate dynamic, future-oriented climate data to static sensitivity data.

Our recommendations for future pan-European monitoring are also pointing mainly in this direction. Up to now hardly any data are available for dynamic sensitivity indicators although a sophisticated vulnerability assessment should be based on projections for both exposure and sensitivity referring to the same past and future time periods. In this regard a regular, centrally organised monitoring may hold the potential to enable better projections on dynamic indicators of regional sensitivity and adaptive capacity.

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