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THE CLIMATE CHANGE CHALLENGE FOR EUROPEAN REGIONS[1]

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EXECUTIVE SUMMARY

There is growing evidence that greenhouse gas emissions from human activity are causing climate change. Over the last 100 years, the global average surface temperature has increased by 0.74°C, and sea level has risen by 17 cm during the 20th century. Current trends are projected to continue and accelerate in the coming decades. Europe will also be increasingly confronted with the impact of climate change. Climate change will come about gradually in the form of average temperature increases, with the main impacts of gradual changes being felt in the long term. However, the impact of more frequent extreme weather events will be felt in the short and medium term.

Climate change is one of the main long term drivers of economic, social and environmental change. Its impact is global with very different regional expressions. It influences regional growth potential, regional sustainability as well as the quality of life via changing natural conditions. The impact of climate change is asymmetric across European regions, and depends on the magnitude and rate of climate change, the exposure and sensitivity of ecological and socio-economic systems, and the ability of societies to adapt to these changes.

Sectoral challenges will occur mainly in agriculture, fisheries, forestry, energy and the tourism industry, and significant investment will be required to face drought, heat waves, forest fires, coastal erosion and flooding. In particular, urban life will have to adapt to more extreme weather conditions which is likely to put strain on existing infrastructure in areas such as water supply, drainage, health, energy and public transport.

Regions will have to mitigate greenhouse gas emissions, as well as adapt to unavoidable impacts of climate change. Regional mitigation and adaptation action will have to be consistent with long-term conditions far beyond the time horizon of a programming period, as well as far beyond private profitability concerns. Choices of today, particularly regarding investments in infrastructure, greatly influence the ability of regions to react to the impact of climate change and to the impact of climate change policy, which will make itself felt through increasing carbon prices.

This paper summarizes main findings regarding changes in climate conditions in Europe, outlines some of the impacts of climate change on socio-economic conditions, and identifies the regional distribution of these impacts. Preliminary conclusions are drawn in respect of the impact of climate change on regional growth potential, sustainability and quality of life.

1. INTRODUCTION

There is now unequivocal evidence that climate change is taking place, and it is very likely, that increases in atmospheric greenhouse gas concentrations resulting from human activity are causing global warming.[2] Eleven of the last twelve years rank among the warmest years ever recorded since global surface temperatures are measured, i.e. since 1850.[3] Over the last 100 years, global surface temperature has increased by 0.74°C.[4] Sea level has risen by 17 cm during the 20th century.[5] In the past few years we have witnessed more frequent extreme weather conditions and a decline of the ice coverage in mountains and the Polar Regions. The Intergovernmental Panel on Climate Change (IPCC) has developed climate change projections based on complex models, mainstream consensus appears to have been reached regarding the causes of climate change, and there is decreasing uncertainty regarding the magnitudes of its impact.

Europe will also be increasingly confronted with the impact of climate change. Climate change will come about gradually in terms of average temperature increases, as well as changes in precipitation; the main impact of these changes will be felt in the long term. However, effects of the increasing frequency of extreme weather will be felt already in the shorter term, which will constitute a major short-term challenge.

The European Union has responded to the challenge of climate change by setting ambitious mitigation goals for itself. The EU's objective is to limit global average temperature increase to 2°C compared to pre-industrial levels. The European Council Presidency Conclusions 8/9 March 2007[6] endorsed a decision for the EU to unilaterally reduce GHG emissions by 20% by 2020 compared with 1990, and agreed to increase emission reductions to 30% if other developed countries take on reduction targets with comparable ambition and more advanced developing countries contribute adequately. The Council Presidency Conclusions also point to the fact that medium term emission reductions in developed countries have to be achieved with a view to collectively reducing their emissions by 60-80% by 2050. The EU is also set to increase the share of renewable energies in its energy consumption to 20% by 2020, and has set a separate 10% target for renewable energy in transport. The EU Emissions Trading Scheme,[7] which has been in place since the beginning of 2005, is aimed at reducing GHG emissions from large energy-intensive installations. The scheme is under revision to include a larger number of installations and more gases, at the same time also increasing the level of ambition of the scheme. The legal framework on the geological storage of

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2 IPCC (2007a) p. 10.

3 Based on WMO (2008) and a preliminary report of the WMO (http://www.wmo.int/pages/mediacentre/press_releases/pr_835_en.html)

4 IPCC (2007a) p. 5.

5 IPCC (2007a) p. 7.

6 Council of the European Union, Presidency Conclusions, Brussels European Council, 8-9 March 2007

7 Directive 2003/87/EC of the European Parliament and of the Council of 13 October 2003 establishing a scheme for greenhouse gas emission allowance trading within the Community and amending Council Directive 96/61/EC

carbon dioxide is also underway. European efforts to reduce emissions and energy consumption are being made in several areas, e.g. legislation for reducing carbon-dioxide emissions from passenger vehicles is underway, and the directive on the energy efficiency of buildings is under revision. Several Member States within the EU have also prepared national climate change and adaptation strategies.

Climate change is one of the main long term drivers of change. It is projected to have significant impacts on a global scale, with very different regional expressions. The climate challenge is closely linked to the energy challenge, emissions from fossil fuels account for the largest share of greenhouse gas emissions worldwide. It also interacts with the demography challenge, in particular in terms of potential migration currents within the EU, as well as potential migration from regions from outside the EU. Climate change influences regional growth potential, regional sustainability, as well as regional equity via changing natural conditions. The impact of climate change is asymmetric across European regions. The four large climate zones in Europe will be differently affected, and economic and social systems of the regions within these zones are exposed differently to the risks of climate change.

Regional responses to the climate challenge will have to play a role in mitigation, as well as in adaptation to unavoidable climate change. The agriculture, fisheries and tourism sectors will face significant challenges in certain areas, and significant investment will be required in adaptation activities to face drought, heat waves, forest fires, coastal erosion and flooding. Urban life will have to adapt to more extreme weather conditions which is likely to put a strain on the existing infrastructure in areas like water supply, drainage, health, energy and public transport. Adaptation will attempt to counteract the different impacts of climate change on regional conditions.

This paper summarizes main findings on the impact of climate change on temperature and precipitation, outlines some of their impacts on socio economic conditions as well as identifying vulnerable regions. Conclusions are drawn in respect of the impact on the regional growth potential, sustainability and equity. The analysis on which the findings of the note are based are uncertain to some degree, as they relate to projections of climate conditions in the future. There are also significant uncertainties involved in presenting impacts on a regional level which result from modelling results which are based on more aggregated data.

2. CLIMATE CHANGE IN EUROPE

The effects of climate change can already be observed in Europe, and further changes in climate are projected to take place in the future. During the 20th century, Europe experienced an increase in average annual surface temperature of 0.8°C, with an increased rate of warming over time. The 1990s were the warmest on record.[8] Warming has been stronger in most regions in winter than in summer. An increase in warm extremes has been observed rather than a decrease in cold extremes.[9]

[8] IPCC(2007b) p. 544.

[9] IPCC(2007b) p. 545.

Precipitation trends are more varied for regions across Europe. Trends in the 20th century showed an increase in Northern Europe by 10-40% and decrease in some regions in Southern Europe by up to 20% in average annual precipitation. The intensity of rainfall has increased, even in some areas with decreased average annual precipitation.[10]

The Intergovernmental Panel on Climate Change (IPCC), in its Fourth Assessment Report, developed a number of emission scenarios with a projection period covering the 21st century. The main assumptions are based on different long term trends of green house gas (GHG) emissions resulting from different economic and demographic trends and varying concerns about sustainability. The scenarios span from a free trading environment with rapid innovation and high turn over of capital but with little concerns about environmental sustainability (A1) to a world of increased concern for environmental sustainability (B2).[11] A1 is the scenario with the highest GHG emissions, while B2 is the one with the lowest. Consequently, long term average temperature increases as well as the impact on yearly rainfall is the highest in A1 and the lowest in B2. Modelling results are presented for the period 2070-2099, the baseline period is 1961-1990. Most European research uses scenario A2, which is a moderately free trading world with a regional focus and some sustainability objectives, and contrasts it with B2.

The IPCC projections show that a strong differentiation of the impacts of different scenarios can only be observed in results for the years after 2040. Before that time most of the effects are determined by emissions which already took place. The results confirm by and large the accelerated continuation of present trends until 2040.

2.1. Projected temperature change

Modelling results show that annual mean temperature in Europe is likely to increase more than the global mean temperature. Until the end of this century the average annual temperature in Europe is projected to increase by 2.5-5.5°C for the A2 scenario, and 1-4°C for the B2 scenario. Some regions may experience lower or higher temperature increases than average. For the A2 scenario, temperature increase in some regions in Europe may be as low as 2°C or even higher than 7°C in the scenarios. Southern Europe will be most affected, with consistent temperature increases between 3°C and more than 7°C, with warming even greater in the summer. Northern Europe will experience temperature increases by less than 2°C and up to 4°C, depending on the scenario and the region, with mainly winters getting less cold. Temperature extremes will decrease in the winter, but increase in the summer. [12]

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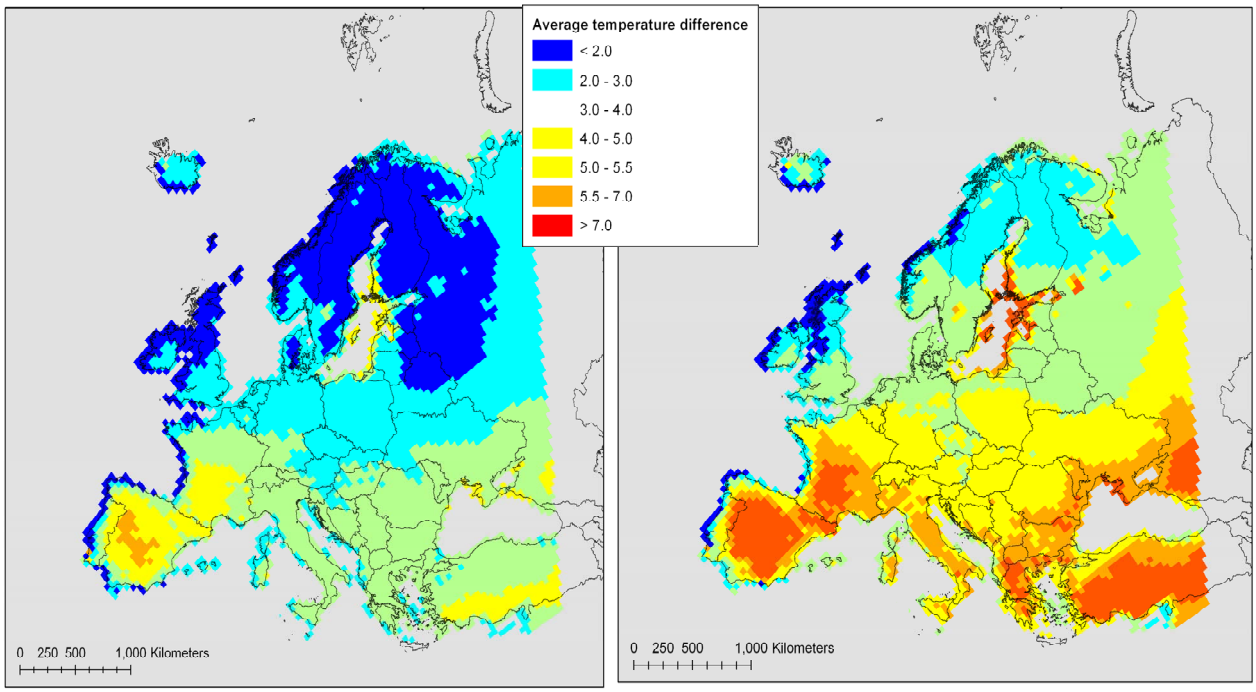
[10] IPCC(2007b) p. 544.

[11] IPCC (1996)

[12] IPCC(2007b) p. 547.

Figure 1: The projected increase of average temperatures in 2071 to 2100 compared with 1961-1990 under significant behavioural change/successful mitigation (B2 scenario) and under largely unchanged behaviour (A2 scenario)



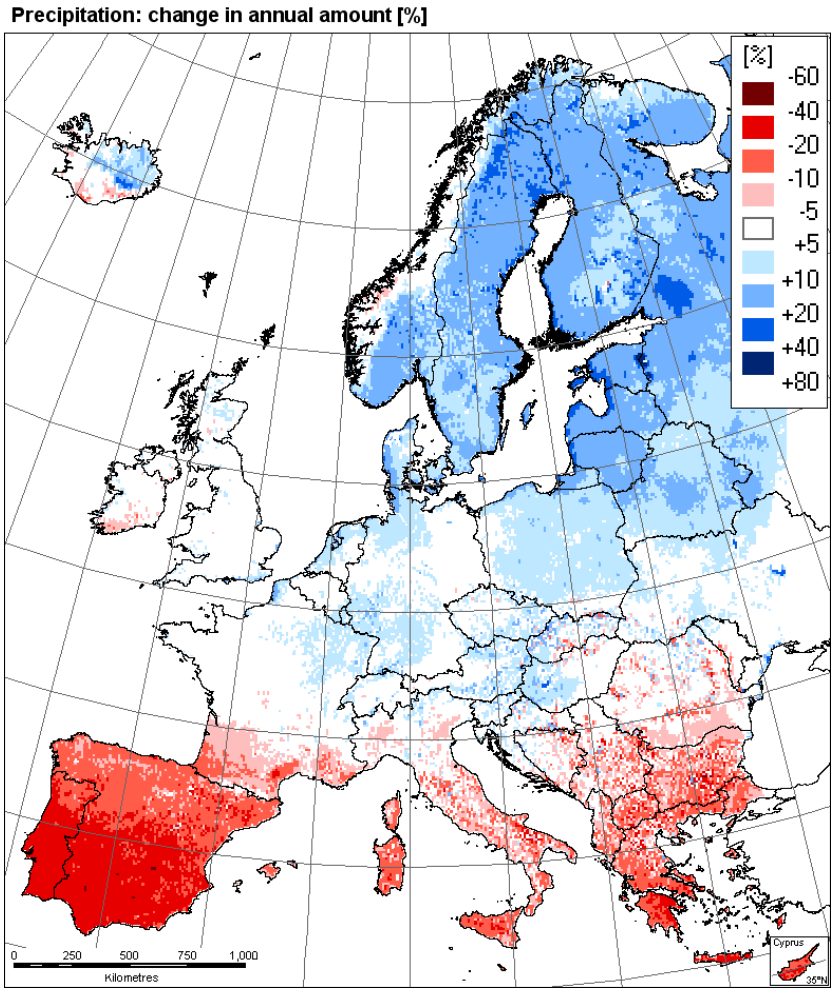
Source: PRUDENCE project

2.2. Projected changes in precipitation and wind

Annual average precipitation will increase in northern and north central Europe, while it will decrease in southern Europe. Annual precipitation patterns will also change. Southern Europe will experience lower rainfalls all year round. There will be less precipitation during summer time in Atlantic and continental Europe, but more winter precipitation. Decreases in annual average precipitation in southern and central Europe can be as high as 30-45%, and as high as 70% in the summer in some regions. [13]As a result of this, and warmer summer temperatures, the risk of summer drought is likely to increase in central Europe and in the Mediterranean area.

[13] IPCC(2007b) p. 547.

Figure 2: The projected changes in average yearly rainfall in 2071 to 2100 compared with 1961-1990 under largely unchanged behaviour (A2 scenario)



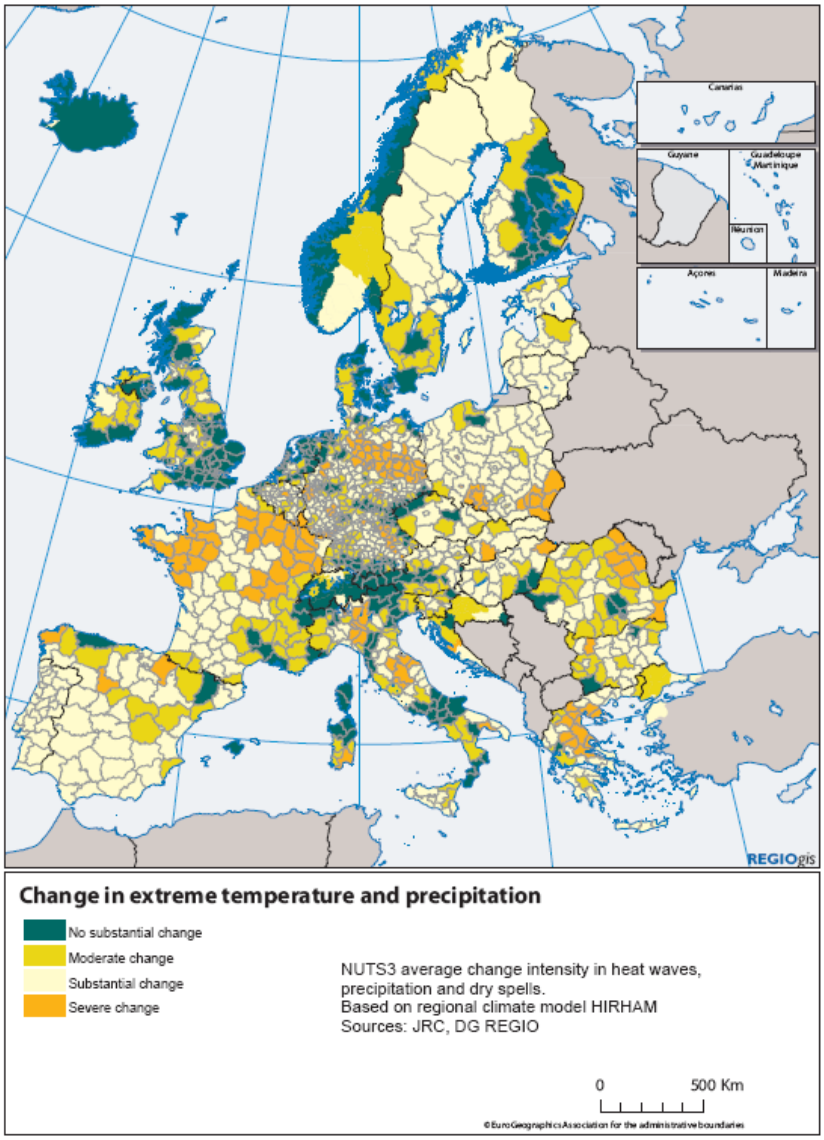
Source: PESETA project

Confidence in future changes in windiness is relatively low, but it seems more likely than not that there will be an increase in average and extreme wind speeds in northern Europe.

In the medium term extreme weather events, i.e. weather phenomena that are at the extremes of the historical distribution, will most likely have a more palpable effect than long-term changes in annual average indicators. Extreme weather events which are expected to increase in likelihood and intensity in Europe as a result of climate change are droughts and heat waves, particularly in southern Europe, storms, extreme precipitation and resulting floods. Even in some areas with a decrease in average temperature, a large increase in the intensity of rainfall events is expected.[14] Extremes of daily precipitation are very likely to increase in northern Europe.

[14] IPCC(2007b) p. 548.

Figure 3: Change in extreme temperature and precipitation by 2080s relative to the period 1961-1990 under the A2 scenario



Source: DG REGIO based on JRC(2008)15

All the changes in averages of temperature and precipitation are gradual over a long time period, affecting the four climatic zones quite differently. Northern Europe will face lower summer rainfall and more storms. The Baltic regions will see higher coastal erosion due to more frequent and stronger winter storms. The average temperature increase in these regions will be relatively modest. Atlantic Europe will face increasing winter rainfall, dryer summers, more winter floods and more risks of coastal erosion. Continental Europe will face higher winter rainfall, more winter floods, and lower summer rainfalls with subsequent higher risks of summer droughts. Temperature increases will be significant. Mediterranean Europe will face more extreme temperature increases, continuous droughts and occasional flash floods.

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[15] The map shows a classification of regions according to the changes in three types of weather extremes: change in the annual 5-day maximum precipitation, relative change in the number of heat waves annually, and change in the duration of the longest annual dry spell.

The main medium term impact will come from a higher frequency of extreme weather events such as very hot summers with risks of water shortages, heavy rainfalls with subsequent flooding, heavy storms with damages and risks for floods and coastal erosion. These events will challenge existing infrastructure and significantly influence regional conditions, more so than the average yearly changes in temperature and rainfall until 2020.

3. THE SOCIO-ECONOMIC IMPACT OF CLIMATE CHANGE ON EUROPEAN REGIONS

Changes in the climate system ultimately result in changes in social and economic systems. The effects of climate change vary by region within Europe. The results of a number of studies which have examined the effect of climate change on regions are presented here on a sectoral basis. Although a growing literature is available on the long-term impacts of climate change, less information is available on medium term impacts, and even less on the costs of medium term impacts.[16] In many cases forecast results are therefore presented for the distant future. However, extreme weather events resembling those forecasted for the distant future will occur already in the next 15 to 20 years.

Some caution needs to be exercised when interpreting the results of the scenarios presented, because these show results for a situation without adaptation. Adaptation can significantly reduce damage in some cases. For changes which come gradually over a long time period, such as a change in annual average temperature and precipitation, some adaptation action, e.g. changes in agriculture to more drought resistant crops, is likely to happen autonomously. Moreover, the scenarios presented do not take into account potential developments in technology and innovation. Nevertheless, the studies demonstrate the increasing risks of exposure to the long term impacts of climate change.

The ultimate impact of climate change will differ from one region to the other. Regional endowments determine the asymmetric impact of climate change, depending on:

- the exposure of a region to climate change: character, magnitude and rate of climate variation will differ among regions
- the sensitivity of the system impacted by climate change: impacts on socio-economic systems can result directly from climate impacts or indirectly through effects of climate impacts on ecosystems
- the adaptive capacity of systems exposed.

The effect of climate change on European regions will therefore depend on a complex interaction between the climate system, ecosystems and socio-economic systems. Differences in these will result in different effects in the regions.

The impact of climate change on ecosystems is projected to be significant and have strong direct implications for human well-being. Effects such as a significant loss of biodiversity, shifts in the geographic distribution of species, or lowered ecosystem resilience will be felt across Europe. These changes have important implications for

[16] The PESETA project is still ongoing, it aims to estimate costs of impacts for Europe on the medium and long term.

sustainability. They are, however, not explored here, as forecasts for ecosystem changes are uncertain, and unavailable at the European level.

This section discusses the main socio-economic impacts of climate change. The first impact discussed is the risk of coastal erosion. In the long-term this risk will be posed by increasing sea levels. In the next 10 to 15 years however, extreme weather conditions in the form of storms will have a more significant impact, and expose especially Northern and Western European coasts, causing damages in densely populated areas and to infrastructure. The second impact examined is related to gradually changing rain quantities and patterns of yearly rainfall, but mostly to incidents of heavy rainfalls which are projected to increase substantially in intensity over the medium term. This will expose certain regions to flooding risks, which will affect buildings and infrastructure, while in other regions the risk of flooding may even decrease. A third impact is related to human health and changing risks related to mortality. In addition, expected effects of climate change on vulnerable sectors in Europe will also be summarized. It is important to note that the discussions of impacts below do not take account of the adaptive capacities of regions, only of exposure to climate change and sensitivity of systems affected.

3.1. Built environment and densely populated areas

Buildings and infrastructure will be affected by coastal erosion and flooding, and also extreme weather events such as floods, storms and heat.

Gradually rising sea levels will put more population at risk of flooding in coastal regions in the long term. 38.4 % of EU27 population lives within 50 km of the coast.[17] However, the increase in the frequency of extreme weather events will be the main factor causing coastal erosion in the next 10 to 15 years. In the long term increases in wind speeds are projected to occur in the north-east Atlantic, and there are projected to be fewer but more extreme weather events in the Baltic and North Sea regions, there may be increased localized storminess in the Adriatic, Aegean and Black Sea, while wind intensity may decline in the Mediterranean.[18] The rate of sea level rise is projected to increase. Significant effects of sea level rise, such as flooding and salinization of ground water will be experienced in the long term, but coastal retreat rates are already 0.5-1 m/year for the Atlantic coast.[19]

Vulnerability of a coastal area to the effects of climate change depends on altitude above sea level, tidal ranges, density of population, infrastructure and the built environment. 140,000 km^2 of land in Europe is within 1m of sea level.[20] Under sea level rise scenarios of around 50 cm, the number of people flooded annually may reach between 0.1 and 1.3 million, and 2,000 to 17,000 km^2 of land may be permanently lost by 2080. The economic costs of such a scenario are estimated at

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17 DG REGIO calculation based on EUROSTAT disaggregated local 2001 census data.

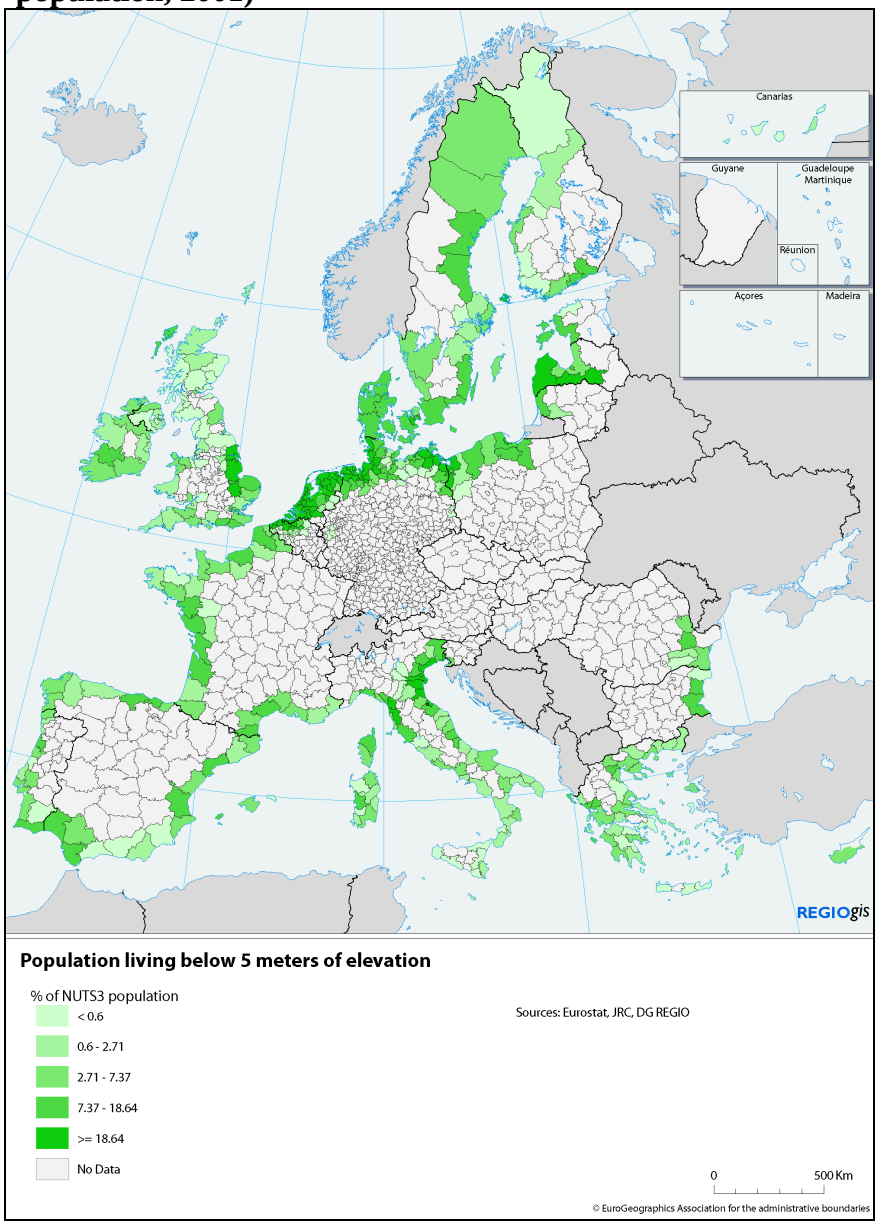
18 IPCC(2007b) p. 545.

19 IPCC(2007b) p. 551.

20 Stern p. 152.

EUR 18 billion.[21] Under a 0.5 m sea level rise scenario, by 2100 in the cities of Amsterdam, Rotterdam, Hamburg, London, Copenhagen, Helsinki, Provence, Athens, Napoli, Lisbon, Porto, Barcelona, Stockholm and Glasgow the population exposed to a 100 year storm event would rise from 2.3 million to 4 million, with exposed assets rising from 230 to 1430 billion EUR.[22] Of these cities the highest damages are expected in London, Amsterdam and Rotterdam.

Figure 4: Population living below 5m elevation in coastal areas (% of regional population, 2001)



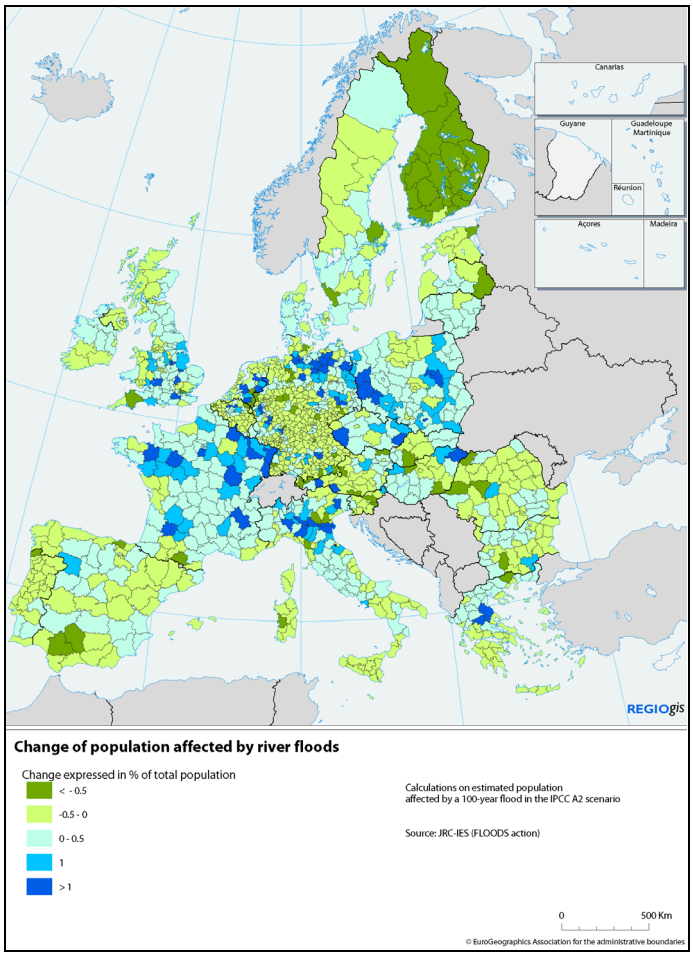
Source: DG REGIO

[21] EEA/JRC/WHO (2008) Ch 7. p. 12.

[22] EEA/JRC/WHO (2008) Ch. 7. p. 14.

The changing patterns of rainfall will increase the risks of **flash flooding** in many areas in Europe. Damage from **river floods** will also increase, with estimates for the Upper Danube showing that damages from a 100 year flood could increase by 19% under the B2 scenario, and 40% under the A2 scenario by 2100.[23] The Mediterranean will also see occasional flash flooding despite lower rainfalls and risks of continuous droughts. However, flooding will decrease in some Mediterranean regions. Some studies show that damage from floods could increase 10-20 times by 2080 under high emissions and high economic growth scenarios in England and Wales.[24]

Figure 5: Change in regional population affected by river floods (% of total population, change between 2001-2100, A2 scenario)



Source: DG REGIO based on data provided by JRC

The economic damage from floods will be largest in absolute terms in areas where the value of the assets affected is high, which is mostly in areas with high income. The damage in relative terms, compared with GDP, can also be high in areas with lower income and lower absolute value of assets affected. Whereas absolute damages are in general larger in old Member States, relative damages show a very varied picture across Europe.

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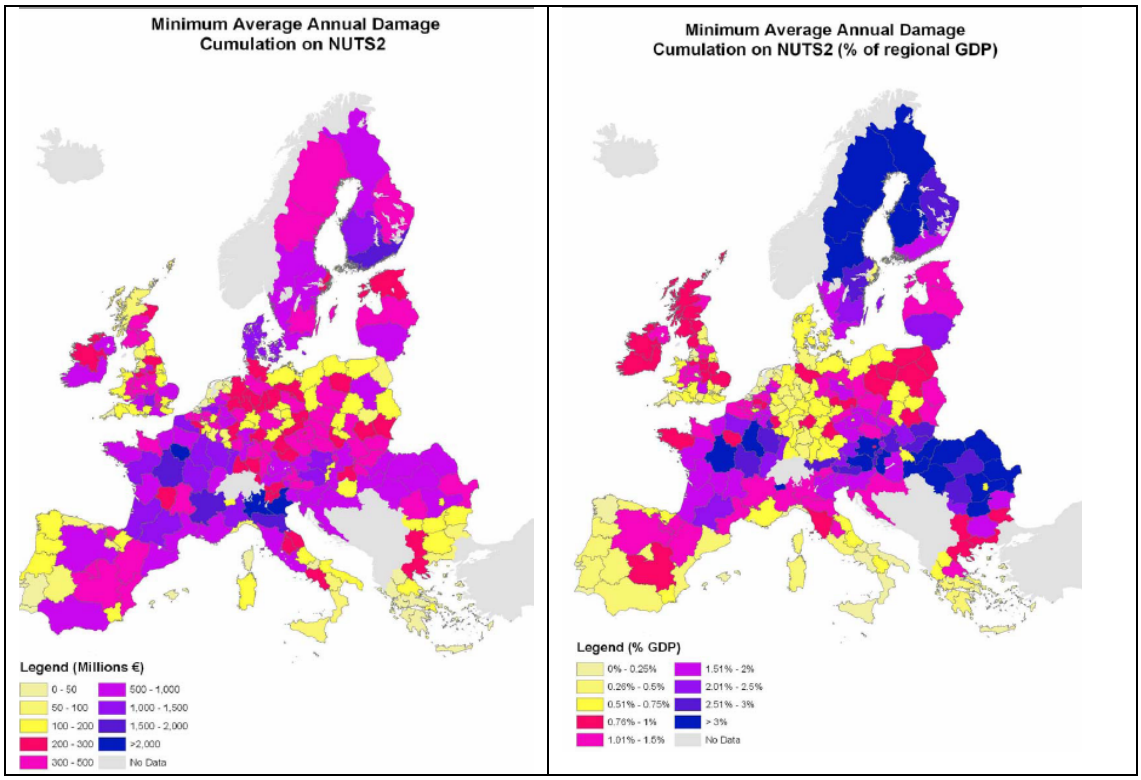
23 OECD (2007a) p. 22.

24 Thorne et al (2007)

Figure 6: Annual average expected damage cumulated across administrative units (NUTS2, lower estimate, but based on assumption of no defence)



Source: JRC

Storms will become more powerful as ocean temperatures increase. A 5-10% increase in the intensity of major storms under a 3°C scenario would double damage costs.[25] In Europe costs of a 100 year storm event could double by 2080 to 40 billion EUR, and average storm losses could increase by 16-68% over the same period.[26] **Heat waves** will cause both direct damage to infrastructure, and increase the risk of fires.

3.2. Human health

Climate change is likely to affect human health as well. There are five main factors which will play an important role and will lead to an asymmetric impact of climate change on health and mortality in European regions. The first factor is the direct effect of weather on human health. The increase in average annual temperature, and in particular the increases in peak summer temperatures will result in an increase in heat-related deaths, mainly in southern Europe. Under a 2°C scenario, the number of heat-related deaths in urban areas could increase 2-3 times.[27] Heat related deaths could reach 50,000 a year under the B2 scenario and 100,000 a year under the A2 scenario in 2100. Cold-related deaths will decrease, mainly in northern Europe. By 2080 under the A2 scenario the net effect of the decrease in cold related deaths and the increase in heat-related deaths is 86,000 more deaths a year. The B2 scenario

[25] Stern p. 132.

[26] Stern p. 133.

[27] Stern p. 133.

would result in an increase of 36,000 deaths. (PESETA) [28] The risk of mortality will also increase with certain extreme weather events, such as storms and floods. The second factor is the availability and quality of drinking water. The additional number of people affected by water stress by 2070 could range from 16 to 44 million.[29] The third factor is the increase in food and vector born diseases in previously relatively unaffected regions. Fourthly, the ageing of the population will continue, increasing the number of people most sensitive to the above mentioned factors. And finally, the density of health infrastructure will determine how efficiently increases and peaks in demand can be dealt with in a given region. Forecast results for the effects of these changes on human health are not available on a regional level, however, the Mediterranean regions appear to be the most affected in terms of human health aspects, and will experience a decrease of the quality of life.

One of the indicators measuring the density of health infrastructure is the number of hospital beds in a given area. Health infrastructure is fairly unevenly distributed among Member States. Mediterranean Europe generally has a lower density of health infrastructure than north-western and central Europe. This coincides with the regions which will likely be most exposed to health risks. Here longer periods of droughts and more restricted drinking water availabilities combined with a lower density of health infrastructure might lead to a situation of an increasing risk of mortality, particularly in urban centres and agglomeration zones.

The ongoing demographic changes in Europe will exacerbate health impacts of climate change. Health infrastructure, particularly hospitals will see a generally increasing demand due to the ageing of the European population. Migration currents, particularly of pensioners, could lead to an over proportional increase in the vulnerable part of the resident population, especially in the Mediterranean regions.

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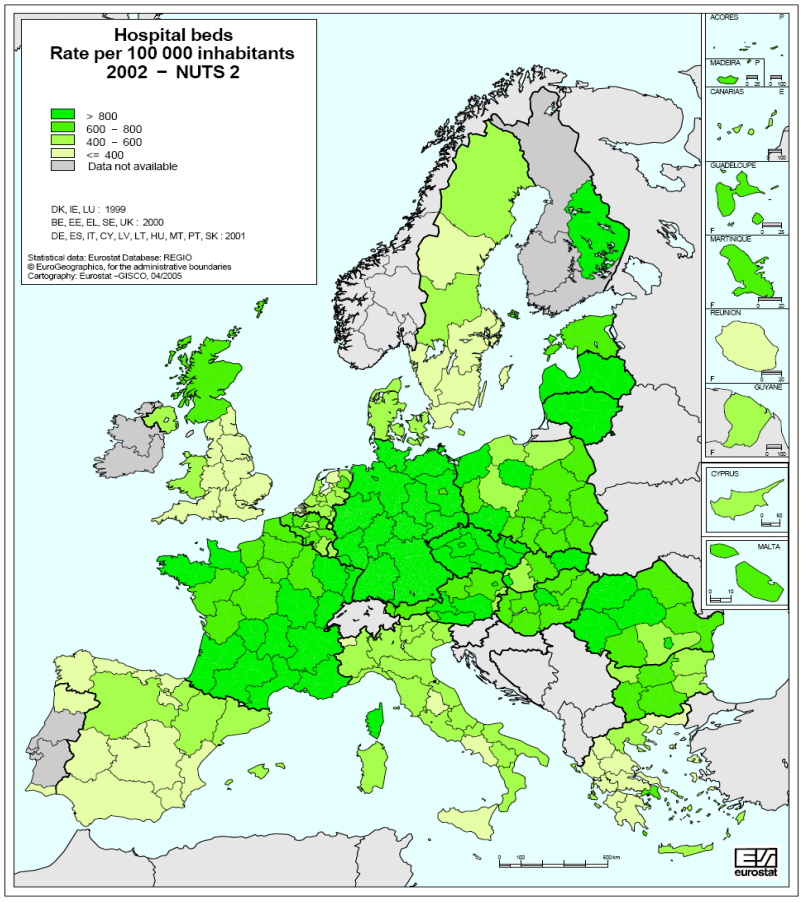
[28] Commission Staff Working Document SEC(2007) 8, p. 20.

[29] IPCC (2007b) p. 550.

Figure 7: Hospital beds per 1000 inhabitants in 2002



Source: EUROSTAT

Other European climate zones will also be affected by more frequent peak summer temperatures. However, health infrastructure appears to be denser and more apt to deal with sudden increases in its use particularly in the western European regions.

Milder temperatures in Atlantic, continental and northern Europe in combination with higher rainfalls could increase the possibility of food and vector born diseases. However, climate change will generally decrease the mortality related to cold weather conditions particularly in northern and central Europe. Here climate change might lead to a situation of short term improvements in quality of life over the next 10 to 15 years. In the longer run however, quality of life will decline.

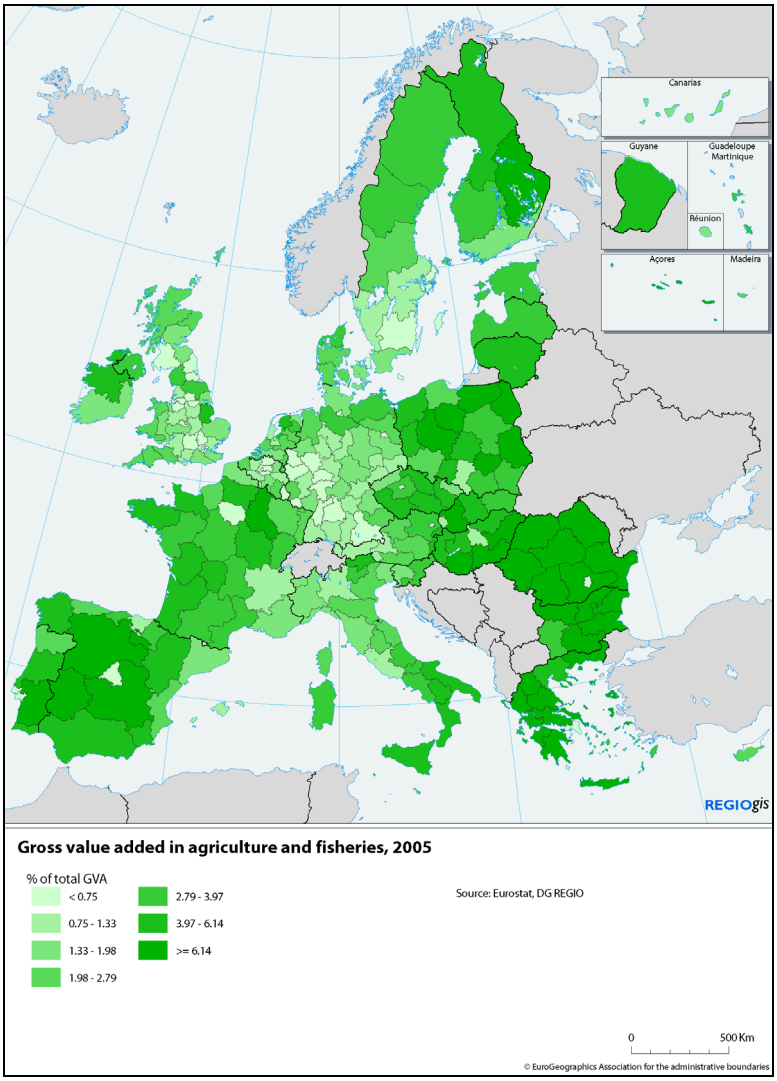
3.3. Vulnerable Sectors

Five sectors are singled out as most vulnerable to climate change, because they depend largely on natural conditions. These are tourism, agriculture, fishery, forestry and energy.

Fishery, relevant to coastal zones, is already experiencing effects of the stress on marine ecosystems resulting from overfishing, and will be further affected by climate change. Sea surface temperature increase in the last decades has already had visible effects on marine ecosystems, with species moving north. Changes in temperature are also likely to increase susceptibility of fish to diseases, reducing populations. Impacts of other changes, and the interactions between these, such as changes in salinity and acidification, as well as losses of coastal ecosystems, are not yet fully understood.

Income from **agriculture** varies across European regions, and is generally high in relative economic terms in Portugal, Spain, Greece, France and the New Member States.

Figure 8: Regional share of agriculture and fisheries in GVA, 2005



Source: DG REGIO calculation based on EUROSTAT

Agriculture depends largely on temperature and rain, particularly in the growing season. Agricultural production is not expected to be negatively influenced in the medium term in Europe as a whole, but the consequences of climate change will be very different in the different regions of Europe, with increasing yields in some regions, and significant yield decreases in other regions. For the next 15 to 20 years conditions for agriculture will develop differently in the four climate zones. The Mediterranean and Balkans will experience the most negative developments of natural conditions for this sector. In Southern Europe, summer water availability may fall by 20-30% under a 2°C scenario, and by 40-50% under a 4°C scenario.[30] The decrease in crop yields could be as high as 30% by 2100 in southern parts of Europe.[31] The exposure to drought risks will increase the vulnerability of agriculture

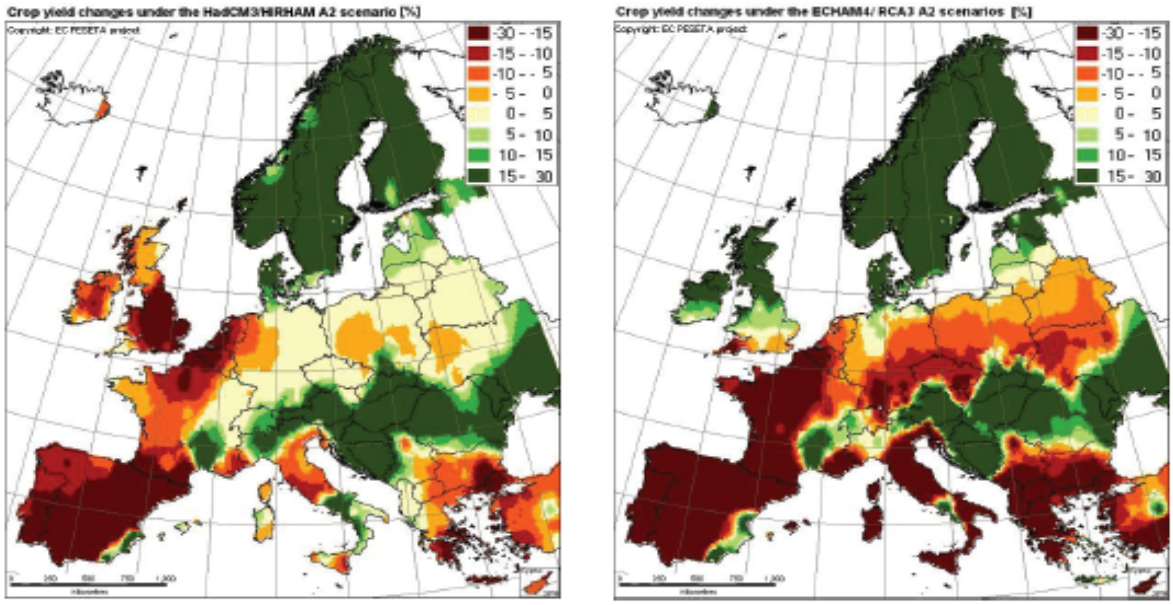
30 Stern p. 123.

31 PESETA http://peseta.jrc.ec.europa.eu/docs/Agriculture.html

already in the short term. The risk of long drought periods will increase and water will become a scarce factor, for which direct human use (urban life, tourism) will be a strong and probably more important competitor. Therefore, lower opportunities to increase and maintain irrigation will come along with higher temperatures, resulting in decreasing agricultural yields. The continental climate zone will see a worsening of the conditions related to more frequent summer droughts and winter flooding. Water basin areas in Europe under severe water stress could increase from the current 19% to 34-36%.[32] In the medium term increases in extreme weather events will probably be of more significance, with higher peak temperatures and droughts increasing variability in crop yields. Heat waves will also affect mortality of livestock.

In the Atlantic climate zone, however, conditions for agriculture will improve over the next 10 to 15 years. Agriculture in Northern European regions might benefit most from developments because cropping could move farther north and vegetation periods will prolong. However, the occurrence of adverse weather conditions will also increase. In the long run it is expected that conditions will start to worsen due to longer dry summers and heavier rain falls during winter.

Figure 9: Simulated crop yield changes by 2080s relative to the period 1961-1990 under the A2 scenario for 2 different climate models: HadCM3/HIRHAM (left) and ECHAM4/RCA3 (right)



Source: PESETA project

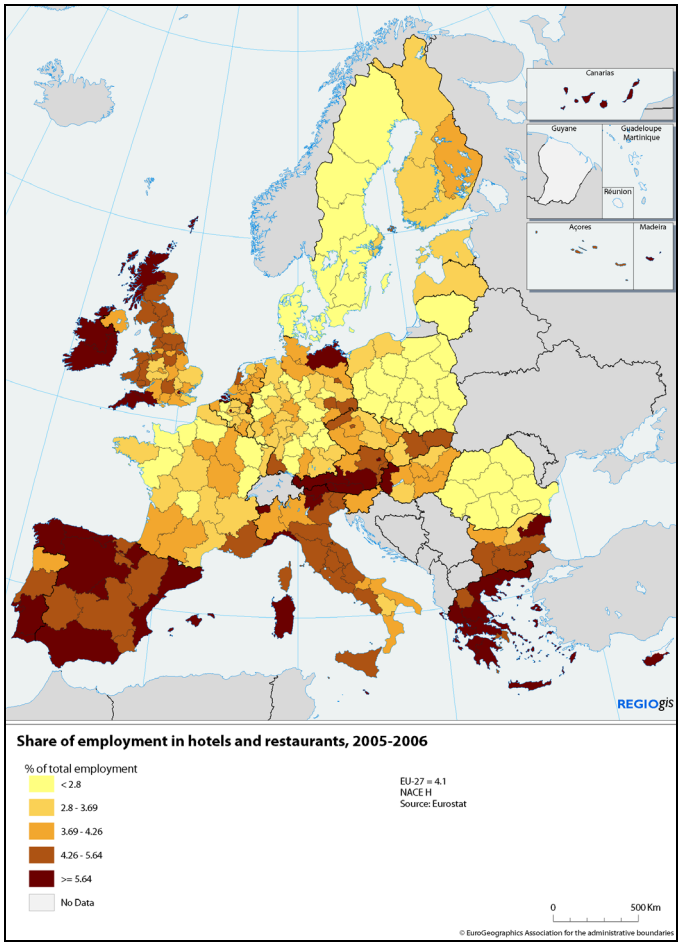
A decrease in agricultural yields will affect the Iberian peninsula, Greece, Bulgaria and France negatively, and depending on the model used for forecasting, also Poland and the Czech Republic will be negatively affected, where relative income from agriculture is high.

Similarly to agriculture, **tourism** depends on natural conditions. Current weather and climate conditions favour the Mediterranean regions in the summer, and the

[32] IPCC(2007b) p. 550.

mountainous regions in winter. However, these regions are likely to suffer a decline in tourism over the medium term, because of worsening weather and climate conditions. The duration of the snow season is very likely to shorten in all of Europe, and the change will be large in mountainous regions, affecting winter tourism negatively. Recent warming in the Alps has been three times the global average.[33] The number of snow reliable areas (with adequate snow cover for at least 100 days per year) under a 2°C increase scenario would be reduced from the current 600 to 400, and to 200 under a 4°C scenario[34] which will result in a decrease in winter tourism in these areas, although there may be an increase in summer tourism. The Mediterranean region will become less attractive due to drought and heat waves, which will raise temperatures above the heat comfort zone, as well as the general scarcity of water.

Figure 10: Regional share of employment in hotels and Restaurants, (% of total employment), 2005-2006



Source: DG REGIO based on EUROSTAT

On the other hand, regions in the Atlantic, northern European regions and some parts of the Continental climate zones' might become more attractive for tourism. Summers there will become dryer with higher temperatures.

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33 OECD (2007b) p. 1.

34 EEA/JRC/WHO (2008) Ch 7 p. 26.

Forestry will also be impacted. A change in the resilience of tree species in many regions will result from the change in climate conditions, and the number of pests will also increase. However, the north of Europe may benefit significantly through an increase in growth rates, as well as a northward expansion of forests. A study for Finland has shown that increase in growth rates may be as high as 44% under the A2 scenario.[35] Forest growth rates will decline in the south, and there will be an increased risk of forest fires.

Climate change will also affect the **energy** sector. One of the main impacts will be due to increasing demand for summer cooling and decreasing demand for winter heating, the first effect will give rise to costs mostly in southern Europe, the second effect will benefit northern Europe. A change in hydropower production is also expected. The increase in hydropower production potential may exceed 25% in the north, a decrease by the same percentage may occur in the south.[36] An increase in the temperature of cooling water of power plants will also result in decreased production levels, especially in the south. The potential production of biomass will be affected differently in different climate zones. Conditions for solar energy production may improve. Climate change is likely to lead to greater fluctuations of energy production, particularly in regions with a high share of renewable energy and varying water availability for cooling. Energy grids therefore need to have the capacity to offset regional fluctuations of supply and demand.

- Climate change is likely to significantly change sectoral conditions. Therefore, certain regions will face increasing pressure for sectoral adaptation and in the worst case restructuring of the regional economy.

4. ADAPTATION TO CHANGING CLIMATE CONDITIONS

Adaptation to changing conditions due to climate change is necessary because some changes in climate can no longer be prevented. If all emissions stopped now, a further 0.5-1°C increase in the global annual mean surface temperature would be experienced in the coming decades.

Adaptation is "an adjustment in the natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities associated with climate change."[37] The objective of adaptation is to reduce vulnerability to climate change and variability, thus decreasing the economic and social costs of climate change. Adaptation action can take the form of policies, practices and projects.[38]

Since the objective of adaptation is to reduce the vulnerability of economic and social systems to climate change, vulnerability needs to be defined. Vulnerability, according to

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35 Carter (2007) p. 57.

36 EEA/JRC/WHO (2008) Ch 7 p. 23.

37 IPCC (2007b) p. 27.

38 EEA (2007). p. 12

the IPCC, is "the degree to which a system is susceptible to, or unable to cope with adverse effects of climate change, including climate variability and extremes."[39] The Stern Review defines vulnerability to climate change as "*exposure* to changes in the climate, *sensitivity* – the degree to which a system is affected by or responsive to climate stimuli, and *adaptive capacity* – the ability to prepare for, respond to and tackle the effects of climate change."[40]

The effects of climate change reach the economic and societal systems through a chain of events. Changes in climate, coupled with other conditions cause changes in the natural or built environment, this in turn affects the provision of services, resulting in economic and social impacts. From the chain of impacts it is evident that the degree to which the economic and social system in a given country or region is affected by climate change depends on climate, environmental, social and economic variables.

The role of adaptation is important, as it can significantly reduce costs. The economic cost of coastal flooding is estimated at EUR 18 billion under a scenario of 50 cm sea level rise, but adaptation may significantly reduce damages, to EUR 1 billion a year.[41] Adaptation measures with low costs also exist in other areas, e.g. a significant proportion of heat-related deaths can be prevented solely by providing information.

Some adaptation is expected to take place autonomously, while other actions will only happen with public support in the form of information dissemination, through incentives to the private sector, or public investment.

Several factors influencing adaptive capacity have been identified. These include:[42]

- *information* on the nature and evolution of the climate hazards faced by a society and information on socio-economic systems, including both past and possible future evolution, is important.

- *resources*, including financial capital, social capital (e.g., strong institutions, transparent decision-making systems, formal and informal networks that promote collective action), human resources (e.g., labour, skills, knowledge and expertise) and natural resources (e.g., land, water, raw materials, biodiversity)

- *the ability of a society to act collectively*, and to resolve conflicts between its members, which is heavily influenced by governance, key actors accepting responsibility for adaptation.

According to another typology, the inability to adapt can stem from “technical, economic, institutional limitations.”[43] All of these factors, information, resources and the

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39 IPCC (2007b) p. 21.

40 Stern p. 93.

41 EEA/JRC/WHO (2008) Ch 7. p. 12.

42 UNDP (2004) p. 168.

43 EEA (2007). p. 27.

ability to act collectively will differ among regions, influencing the vulnerability of regions to climate change.

5. CLIMATE CHANGE MITIGATION

The IPCC Fourth Assessment Report has indicated that global emissions will have to be reduced by 50-85% by 2050 compared to 2000[44] if the global average surface temperature increase is to be kept as low as 2-2,4°C. It is widely accepted by the international community that developing countries will have to take the lead in reducing their emissions, which means that the EU will have to achieve larger emission reductions by 2050 than the global average. Council conclusions have endorsed a 20% reduction by 2020 compared with 1990 levels (which will be increased to a reduction of 30% if a global comprehensive agreement is reached whereby it is ensured that other developed countries take on emission reduction commitments with comparable ambition and economically more advanced developing countries also contribute in accordance with their responsibilities and capabilities), and point towards a 60-80% emission reduction in developed countries by 2050.

The climate and energy challenge will present itself in Europe in the form of rising fossil fuel prices, and increasing carbon prices. Oil and natural gas prices have risen steeply in the past years, far beyond earlier price projections, and then fallen again. Different projections exist for the price of carbon, the most comprehensive European modelling exercise has been conducted for the impact assessment of the climate and energy package proposal of the Commission using the PRIMES model. The price of carbon for industry in the trading sector is projected to be 30 EUR per tonne if a 20% reduction in European emissions is to be achieved by 2020[45]. Electricity prices are forecast to rise by about one fifth due to the energy and climate package, compared to a scenario with no carbon price and no renewable energy target.[46] Carbon prices are forecast to increase steadily in the future, as low cost emission reduction possibilities are exploited, and further reductions in emissions are required.

Increasing carbon and energy prices will pose a challenge to economies heavily dependent on energy. Rising carbon prices and more volatile fossil fuel prices will incentivize the decarbonisation of the economy, which is essential to meet the challenge of climate change. Regional differences in exposure to changing economic conditions will depend on various factors, including the structure of the regional economy, the energy mix, and dominant transport modes. Regions dependent on heavy industry, with a dependence on fossil fuels and distant markets will be most exposed. The ability of

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[44] This is equivalent to an approximately 40-80% reduction compared with 1990 levels, and would require peaking of emissions between 2000-2015. The likelihood of this being achieved is small. A 2,4-2,8°C target can be reached by reducing global emissions by 30-60% by 2050 compared with 2000, and global emissions peaking between 2000-2020.

[45] Commission Staff Working Document. SEC(2008) 85 VOL. II., p. 75.

Because of the nature of the package proposed by the Commission, which takes into account fairness and national circumstances, efforts are not distributed among member states according to the principle of cost-efficiency. Therefore in the non-trading sector, some countries will be faced by higher, and some by lower implicit carbon costs in these sectors. Sectors in the non-trading sector include e.g. agriculture, transport and direct energy use in buildings.

[46] Commission Staff Working Document. SEC(2008) 85 VOL. II., p. 80.

regions to answer the challenge of decarbonising the economy will depend on the capacity of the regional economy to respond to changes in the economic context, which is a function of inter alia the economic structure and extent of changes necessary to the economy, as well as regional income. Cities will play an important role in this context as they are the locations where energy consumption can be reduced most efficiently[47].

6. CONCLUSIONS

Climate change alters climate conditions, including temperature, rainfall and the frequency and magnitude of extreme weather events. Over the next 15 to 20 years the latter will have the most important impact on of European regions. Extreme weather events will give a foretaste of average conditions projected for later this century. Droughts and peak summer temperatures will be an increasingly frequent event in the Mediterranean regions, while winter floods and summer droughts will become more common in continental Europe. Storms and heavy rainfalls as well as mild winters will change biophysical conditions in Western Europe.

Exposure and sensitivity of regions to climate change already displays a significant asymmetry, different regions are differently affected depending on among others on the location in the European climate zones. Regions also differ in adaptive capacity, therefore the impact on regional growth potential, environmental sustainability as well as equity will be asymmetric as well. Typically ecosystem dependent sectors such as agriculture, fishery, forestry, tourism and water-dependent activities such as large scale energy production will be sensitive to overall changes. In this respect the Mediterranean regions will suffer the most from worsening conditions.

The impacts of climate change on European regions are presented in the form of a synthetic index. The climate change index combines information on vulnerability to drought, population affected by river floods and exposed to coastal erosion, exposure to climate change of the agriculture, fisheries and tourism sector.[48] The index shows an asymmetric core periphery pattern for the EU. More than one third of the EU population

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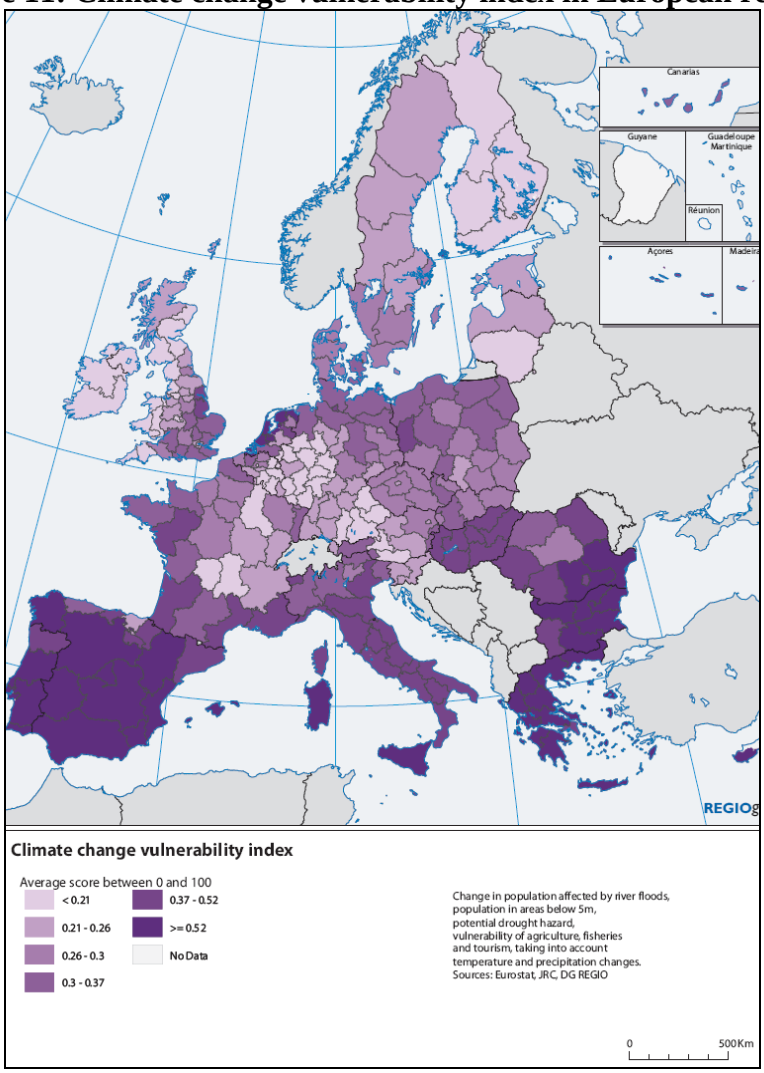
[47] According to recent estimations of the last World Energy Outlook, ,"Much of the world's energy – an estimated 7 908 Mtoe in 2006 – is consumed in cities. Cities today house around half of the world's population but account for two-thirds of global energy use. City residents consume more coal, gas and electricity than the global average, but less oil. Because of relatively larger consumption of fossil fuels, cities emit 76% of the world's energy related CO_2" http://www.worldenergyoutlook.org/index.asp

[48] The index is an average of normalized indicators of vulnerability of areas to drought, change in population affected by 100 year return river floods under the A2 scenario, exposure of the agriculture, fisheries and tourism sector to climate change expressed by proportion of these sectors in regional GVA in regions where these sectors will be negatively affected, and exposure of densely populated areas to coastal erosion expressed in coastal populations living below 5m elevation. The methodology has entailed that all impacts are weighted equally, despite the fact that these impacts will incur different costs. Implicit in the calculation of the index is also that it does not account for positive effects of climate change in some regions, and does not consider how effects of climate change will be dampened by adaptation activities. In addition, indicators for some significant expected impacts have not been included due to a lack of information, e.g. effects of climate change on mountaineous areas, health effects and ecological effects, Due to these shortcomings the index should not be used to compare impacts between regions, rather should be seen as a demonstration of the fact that the impacts of climate change will vary across regions.

lives in the regions most affected by climate change, with a total population of 170 million. Regions under highest pressure are generally located in the south and east of Europe, the whole of whole of Spain, Italy, Greece, Bulgaria, Cyprus, Malta and Hungary, as well as most of Romania and southern parts of France. This is due mostly to changes in precipitation and an increase in temperature which have an impact on vulnerable economic sectors, with river floods also contributing to the overall effect in Hungary and Romania. Limited impacts will be recorded for Northern and Western Europe, apart from lowland costal regions around the North and Baltic Seas with a high exposure to costal erosion through extreme weather events. In some cases severe impacts will be felt in regions with low GDP per capita and therefore lower capacity for adaptation to climate change.

Figure 11: Climate change vulnerability index in European regions



Source: DG REGIO

ANNEX

The analysis of the challenge of climate change on regional disparities follows a logic which is laid down in the impact matrix. The impacted regional variables are interregional disparities in growth potential, environmental sustainability and interregional social disparities. The impacts are shown qualitatively.

Please note that the sign goes from "no clear link" to "+", and "++" as a strong impact. The signs do not give the direction of change, but only the level of influence on the impacted regional variable.

…and their Impacts on / **The drivers of Challenges…**		**Interregional Disparities in Growth Potentials**	**Environmental Sustainability**	**Intraregional Social disparities**
Climate Change	***Vulnerable sectors (tourism, energy, agriculture and fisheries)***	++ Regions with a high concentration of sectors relying on natural resources and ecosystem services will be affected	++ Regions with a high concentration of sectors relying on natural resources and ecosystem services will be affected	+ Regions with high dependency on vulnerable sectors have to face social costs of structural change or adaptation
	costal erosion and flooding	++ Affected areas might see assets and infrastructure destroyed	+++ Ecosystems are negatively affected	+ Population at risk of poverty face additional costs
	Potential drought hazard	++ Water dependent sectors will suffer	++ Ecosystems are negatively affected	+ high water costs weigh more heavily on low income households

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