COUNCIL OF THE EUROPEAN UNION

Brussels, 18 April 2013

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COVER NOTE

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COMMISSION STAFF WORKING DOCUMENT

Impact Assessment - Part 2

Accompanying the document

COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS

An EU Strategy on adaptation to climate change

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An EU Strategy on adaptation to climate change

This report commits only the Commission's services involved in its preparation and does not prejudge the final form of any decision to be taken by the Commission.

1. ANNEXES

1.1. Evidence of climate change and benefits of adaptation action

Global warming: current evidence

The main climatic drivers are temperature rise, changes in precipitation patterns, changes in intensity and frequency of extreme weather events (extreme precipitation, heat waves, cold spells, storms), sea level rise and changing wind patterns (Altvater et al., 2011a).

The average temperature in Europe has continued to increase. Temperature over the land areas in the last decade (2001-2010) was 1.2°C above the 1850-1899 average (1.0°C for the combined land and ocean area). Considering the land area, 8 out of the last 13 years of the period 1850-2010 were the warmest years since 1850 (EEA, 2011). Consistent with previous trends, the rate of warming has been greatest in high latitudes in Northern Europe.

Annual precipitation trends in the 20th century showed an increase in Northern Europe (10–40%) and a decrease in some parts of Southern Europe (up to 20 %) (EEA, 2008; Del Rio et al. 2011). At the continental scale, winter snow cover extent has a high variability and a non-significant negative trend over the period 1967-2007 (Henderson and Leathers, 2010).

High-temperature extremes (hot days, tropical nights, and heat waves) have become more frequent, while low temperature extremes (cold spells, frost days) have become less frequent in Europe (EEA, 2011) based on Climate Research Unit (CRU) gridded datasets HadCrut3 (land and ocean) and CruTemp3 (land only). In Eastern Europe the summer of 2010 was exceptionally hot, with an amplitude and spatial extent that exceeded the previous 2003 heat wave (Barriopedro et al., 2011). These two heat waves broke the seasonal temperature records over approximately half of Europe.

The recently published special report by IPCC on 'Managing the risks of extreme events and disasters to advance climate change adaptation' (IPCC, 2012) examines the interaction of climatic, environmental, and human factors that can lead to negative impacts and disasters, options for managing the risks posed by impacts and disasters, and the important role that non-climatic factors play in determining impacts. The SREX (IPCC, 2012) states evidence from observations gathered since 1950 of changes in some extremes. Confidence in observed changes in extremes depends on the quality and quantity of data and the availability of studies analysing these data. It consequently varies across regions and for different extreme events. The Special Report identifies a likely increase in the frequency of heavy precipitation events or proportion of total rainfall. SREX also identifies, with medium confidence, an increase in the length or number of warm spells or heat waves.

With regard to human fatalities, the most prominent natural hazard so far is heat waves. The 2003 heat wave killed over 70 000 people in 12 western and central European countries (EEA-JRC-WHO, 2008). Heat waves were also responsible for numerous fatalities in the summers of 2006 in Western Europe and the summer of 2007 in Eastern Europe.

Of all types of natural disasters, flooding and storm events result in the greatest economic losses compared with other types of disasters in the EU (25% by flooding and 32% by storms). The most significant flooding events in terms of economic losses were in the UK in the summer of 2007 (4 billion), in Switzerland, Austria and Germany in 2005 (2.8 billion) and in France in December 2003 (1.6 billion).

It is important to note that the existing estimates of loss linked to natural hazards are to be considered low estimates (IPCC 2012) because many impacts, such as loss of human lives,

cultural heritage, and ecosystem services, are difficult to value and monetize, and thus are either omitted or only poorly reflected in loss estimates.

Current pledges and projections

Achieving the EU goal of limiting the rise of global mean temperature to below 2°C above pre-industrial levels, as agreed by Parties to the UNFCCC in Cancun in 2010, may limit the most serious risks of climate change. The European Council reconfirmed in February 2011 the EU objective of reducing greenhouse gas emissions by 80-95% by 2050 compared to 1990, in the context of necessary reductions by developed countries as a group[1], in order to keep climate change below 2ºC.

In December, 2009, countries were encouraged to submit pledges for reducing greenhouse gas emissions for the year 2020 as part of the Copenhagen Accord. Subsequently, 42 industrialized countries and 44 developing countries submitted pledges. At the climate conference in Cancun one year later, parties formally recognised country pledges and decided "to hold the increase in global average temperature below 2°C above pre-industrial levels". Although the country pledges help in reducing emissions to below a business-as-usual level in 2020, they are not adequate to reduce emissions to a level consistent with the 2°C target, and therefore lead to a gap.

Therefore, Europe must prepare to face more significant consequences of climate change. Mitigation on its own will not be enough to address the climate problem. Two important clarifications must be added: i/ even if greenhouse gas emissions were to stop now, the earth's climate will continue to change for decades. Adaptation is therefore inevitable; ii/ the climate scenarios only start to show diverging trends in terms of temperature increase or precipitation levels after 2050. This is to say that for any policy or action with a medium-term horizon (around 20-30 years), the emission path is not key. However, for any policy aiming at affecting investments with a longer-term horizon now, the emission pathways must be factored in.

1.1.1. Climate scenarios

1.1.1.1. Description of current scenarios

A range of different climate scenarios are used in the studies analysed for this report. This section aims to provide an overview of these different climate models.

Figure 1 shows a schematic illustration of Special Report Emission Scenarios (SRES) scenarios produced by the IPCC. Four qualitative storylines yield four sets of scenarios called "families": A1, A2, B1, and B2. Altogether 40 SRES scenarios have been developed by six modelling teams. All are equally valid with no assigned probabilities of occurrence. The set of scenarios consists of six scenario groups drawn from the four families: one group each in A2, B1, B2, and three groups within the A1 family, characterizing alternative developments of energy technologies: A1FI (fossil fuel intensive), A1B (balanced), and A1T (predominantly non-fossil fuel). Within each family and group of scenarios, some share "harmonized" assumptions on global population, gross world product, and final energy.

These are marked as "HS" for harmonized scenarios. "OS" denotes scenarios that explore uncertainties in driving forces beyond those of the harmonized scenarios. The number of scenarios developed within each category is shown. For each of the six scenario groups an illustrative scenario (which is always harmonized) is provided. Four illustrative marker scenarios, one for each scenario family, were used in draft form in the 1998 SRES open

[1] Taking into account necessary efforts from developing countries, this will allow a global reduction of 50% in emissions by 2050.

process and are included in studies summarised in this Report. Two additional illustrative scenarios for the groups A1FI and A1T are also provided and complete a set of six that illustrates all scenario groups. All are considered to equally sound.

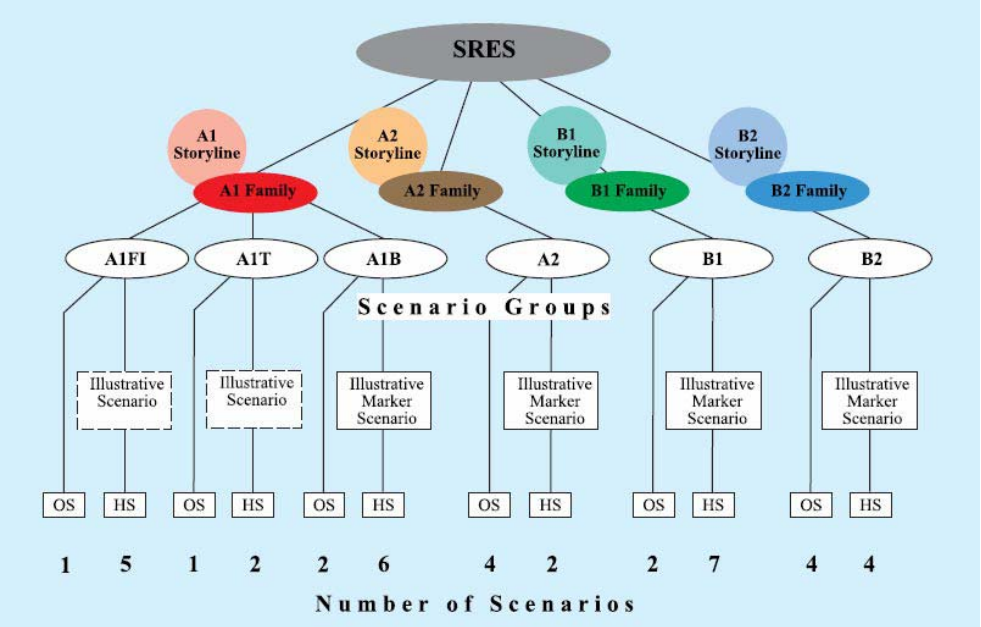


Figure 1: The main characteristics of the four SRES storylines and scenario families Source: IPCC, 2000

The IPCC related work has considered how, by 2100, the world will have changed. Each storyline assumes a distinctly different direction for future developments. Together they describe divergent futures that encompass a significant portion of the underlying uncertainties in the main driving forces. They cover a wide range of key "future" characteristics such as demographic change, economic development, and technological change. For this reason, their plausibility or feasibility should not be considered solely on the basis of an extrapolation of current economic, technological, and social trends.

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 A2 storyline and scenario family describes a very heterogeneous world. The underlying theme is self-reliance and preservation of local identities. Fertility patterns across regions converge very slowly, which results in continuously increasing global population. Economic development is primarily regionally oriented and per capita economic growth and technological changes are more fragmented and slower than in other storylines.

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 toward 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 B2 storyline and scenario family describes a world in which the emphasis is on local solutions to economic, social, and environmental sustainability. It is a world with continuously increasing global population at a rate lower than A2, intermediate levels of economic development, and less rapid and more diverse technological change than in the B1 and A1 storylines. While the scenario is also oriented toward environmental protection and social equity, it focuses on local and regional levels.

1.1.1.2. Bias correction method

The JRC PESETA II project used high resolution climate simulations developed in the framework of the FP6 project ENSEMBLES (van der Linden and Mitchell, 2009) under three emission scenarios, namely the A1B, E1 and RCP8.5.

The E1 scenario was developed within the ENSEMBLES project as an attempt to match the European Union target of keeping global anthropogenic warming below 2°C above pre-industrial levels. The E1 scenario was derived by using an "Integrated Assessment Model" which includes the energy system, land use, carbon cycle and also a simple climate model, following a methodology used earlier to develop low stabilization scenarios from B2 baseline (Van Vuuren et al, 2007).

The Representative Concentration Pathways (RCP's) are new set of scenarios developed for the upcoming IPCC 5th assessment report. The RCP8.5 scenario combines assumptions about high population and relatively slow income growth with modest rates of technological change and energy intensity improvements, leading in the long term to high energy demand and GHG emissions in absence of climate change policies. RCP8.5 thus corresponds to the pathway with the highest greenhouse gas emissions, without any specific climate mitigation target.

Figure 2 depicts the projected emissions for each scenario.

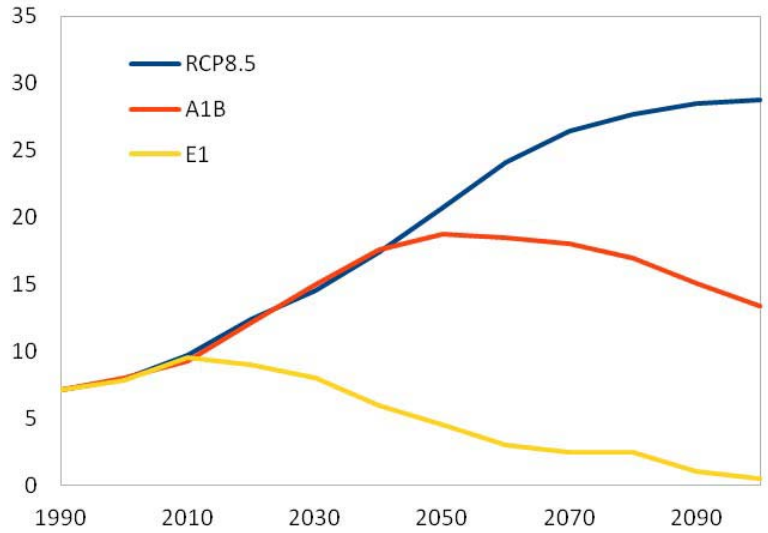


Figure 2: Total CO2 emission per year as projected by different scenarios (Source: JRC PESETA II project, based on IPCC SRES (A1B), ENSEMBLES project (E1) and IIASA (RCP8.5).).

As climate model outputs may present significant errors (biases) when compared to observations, the climate runs originally obtained from the ENSEMBLES project were statistically corrected for biases (Dosio and Paruolo, 2011; Dosio et al. 2012) thus reducing the overestimations and underestimations of temperature and precipitation.

Due to differences in the models' formulation and physical parameterization, the climate change signal projected by different climate models may present significant differences. However, all the model's runs driven by the same A1B emission scenario represent an equally probable projection of the future evolution of the climate. To better represent the climate variability related to the model choice, in PESETA II a combination of different climate models were used.

Figure 3 shows the geographical distribution of the (multi-model) mean summer and winter temperature and precipitation climate change signal (i.e. the difference between the period 2071-2100 and the reference period 1961-1990) undere the A1B scenario. These results are in accordance with those shown for instance in the ENSEMBLES final report (van der Linden and Mitchell, 2009) and show a general warming up by more than 4°C in Northern Europe in winter and in Southern Europe in summer.

Daily precipitation change at the end of the century shows a general positive trend in winter (with the exception of the Iberian Peninsula), where the increase over Northern Europe and Scandinavia ranges between 20 % and 45 %. However, over Middle, Southern, and Eastern Europe, the value (and in some cases also the sign) of the change depends strongly on the model.

In summer, Southern Europe will face a reduction in precipitation up to more than 40%. Over great part of Central and Eastern Europe, however, the value of the change is very small (less than 15%) and comparable to the value of the inter model variability (Dosio et al, 2012).

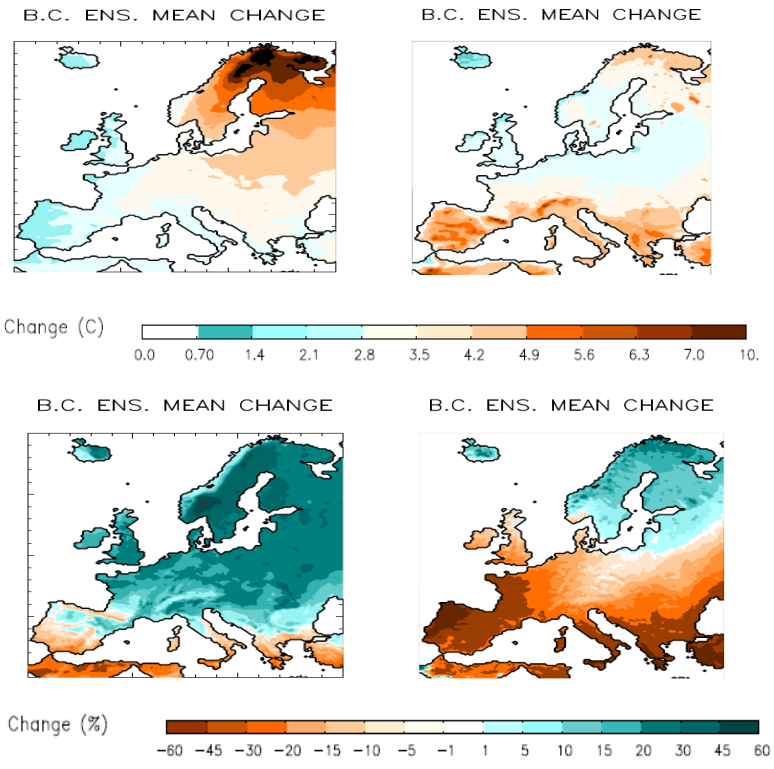


Figure 3: Mean seasonal climate change signal for bias corrected temperature (upper row) and precipitation (lower row) in winter (left column) and summer (right column) under A1B scenario (source JRC PESETA II)

1.1.2. Uncertainties

As pointed out above when summarising the various IPCC scenarios, there is great uncertainty about the trajectory of greenhouse-gas emissions, which is dependent on future socioeconomic development and policy decisions.

Future warming of the earth will affect many aspects of the climate system, for instance leading to increasing sea levels, and changes in weather extremes. Observations show increases in ocean temperature, in atmospheric water content, and in sea level, whereas the ice sheets snow cover in both hemispheres are declining rapidly. Significant changes have also been observed in precipitation amounts, ocean salinity, and wind patterns, whereby the direction and magnitude of change differs across regions (Solomon et al., 2007). Extreme weather events have also changed, including increases in heat waves, droughts, heavy precipitation, and the intensity of tropical cyclones. Economic losses from weather- and climate-related disasters have increased, but with large spatial and interannual variability (SREX, 2012).

Scientific research in the next decades will resolve some of the present uncertainties, as our understanding of complex climate processes and the adaptive capacity of ecosystems improves. However, a significant amount of uncertainty will remain, as embracing more complex processes means adding in 'known unknowns', such as the rate at which ice falls through clouds, or the rate at which different types of land cover and the oceans absorb carbon dioxide. Several international reviews and initiatives on the issue of uncertainty assessment and communication have been carried out over recent years, including by the IPCC. As regards marine observations and monitoring of the sea, the impact assessment for Marine Knowledge[2] already highlighted that reducing uncertainty in sea-level rise by 25% would deliver savings of about €100 million a year in terms of coastal defence work.

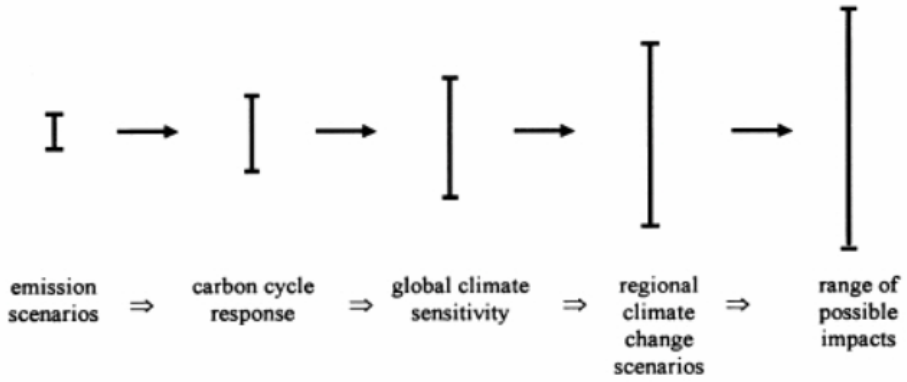


Figure 4: Cascade of uncertainties: Range of major uncertainties typical in impact assessments showing the "uncertainty explosion" as these ranges is multiplied to encompass a comprehensive range of future consequences, including physical, economic so

1.1.3. Climate impacts

Figure 5 below summarises some of the impacts to be associated with climate change.

[2] COM(2010) 461. Impact Assessment on an European Marine Observation and Data Network

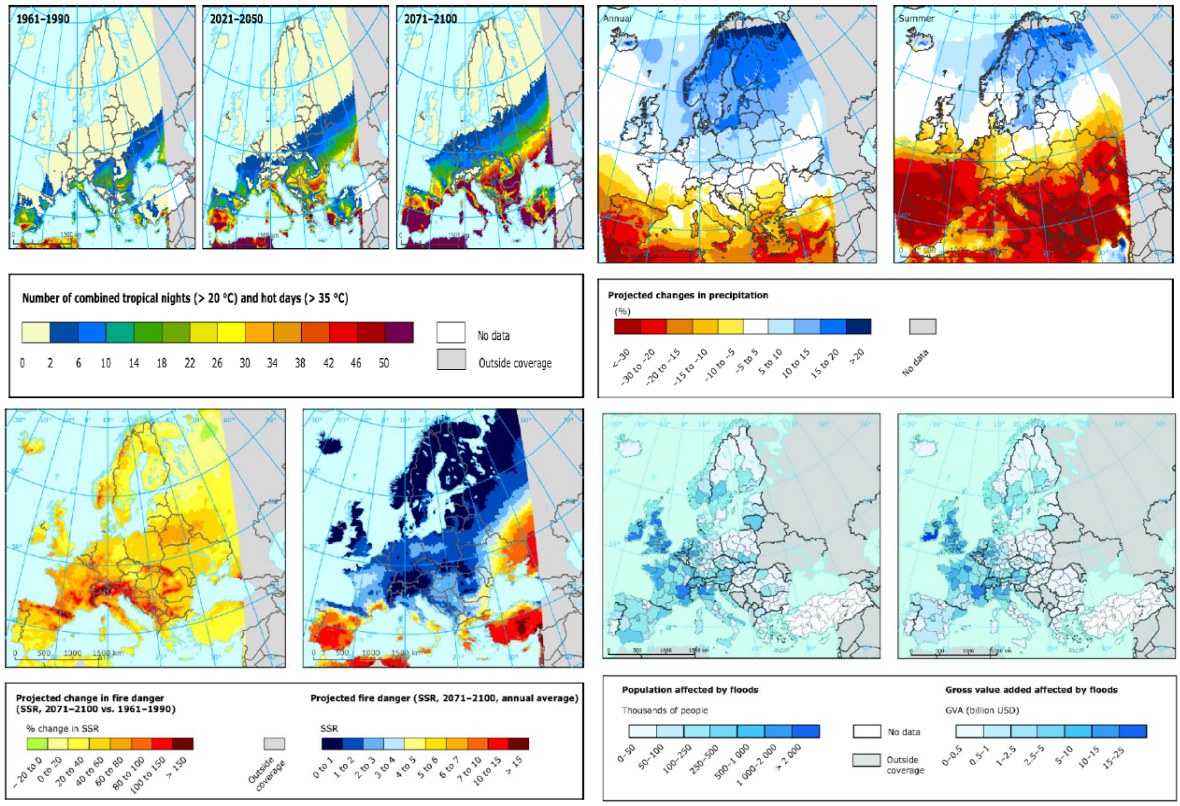


Figure 5 Projected impacts of climate change and associated threats. Based on EEA report Climate Change Impacts and Vulnerability in Europe (2012).

The top left part of the figure refers to the number of days that combine a hot summer day (defined as having a temperature exceeding 35 °C) and a tropical night (defined as having a minimum temperature higher than 20 °C). It is a basic indicator of human comfort due to heat stress. Model projections presented here are the average of six regional climate model (RCM) simulations of the EU ENSEMBLES project using the IPCC SRES A1B emission scenario for the periods 1961–1990, 2021–2050 and 2071–2100. The number of such combined heat stress days is projected to double across most parts of southern Europe by 2071 to 2100 (Source: Fischer and Schär, 2010).

The top right part of the figure refers to projected changes in annual (left) and summer (right) precipitation (van der Linden and Mitchell, 2009). Seasonal mean precipitation values and inter-annual variability is better reproduced by an ensemble of RCMs than by any single RCM (Beniston et al., 2007; Tapiador, 2010). These projections indicate a general increase in annual precipitation in northern Europe and a decrease in southern Europe. Projections for summer precipitation show a decrease over southern, central and northwest Europe, which can reach of up to 60 % in parts of southern Europe. Precipitation is projected to remain constant or to increase slightly in northeast Europe (van der Linden and Mitchell, 2009; Tapiador, 2010).

The bottom right figure refers to projected changes in fire danger. Daily severity values can be averaged over the fire season obtaining a Seasonal Severity Rating (SSR) index, which allows objective comparison of fire danger from year to year and from region to region. Although the index is dimensionless and mainly used for comparison purposes, SSR values above 6 may be considered in the extreme range. Projected climate changes would increase the length and severity of the fire season, the area at risk and the probability of large fires, possibly enhancing desertification. The figures presented here compare modelled fire danger projections for baseline (1961–1990) and projected (2071–2100) climate conditions. The

results suggest that climate change would lead to a marked increase of fire potential in south-eastern and south-western Europe; in relative terms the increase in SSR would be particularly strong in western-central Europe (Source based on Camia et al., 2008 as referred in the EEA report N°12/2012.)

The bottom right figure refers to the affected population and gross value added (GVA) affected by floods for the 2050s for the 'Economy First' scenario, taking into account both climate change and socio□economic changes. Specifically, it looks at the number of people (left) and amount of manufacturing gross value added (GVA), (right), affected by 100-year flood events in the 'Economy First' scenario for the 2050s. Calculations are based on median ensemble results from LISFLOOD linked to population projections from SCENES scenarios (Source: Flörke, Wimmer, Cornelius, et al., 2011). It is based on underlying work of the JRC[3]. The figures on population and Gross Value Added affected present only the future (2050) situation. Note that the maps show the absolute number of affected people or GVA in a region rather than the percentage of population or GVA. It should also be noted that there are large differences in changes in projected flood frequency

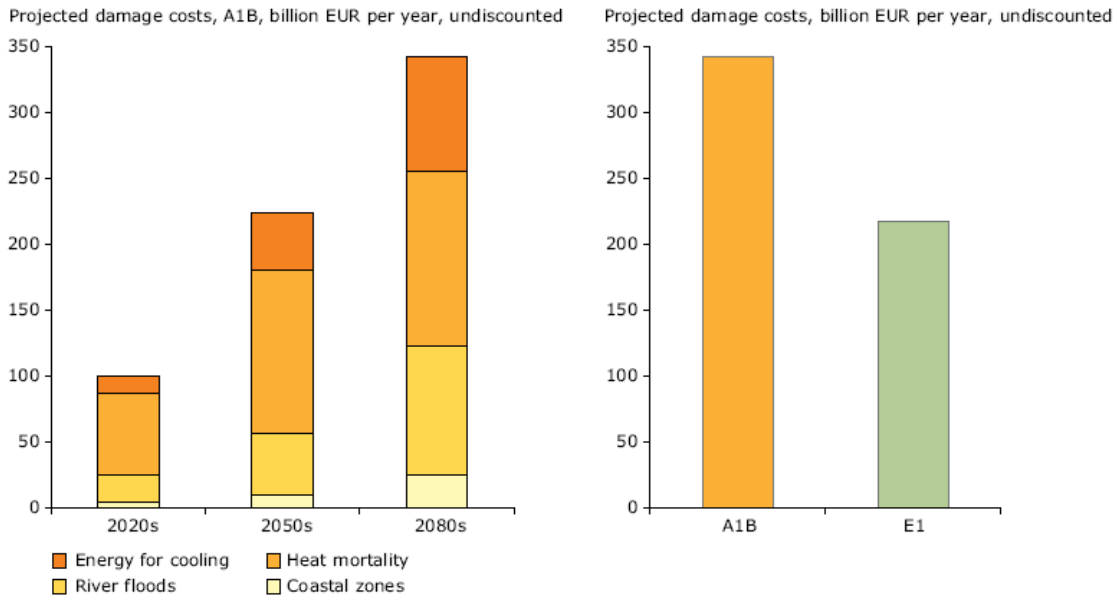
1.1.4. The benefits of adaptation

The minimum cost of not adapting to climate change is estimated to range from € 100 billion a year in 2020 to € 250 billion in 2050 for the EU as a whole[4]. Between 1980 and 2011, direct economic losses in the EU due to flooding alone amounted to more than € 90 billion. This amount is expected to increase, as the annual cost of damage from river floods is estimated at € 20 billion by the 2020s and € 46 billion by the 2050s. Floods resulted in more than 2500 fatalities and affected more than 5.5 million people over the period 1980-2011. Taking no further mitigation or adaptation measures could mean an additional 26 000 deaths/year from heat by the 2020s, rising to 89 000 deaths/year by the 2050s[5]

[3] Rojas, R., Feyen, L., and Watkiss P., 2013. Climate Change and River Floods in the European Union: Socio-Economic Consequences and the Costs and Benefits of Adaptation. Global Environmental Change, in review

[4] EEA report No 12/2012 'Climate change, impacts and vulnerability in Europe'. Medium to high greenhouse gas emissions scenario, leading to temperature increases above the 2°C objective.

[5] ClimateCost. Medium to high emission scenario as above.



Note: Left: damage costs for the A1B scenario for energy for cooling, heat-related mortality (weighted average of Value of a Statistical Life (VSL) and Value of a Life Year Lost (VOLY)), river floods and coastal zones. Time horizon: 2010–2040, 2040–2070 and 2070–2100.
Right: A1B and E1 scenarios, 2070–2100.

Figure 6: Projections of economic costs from climate change and socio□economic developments for four major categories (source: Watkiss (2011) as reported in EEA (2012) "climate change impacts and vulnerability in Europe"

When faced with the potential impacts of climate change, three options are possible: self-protect – that is, adapt – purchase insurance against climate change damage, or do nothing. Uncertainties on climate hazards and damage costs notwithstanding, there is evidence of benefits for adaptation in terms of risk reduction and sharing.

First, there is ample evidence of the benefits of effective adaptation action at local level. Case studies of adaptation measures have been made available on Climate-ADAPT[6]. Methodologies have been derived to help assess the costs and benefits of adaptation action, taking account of the uncertainty surrounding some of the costs of climate change as well as of the co-benefits to be expected from adaptation measures for other objectives. Such studies show that investing in adaptation can reduce the overall damage costs with climate change.

Second, the sectoral coverage of the adaptation cost estimates is limited, though the evidence base is now growing. To take an example, the ClimateCost study shows that the avoided costs due to adaptation action from the impacts of sea level rise in the EU are estimated, depending on the climate scenario, around EUR 3,5bn (A1B) and 4bn (E1) per year in the 2020s, around EUR 8,6bn (A1B) and 9,9bn (E1) per year in the 2050s, and around EUR 22,7bn (A1B) and 15,4bn (E1) per year in the 2080s[7]

ClimateCost results[8]	Economic impacts			Adaptation costs			Reduction in damage costs		
	2020s	2050s	2080s	2020s	2050s	2080s	2020s	2050s	2080s
Sea-level rise	5bn	11bn	25bn	1bn	1.5bn	1.6bn	3bn	9bn	23bn

6 http://Climate-ADAPT.eea.europa.eu/web/guest/adaptation-measures

7 Brown, S., Nicholls, R., Vafeidis, A., Hinkel, J. and Watkiss P. (2011) Sea-Level Rise on Coastal Zones in the EU and the Costs and Benefits of Adaptation: Summary of Sector Results from the ClimateCost project, funded by the European Community's Seventh Framework Programme,

8 Annual figures. Euros, A1b scenario, i.e. medium to high emission scenario, including socioeconomic factors

Floods	20bn	46bn	98bn	1.7bn	3.4bn	7.9bn	8bn	19bn	50bn
Energy		30bn	109bn						

Third, macroeconomic evidence exists of the potential benefits of adaptation (Bosello, 2010, Bosello *et al*., 2010). Modelling results show that adaptation measures can effectively complement mitigation efforts and reduce overall damage costs due to climate change. Moreover, in several cases, adaptation activities can simultaneously produce mitigation benefits, while sustaining production and growth. This is the case of a number of sustainable agricultural practices or of energy efficiency measures for instance.

1.2. Climate change impacts and adaptation needs across the EU

1.2.1. Economic sectors and systems

1.2.1.1. Agriculture[9]

Expected impacts of climate change

Over the coming decades agriculture will be influenced by climate change both globally and within the EU. Even though EU agriculture is technologically developed, its capacity to deliver food and to contribute to ecosystem services for the European society is directly dependent on climatic conditions. Socio-economic factors, international competition, technological development, as well as policy choices will eventually determine the impact that climatic changes will have on the EU agricultural sector in the future.

Agriculture is **highly sensitive** to climate, both in terms of longer-term trends in the average conditions of rainfall and temperature, which determine the productivity and spatial distribution of crops, but also in terms of year-to-year variability and the occurrence of droughts, floods, heat waves, frosts and other extreme events. Direct effects are primarily expected from higher CO_2 levels resulting in increased biomass production and water use efficiency. Indirect effects come through changes in climatic variables, such as temperature, precipitation, radiation, humidity and extreme weather events, which affect plant water uptake, occurrence of weeds, pests and diseases, soil moisture, and ultimately influence crop growth.

Climate change is already having an impact on agriculture. It has been recognized as one of the factors contributing to recent stagnation in wheat yields in parts of Europe despite continued progress in crop breeding (Brisson et al., 2010). The variability of crop yields has also greatly increased over the last decades mainly as a consequence of extreme climatic events, such as recent heat waves and drought.

Year-to year variability of crop productivity is generally expected to increase trhoughout the EU due to the projected rise in the frequence and severity of extreme climate events and other facrors suh as pests and diseases (EEA, 2012a). The projected increase in the occurrence of such events would be particularly detrimental for crop production in central and southern Europe, where such events will occur more frequently and add to current stresses The latter may exacerbate the trend towards **rising price volatility** over the last years.

Studies indicate a **strong regional divergence** in climate change effects in the EU. In **northern areas** climate change may produce positive effects on agriculture through the introduction of new crop varieties, higher yields and expansion of suitable areas for crop cultivation. Increased crop productivity, especially for cereals, is due to the expected increase in the duration of the thermal growing season, decreasing cold spells and extended periods

[9] Please note that the impacts of climate change on the fisheries sector are covered under territorial challenges/coastal areas.

without frost. Negative impacts are also projected in northern areas such as increased pests and diseases, nutrient leaching, and reduced soil organic matter.

In **southern areas** the disadvantages are likely to be predominant, although the picture is very different depending on the models used, the time horizon and the crops considered. The overall expected reduction in precipitation and water avalability, and extreme heat events may negatively affect crop productivity,lead to higher yield variability and, in the long term, drive a change in the range of current cropping possibilities.

Effects are expected to be increasingly visible towards 2050, when climatic changes intensify. In extreme cases, a reduction in suitable areas for cultivation in certan European regions can be expected (Olesen and Bindi 2004; Olesen et al. 2011; Iglesias et al. 2009). For instance, farmland in coastal areas may decrease considerably in the future, due to the potential increase of flooding and inundation of fields. In addition, saltwater intrusion of groundwater aquifers could negatively impact water for irrigation affecting crop yield if suitable source alternatives are not available.

Impacts on crop production – findings from AVEMAC[10]

This project, carried out by the JRC, assesses the potential impacts of changing climatic conditions on main arable crops in the coming decades (2020 and 2030) by using two realisations of one emission scenario (A1B)[11]*. These scenarios do not differ remarkably on projections for air temperature, but they show contrasting results in precipitation patterns (in terms of magnitude but also direction of the change). Rainfall trends are particularly critical for rainfed crops in Southern Europe, and they can lead either to an improvement or to a deterioration of crop productivity. The main simulation results by **2020** without explicitly considering farm-level technical adaptation are as follows:*

- *the simulations for wheat show a negative response at northern latitudes, and a rather unchanged yield level at southern laitudes.*
- *For rapeseed a negative potential impact was simulated at southern latitudes. Sunflower yield was simulated to potentially improve at northern latitudes, but with negative effects on yield at southern latitudes.*
- *For maize, a potential rise in yields is expected at northern latitudes, while lower yields are simulated at southern latitudes.*
- *Under waterlimited production the different precipitation patterns estimated by the two models led to a different response of rain-fed crops (wheat, rapeseed, sunflower). Under the "warm" scenario, potential yields were simulated to improve in Southern Europe.*

The simulation including technical adaptation in the form of autonomus adjustement of technical management by farmer (e.g., different varieties, changing sowing time, increased/reduced irrigation) has shown in many cases an alleviation of the most negative impacts. Improvement of results are especially perceiced under the "cold" scenario in Southern Europe in general, and with a more modest effectiveness in Southern Spain. Also, yield estimates in many areas show improvements under the "warm" scenario in Southern Europe.

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10 Donatelli and al. (2011): *Assessing agriculture vulnerabilities for the design of effective measures for Adaptation to Climate Change*.
See http://ec.europa.eu/agriculture/analysis/external/avemac/index_en.htm

11 The two A1B emissions climatic scenarios are: a 'warm scenario' provided by the HadCM3 model and a 'mild scenario' provided by the ECHAM5 model. The 'warm' scenario estimates more than 3º C increase while the 'mild' scenario limits the average temperature to 1º C in 2020 compared to the average temperature in Europe in the year 2000 . The precipitation regime also shows a substantial difference in these two scenarios. The 'warm' scenario shows a much strong increase in precipitation especially around south of Alps and southern Spain relative to year 2000 (up to 100% increase) whereas the precipitation under the 'mild' scenario does not show any dramatic change.

One of the expected impacts is the increasing year-to year weather variability, which may exacerbate the trend towards **rising price volatility** over the last years.. The variability of crop yields has indeed greatly increased over the last decades mainly as a consequence of extreme climatic events, such as recent heat waves and drought. The projected increase in the occurrence of such events would be particularly detrimental for crop production in central and southern Europe, where such events will occur more frequently and add to current stresses (EEA, 2012a).

The relevance of **pests and plant diseases** to agricultural losses should not be underestimated. A changing climate is associated with increased a incidence and geographical spread of pests and diseases. It is estimated that 30% of losses caused by harmful organisms can be attributed to new pests and diseases (Pimentel, 2005), although poor agricultural practices may be responsible to a larger extent in less developed countries. Kenis & Branco (2010; as quoted by Pimentel, 2011) estimate annual economic losses for the EU of approximately €10 billion caused by already introduced alien insects, not including control, eradication, or quarantine costs, nor costs linked to foreign trade or market aspects. This does not yet consider similar costs due to introduced non-European viruses, bacteria, fungi and nematodes, which add up to a multiple of that figure.

Dryer conditions and rising temperatures will affect **livestock** activities in different ways, including implications for animal health and welfare. Climate change has a complex influence on the livestock sector due to the great diversity of production systems in the EU. Warming and extreme events, such as heat spells, will also have direct impacts on **animal health**, **growth and output,** as well as on **reproduction**. There will also be indirect effects through changes in the productivity of pastures and forage crops, and in the distribution of animal diseases.

Highly adverse impacts are likely to be felt in extensive grazing systems which are directly dependent on climate conditions for the provision of feed and shelter. Changes in transhumance and grazing patterns may also facilitate the spread of diseases by increased congregation of animals for feeding or watering at smaller surfaces.In Mediterranean areas warmer temperatures and summer precipitation deficits will shorten the grazing period and decrease forage production and its quality. In the North-Western humid areas a moderate warming can, however, be beneficial to livestock activities in the short to medium term because of the productivity increase of pastures.

At **global level**, there is rising concern that climate change could also contribute to exacerbate the food security problems. Global food production will still be possible at levels similar to or above current production levels, but new farming practices to adapt to climate change will be needed, and these may increase production costs.

Food supply chains could also be affected and have an impact on retailers. Additional work is needed to investigate the possible implications on food supply chains.

Economic effects of climate-related risks – results from JRC PESETA II project

A quantitative modelling framework has been developed by the JRC analysing the impacts of climate change and examining the adaptation measures in Europe in the horizon 2020, compared to the reference situation of no climate change. CAPRI, an agricultural partial equilibrium model, was used for this purpose, using biophysical impact estimates from the JRC BioMA modelling framework (as assessed by AVEMAC). Nine scenarios were assessed. Two adaptation scenarios – "no-adaptation" and "best-adaptation" – were included. For each adaptation scenario two climate scenarios with fixed prices (warm and mild[12]) and two climate scenarios with price effects (warm-global and mild-global)

[12] For this study, the BIOMA

were run. Additionally, a baseline scenario defines the reference situation and thus serves as a comparison point for the 8 counterfactual scenarios.

The simulation results indicate that by 2020 climate change effects will reduce the prices of agricultural commodities in the EU. The price decrease under the "no-adaptation" scenario is lower than in the "best-adaptation" scenario. This is because for the overall EU,, climate change tends to have a positive impact on agricultural production due to higher yields although there are strong differences in the adjustment pattern between sectors. Adjustment of animal production to climatic changes is relatively lower but positive in all four scenarios. The overall increase in animal production is induced by lower crop prices which reduce animal feed costs (in the global scenarios) and higher yield level of feed crops in all scenarios (e.g. grassland). The impact of climate change on EU land use is relatively small. Climate change will lead to a small positive impact on total welfare. Total welfare could improve due to consumer gain from lower food prices but the change is very small (close to zero). The agricultural income reacts stronger but the effect is still relatively low: between -0.1 and 8% change compared to baseline.

Policy context and current adaptation activities

Since its creation, the European Common Agriculture Policy (CAP) influenced the development of the EU agriculture but also adapted with times. In this context, the European Commission tabled in 2011 proposals for a reform of the CAP after 2013 with the aim to strengthen the competitiveness and the sustainability of agriculture and maintain its presence in all regions, in order to guarantee European citizens healthy and quality food production, to preserve the environment and to help develop rural areas.

The Commission included in its legal proposal for the reform of the CAP various elements that will contribute in a complementary and coherent way to the objective of a more sustainable use of natural resources, mitigating climate change and enhance farmer's resilience to the threats posed by climate change and its variability often referred to as the "greening of the CAP". The "greening" comprises enhanced cross-compliance, the further greening of the first pillar through the granting of a "green" specific decoupled direct payment, the reinforcement of an improved agri-environmental policy under the second pillar encouraging the introduction and/ or maintenance of extensive, environmentally friendly farming systems as well as broad support from the Farm Advisory System and applied research. The new CAP will provide an enhanced framework for sustainable management of the natural environment in which agricultural activity takes place, which will contribute to adaptation to climatic changes.

The EU intends to further pursue and support adaptation in the agricultural sector with four broad types of instruments within the CAP and the EU research and innovation policy:

- improved framework to **sustainable management of natural resources**, such as a new "green" payment as part of the income support, strenghtened cross-compliance for climate change and enhanced environmental and climatic support within the rural sector. One of the key changes proposed for the rural development policy is to structure forthcoming rural development programmes (RDP) around "priorities". Six priorities have been set, two of which relate to the environment and to climate adaptation, such as promoting resource efficiency, and focus on increasing efficiency in water usage by agriculture, and on a low carbon and climate resilient agriculture. Within the current Commission proposal, Member States are encouraged to implement actions related to the six priorities although they may put more emphasis on certain ones according to their situation and priorities. Adaptation is also an aspect to be taken into account when assessing the specific needs of the other five priorities, since climate change is considered a cross-cutting issue. For instance, funding of an upgrade

irrigation equipement will be conditioned to the achievements of a certain level of water saving and efficiency requirements.

- **Financial support**. Rural development policy will continue providing a targeted support to a large array of adaptation measures involving building an adaptive capacity of farmers (e.g. information actions, training) and implementing actions (e.g., agri-environment-climate measures, enhanced support for risk management instruments, such as insurances). Building resilience encompasses a broad range of socio-economic-ecological actions, not necessarily climate-specific but which can help coping with climate variability and change.

- **Enhanced research and innovation**, and a new European Innovation Partnership on "Agricultural productivity and sustainability". The EIP aims at building bridges between research, innovation, advisors and farmers, bringing scientific results to the "field", and having research working on issues needing solutions in co-operation with local knowledge. Adaptation of agricultural systems is a key area for research and innovation. On the other hand, agricultural research in the forthcoming Horizon 2020 framework for EU research and innovation will support transition pathways towards resilient farming systems combining the goals of ensuring productivity while considering all dimensions of sustainability. Achieving a climate-smart agriculture including adaptation of agricultural systems is a key component of the second Societal Challenge of the Horizon 2020 relating to "Food security, sustainable agriculture, marine and maritime research and the bio-economy".

- **Knowledge transfer** and information actions. Enhancing the adaptive capacity of farmers is a necessary condition for sustaining adaptation in agriculture. Strengthening information and advisory support on climate-related matters to farmers and agricultural workers is key for motivation and preparedness to adapt. (improved Farm Advisory instrument covering climate-related issues, actions to enhance knowledge transfer to the farm community).

With regard to plant health, the role of the EU and related legislation concerns measures to prevent the entry, establishment and spread of pests of plants that are not native to the EU. The Commission Work Programme foresees also the adoption of a proposal for a new plant health law by 2012, which will reinforce mitigation of risks from climate change and trade globalisation to plant health.

Main barriers to action

Some barriers have been identified that prevent a higher uptake of adaptation action in the sector. An important one is the **uncertainty** of the effects of climate change and adaptation solutions that may hamper the planning of specific adaptation actions, particularly if these are costly. There is often a chain of uncertainty involved in the projections going from emission scenario, through climate modelling, downscaling and to assessments of impacts using an impact model (Olesen et al., 2007). The extent of all these uncertainties is rarely quantified, even though some studies have assessed uncertainties related to individual components. The crop modelling community has only recently started addressing uncertainties related to modelling impacts of climate change on crop yield and effect of possible adaptation options, and so far only few studies have involved livestock systems (EEA, 2012a).

However, adaptation planning can also bring **opportunities** to build agricultural systems with greater resilience to environmental, climatic and economic risks. The preparation of national and regional adaptation strategies and plans covering agriculture as well as additional guidance and information sharing could better guide Member States and regions on how

adaptation action can be best pursued. In this process, it is important to further engage the farming community in the discussion on adaptation needs and in sharing good practices.

How would the problem evolve by 2020 without further EU action?

The vulnerability of farming varies across the EU depending on the exposure to adverse climate impacts, the socio-economic context and the specific farm characteristics (e.g., size, level of diversification). Existing agro-ecological conditions and the experience in dealing with changing conditions greatly influence farmers' adaptive capacity.

Independently to the contribution of the CAP, autonomous adaptation to climate change occurs at farm level. Adaptation to weather conditions is inherent to farm management. Constant evolution of crop patterns, farm management practices and land use are observed across the EU, partly in response to the perceived climatic variations. Such farm-level adaptations aim at increasing productivity and dealing with existing climatic conditions, and mainly draw on farmers' current knowledge and experience, but these largely depend on farmers' current knowledge, experience and financial possibilities for change. Therefore not all farmers have the same opportunity for developing spontaneous adaptation strategies.

Coping with the increasing short term climatic variability could be more difficult than adjusting to gradual long-term changes in mean climatic variables. This may require greater attention to ensuring **stability and resilience** of agricultural production and farm incomes in vulnerable regions. Diversifying farm activities and income sources, with fundamental changes in farm structures and in some cases, additional investments, may become necessary.

Potential actions by 2020 to increase resilience

To effectively complement what has been proposed for the revision of the CAP, identifying adaptation options at farm and landscape level would help Member States and regions in developing their rural development programmes. A balanced mix of **preventive and coping actions** should be promoted. Insurance schemes/mechanisms that compensate for crop losses due to disaster events should ensure that they do not hinder investment in adaptation.

The climate challenge puts a renewed emphasis on the need for enhancing **agricultural research**, at EU and national levels, to assess the impacts of climate change on agricultural production as well as costs and benefits of adaptation, covering arable and permanent crops as well as livestock systems. Forthcoming research should better integrate the potential effects of extreme climate events and biotic hazards, as well as the increased competition for scarce resources, such as water.

A key challenge is to integrate findings from the physical and agronomic sciences with local knowledge from farmers, so as to develop robust adaptation strategies, which, over a range of climate and socio-economic scenarios, can minimize the negative impacts of climate change. The Farm Advisory System can be an important tool also in this regard.

Equally important is to strengthen the capacity of regional institutions to use appropriate tools to address climatic changes. Partnerships between national and regional research institutions, advisory services and social partners in agriculture as well as setting up of regional networks providing information to farm communities will help to design adequate site-specific strategies.

1.2.1.2. Forests and the forestry sector

Expected impacts of climate change

Forests and the way they are managed are particularly sensitive to climate change because the long lifespan of trees does not allow for a rapid adaptation to environmental changes. Effects

of climate change include increased risk of biotic (pests and diseases) and abiotic (droughts, storms and fires) disturbances to forest health. During the stakeholder meeting convened with forest experts in June 2012 it came clear that, over the last ten years, natural catastrophes have led to a massive increase of damages in several regions . However, the exact effects of climate change on forests are complex and not yet well understood. Potential environmental impacts include: changing tree species distributions in Europe; northwards and upwards (mountains) expansion of broadleaved deciduous species; increasing threats for specialized plant communities; thermophilic plant species become more common, while cold-tolerant species decline; in large areas of western and central Europe, indigenous conifers may be replaced by deciduous trees chance of tree species influences the quality of water.

In southern Europe, slow growth and high forest fire risk might require landowners to carry out more intense thinning strategies and change the species composition towards less productive species. Shortening rotation periods have also been mentioned in the study referred below as a way to reduce the risk from storm or fire damage. Such actions would likely reduce the level of growth per hectare, affecting income and the provision of forest functions (EUSTAFOR, 2011). In Europe no overall assessment has yet been made of the economic implications of climate change, nor of the potential costs of the various adaptation measures needed. The PESETA II project has estimated the cost to the EU economy of forest fires in the Mediterranean region (Spain, Portugal, Greece, Italy and Mediterranean France). The study finds that increased forest fires would reduce economic welfare (mainly due to restoration costs) in the EU as a whole by between 0.01% and 0.04%. The loss would be greatest in Portugal (around 0.8%) and Greece (around 0.2%) since the cost of increased fire instance in these countries is particularly large relative to the size of their economies. These results should be considered a preliminary minimum estimate of the cost of climate-induced forest fires since many important damages have not yet been considered (such as costs of fire fighting and destruction of capital other than in the forest sector).

The impacts of climate change will vary throughout the different geographic European regions, with forest fires likely to dominate in southern Europe and the limited diversity of tree species in boreal forests enhancing the risk of significant pest and disease impacts. Evidence to date suggests that biomass productivity in northern and central Europe has increased and is likely to continue to increase. Further, northward expansion of potential distribution of some tree species is expected and potentially more favourable conditions for summer recreation in mountainous regions will exist.

With more drastic changes in climate towards the end of the century, severe and wide ranging negative climate change impacts have to be expected in most European regions, with the Mediterranean region as the most vulnerable to climate change based on potential impact assessment and adaptive capacity. Due to the long timespan of trees, adaptation action would be required by 2020.

Changes in the patterns of disturbance by forest pests (insects, pathogens and other pests) are expected under a changing climate as a result of warmer temperatures, changes in precipitation, increased drought frequency and higher carbon dioxide concentrations. However there is evidence from an FAO desk review that climate change is having considerable and widespread impacts on forest health worldwide, and, as a result, on the forest sector (FAO, 2008). Climate change can affect forest pests and the damage they cause by: directly impacting their development, survival, reproduction, distribution and spread; altering host physiology and defences; and indirectly by impacting the relationships between pests, their environment and other species such as natural enemies, competitors and mutualists (ibid). Gradual shifts in climatic suitability in previously unsuitable regions of the world provide new opportunities for forest pests to establish in new locations.

Policy context and current adaptation activities

EC Regulation 2152/2003, repealed by Regulation (EC) No 614/2007, established a Community scheme on monitoring of forests and environmental interactions to protect the Community's forests. Monitoring activities also cover the issue of climate change. The new EU Forest Strategy is scheduled for adoption for the first quarter of 2013

There are also other policies where forests and forestry are a significant and essential element and, therefore, these policies also impact forestry management. The proposed Rural Development policy for the period 2014-20 will offer support for forestry measures that will also help adaptation objectives. The Commission Work Programme foresees also the adoption of a proposal for a new plant health law by 2013. The Commission is currently working on a dedicated legislative instrument on Invasive Alien Species.

Main barriers to action

The following barriers for action have been identified: First of all there is an overflow of information at all levels, with several policy areas – such as biodiversity, the CAP or nature conservation – to be simultaneously considered by forest managers when making decisions. The proposed EU Forest strategy will integrate these different policies into an overall strategic framework. Adaptation possibilities are also often limited due to legal requirements in other policy areas such as nature conservation obligations (e.g. planting of new non-native species).

The second large barrier lies within the structure of the sector. The overall discussions on adaptation at EU level hardly reach the ground (single forest owner) due to the diversity and fragmentation of the sector (few large companies versus several small forest owners). Forest management also has different objectives (e.g. economic, nature conservation, protection of human activities), in which adaptation should be integrated to be efficient. This should be considered when trying to convince forest managers to take actions in the area of adaptation to climate change.

Finally there is a lack of awareness. It is important to increase the awareness on adaptation at the local level. This could be done via the use of advisory services and the creation of local forest organisations (co-operations). Such organisations are seen as a suitable entry point for increasing awareness about EU policies in general but also for adaptation in particular. For larger companies it is also important to create a business case for adaptation.

How would the problem evolve by 2020 without further EU action?

It is expected that extreme weather events will continue to have an impact on the forestry sector. In addition, some long-term investment decisions should already factor in the long-term impacts of climate change. Out of the 12 Member States which have developed a an adaptation strategy, 10 address the issue of forestry. Stakeholders' dialogues with the actors of the sector have also indicated that at least those forestry owners which have a business case in forest management will also take adaptation measures in order to ensure the sustainability of the business. The new EU Forest strategy should address climate change – mitigation and adaptation – as a cross cutting objective.

Potential actions by 2020 to increase resilience

In 2008 a list of adaptation measures was developed in a study for the Commission[13]. This list was discussed and amended by the Working Group under the Standing Forestry Committee contributing to the development of a new Forest Strategy. In addition, stakeholders' dialogues

[13] Climate Change on European Forests and Options for Adaptation, AGRI-2007-G4-06 Report to the European Commission Directorate-General for Agriculture and Rural Development, co-ordinated by EFI

with the actors of the sector have shown the need to: i/ Build capacity through information exchange and awareness raising between forest owners on climate change adaptation; ii/ Support research to fill knowledge gaps on vulnerable areas, regional adaptive capacity, economic implications of climate change, the socio-economic adaptation capacity of the forestry sector and how to include regional climate change information into smaller-scale environmental impact assessments. Additional specific topics include: risk prevention measures, location based adaptation, how adaptation efforts in the forestry sector will impact other sectors and vice versa, dealing with uncertainties, etc.

1.2.1.3. Transport

Expected impacts of climate change

Consequences of climate change will both be negative and positive for transportation infrastructure such as for rail, road, shipping and aviation, but will differ from region to region. In particular, the projected increase in frequency and intensity of extreme weather, such as heavy rain (e.g. causing floods), heavy snowfall, extreme heat and cold, drought and reduced visibility can enhance negative impacts on the transport infrastructure, causing injuries and damages as well as economic losses. But also some beneficial impacts on transport due to climate change can be expected, such as reduced snow fall for most European regions improving traffic conditions.

Many impacts aggravated by climatic change, such as flooding and erosion, will affect all transport modes, while some are unique to each mode (e.g. scour on bridge supports, rail buckling). However, the vulnerability of the transport sector is also influenced by human behaviour and societal changes: as different transport modes are differently affected by climate change, the kind of mobility chosen by individuals is influencing the vulnerability of the whole sector. For example, a strong shift from individual transport to public transport could decrease overall vulnerability of the sector as public transport generally is better controllable and manageable.

In terms of cost estimates for future climate change impacts on the transport sector, the Weather project (Fraunhofer ISI, in Trinks et al. 2012) concludes that from 2010 to 2050, due to weather extremes, rail transport will experience the most substantial increase in all cost categories (i.e. comprising direct costs to the transport sector and indirect costs to its users and to other sectors). Most hit are rail services in France and the UK, but also in central Europe and Scandinavia. Regarding road transport the highest increase of costs of approximately 80 % is predicted in the analysis for France. In contrast, a considerable decrease of more than 20 % in infrastructure, service and user costs in road transport related to extreme weather events is predicted for Germany, Spain and Italy. The aviation sector is well adapted to handle weather extremes and the additional cost may in principle be limited in Scandinavia, Central and Eastern Europe and with an increasing tendency in the Mediterranean Area and France. However, the inter-linkages between major airports across and outside the EU – through connecting, returning and onward flights – imply that the closure of one or several airports due to extreme weather conditions relatively fast can become widespread causing further delays and cancellations.

Policy context and current adaptation activities

Climate change impacts will enhance the pressure on transport infrastructure in the future, also in economic terms. This is of particular importance considering the long-term investments – with a life-span-time up to 100 years (e.g. major transport routes, bridges, tunnels, urban transport). The majority of existing EU transport policies does not explicitly address the climatic pressures and impacts which can be expected in the future as potentially

harming transport infrastructure. However, a few policy implementation reports (e.g. Fifth report on economic, social and territorial cohesion) are highlighting the need for climate change adaptation of transport infrastructure. Other policies include mechanism or technical standards which are of importance in terms of adaptation (e.g. Directive on River Information Services requests for implementing information services and providing information on navigation, water level etc.). In addition, adaptation can be integrated in existing policies dealing with new infrastructure projects to ensure climate resilience. In case of the TEN-T-Guidelines , adaptation to climate change has been integrated in the proposal for revision. Besides activities at the EU level, adaptation activities at Member States´ level are also crucial due to the fact that the majority of adaptation actions need to be taken at that or lower levels.

Up to now, the first adaptation activities can be observed in the different transport modes. For example, the rail sector has started to deal with the issue of climate change impacts and some companies (e.g. UK, France) have prepared strategies on how to cope with these impacts. Related activities include research concerning the impact of climate change in the next decades as well as the identification of challenges, constraints, solutions and benefits of adaptation measures. In other transport modes such as road, fewer activities can be observed (result from literature review and stakeholder exchange).

Main barriers to action

To foster adaptation to climate change in the transport sector, a common understanding of problems related to climate change as well as information on possible impacts are required, but often missing. As uncertainties exist in relation to future climate projections and inherently in the occurrence of extreme weather events, planning for adaptation is often postponed as well. Unclear responsibility for climate issues in the transport sector might additionally hinder adaptation. The implementation of adaptation options might face problems due to a lack of knowledge on damage costs as well as costs of adaptation. In addition, funding of adaptation options seems to be a bottleneck.

How would the problem evolve by 2020 without further EU Action?

Transport infrastructure investments boost economic growth; create wealth; enhance trade, geographical accessibility and the mobility of people (COM 2011). Experiences of past catastrophes and research results show clearly that extreme weather events today are not sufficiently addressed by transport systems and in particular by risk or emergency management procedures within the transport sector (Papanikolaou et al., 2011). Extreme weather events have economic impacts, which are closely related to the frequencies of damage-, disruption- and transport restriction events and the availability of transport alternatives. Climate change impacts due to change in precipitation patterns (magnitude and frequency) and to increase of temperature will enhance the pressure on transport infrastructure in the future, also in economic terms. Furthermore, transport infrastructure networks are often trans-boundary and coordination efforts for adaptation are therefore required. Existing EU policies do not accommodate these changes adequately and thus, in case of inaction, additional negative effects might be expected by 2020.

Potential actions by 2020 to increase resilience

The general objective is to enhance the resilience of transport infrastructure in regard to future climate change impacts including extreme weather events. The aim is to decrease the frequencies of damage, disruption and transport restrictions and to enhance the availability of transport alternatives.

Research funding should be available to close knowledge gaps in the transport sector such as regional vulnerability hot spot analyses by transport mode, aggregated costs to transport

systems from climate change, costing of adaptation options, research on technical issues to be able to suggest specific amendments in standards and regulations, etc.

A number of relevant existing policies might provide entry points to integrate climate change adaptation. Such relevant policies at EU level for all transport modes are the TEN-T Guidelines (661/2010/EC); the link to adaptation has been included in the revised version of the guideline. Regarding climate change adaptation in rail, policies focusing on the safety of rail networks and on new development of infrastructure are of specific interest (e.g. mainstreaming climate change adaptation into the TSI-Directive 2008/57/EC on the interoperability of the rail system within the Community). In case of roads, the Directive 2008/96/EC on road infrastructure safety management requires the establishment and implementation of procedures relating to road safety impact assessments, road safety audits, the management of road network safety and safety inspections by the Member States for the trans-European road network, whether they are at the design stage, under construction or in operation. When carrying out these assessments, not only the current climate conditions should be taken into account, but also information on possible future climatic conditions should be considered. The EU's maritime transport policy until 2018 might provide further entry points for mainstreaming of climate change adaptation.

Technical adaptation options should focus on the use of materials for transport infrastructure which better cope with extreme heat events (e.g. to prevent track buckling or softening of pavement materials). A higher dimension of drainage systems should be considered. Sea level rise needs to be taken into account in navigation systems and infrastructure as well as in the design of long-life structures (e.g. dock and wharfs). In addition, early warning-systems (e.g. for forest fires, floods) and monitoring (e.g. land slopes, wind speeds) should be enhanced and improved.

1.2.1.4. Construction and buildings

Expected impacts of climate change

The impact of climate change is particularly pertinent to the construction industry given the life expectancy of buildings and the fact that there is a need to adapt the existing built environment, to deal with a climate that may be significantly different from that in which it evolved. Major threats to construction and buildings requiring short-term action can be aggregated to: i/ extreme precipitation, which can be expected European wide, e.g. leading to water intrusion, damage to foundations and basements, destruction of buildings and infrastructure, overflowing sewers, land- and mud-slides, flooding, etc.; ii/ extreme summer heat events, especially but not only in South Europe, e.g. leading to material fatigue, decreased comfort and potentially severe health implications, high energy use for cooling, etc. iii/ exposure of constructions to heavy snowfall, iv/ rising sea levels that increase the risk of flooding.

In the past, precipitation in its various forms caused the most damage to buildings and infrastructure. This is true for all parts of Europe and all forms of buildings and civil engineering works. For example, heavy snowfall and storms have created serious damage to roofs and the outer shell of buildings, heavy rain and storm waters causing flash flooding lead to infiltration of water into buildings, damage or destruction. Salt water intrusion can cause deterioration of facades, statues and monuments and structural parts of buildings and civil engineering works. Especially urban areas are affected by climate change due to higher sealing-rates related to construction and buildings. European cities close to a river or to the coast are most vulnerable to flooding.

Due to a lack of space, flood plains are more and more used for housing and industry. Short term social, commercial, economic and political pressures may outweigh scientific caution and environmental concerns. Research has shown that the increase in economic damage of the past decade may be due to an increase of economic assets in vulnerable places rather than an early consequence of climate change.

Buildings and infrastructure can be vulnerable to climate change because of their design (low resistance to storms) or location (e.g. in flood-prone areas, landslides, avalanches). Flooding is (after earthquakes) one of the most costly kinds of disasters and this is mainly due to floods in built-up areas. Many European cities have been built along a river; and these rivers will respond to extreme rainfall or snowmelt events with extreme discharges, threatening the cities with floods. There is also a growing problem with overheating of the built environment being exposed to rising temperatures and extreme heat, which is not only an issue for the construction material but also affects the occupant's comfort and health. In coastal areas, coastal protection (e.g. sea walls, barriers) may require increasing maintenance costs and higher frequency of readjustments.

Cultural and nature-based heritage sites are increasingly threatened by climate change. Some of these treasures are at risk as a result of impacts like rising sea levels, flooding and storms, and others are threatened by changes in historic and local climatic conditions. These in turn may lead to subtle but damaging shifts in moisture levels affecting structures directly, or the chemistry and stability of soils in which they are found.

During the past ten years, Europe has seen a number of serious floods and heat waves due in particular to an increase in valuable properties in areas with flood risk, which is expected to become more vulnerable due to climate change.

Policy context and current adaptation activities

Existing EU policies related to construction and buildings do not explicitly address climatic pressures. Where the climate is taken into account, it mainly refers to mitigation and the relation to the fulfilment of the Kyoto 2°C target, but not yet to adaptation.

EUROCODES, a set of unified international codes of practice for designing buildings and civil engineering structures, so far do not incorporate the aspects of future changes of climatic conditions and in the extreme weather events. The EUROCODES aim at eliminating the disparities that hinder free circulation of goods and services within the Community, are meant to lead to more uniform levels of safety in construction in Europe, and are designed to become the reference design codes replacing national codes.

Main barriers to action

Uncertainty in the projections of future climate change and in particular the extreme weather events (temperature, wind, precipitation) that may affect buildings/infrastructure depending on location and design lifespan.

Prevention of flooding is an expensive adaptation option and countries may hesitate to free budget for an effort that may require 20-30 years of investing before it is completed.

Because of the long timescales involved and the inherent uncertainties in the projections it is difficult for construction companies to build competitive advantage based on adaptive innovations.

A lack of information on future risks prevents local governments and citizens to make different choices. Insurance companies often look at history to define flood risks, and do not take climate change into account.

How would the problem evolve by 2020 without further EU Action?

Buildings have a life-span up to 70 years or longer. Without taking climate change into account in these long-term investments, new buildings will be more vulnerable to the negative effects of climate change and higher damages might occur. Old buildings will be cooled with use of fossil fuel, leading to more CO2 emissions, thus further accelerating climate change and enhancing the need for adaptation. Also, the construction of new developments in flood-prone areas is likely to continue as room for settlements is limited in many European countries.

Potential actions by 2020

Additional research on possible impacts is needed to be able to develop effective adaptation measures for construction and buildings (including design, building type, green infrastructure, water storage and communication infrastructure). More knowledge is also needed on the aggregated cost to buildings from climate change covering all impacts and all Europe. Further, adaptation benefits and cost of residual damage need to be evaluated.

Concrete formulation of adaptation needs of buildings into the Energy Performance of Buildings Directive[14] might be an important factor to adapt successfully and create synergies between adaptation and mitigation efforts. Methodologies and guidelines for ensuring climate resilience of buildings could be incorporated into the national plans for increasing the number of nearly zero-energy buildings. A preliminary climate resilience proof check could be required in order to get an approval of a building project. Further, the integration of climate change considerations in technical standards (design, construction and products) is needed. In addition, existing mechanisms such as Environmental Impact Assessment (EIA) and Strategic Environmental Assessment (SEA) need to be explored as appropriate instruments to mainstream adaptation[15].

Specific technical measures to prevent flooding and overheating of buildings can be taken at two levels: the building level and the project or spatial level. The project/spatial level has to be taken into account in an early stage for new developments, while at the building level adjustments to the existing construction might be necessary.

For new building measures may include, inter alia, to plan for a minimum elevation above street level so that the streets will drain excessive water while buildings remain dry; building ground floors of water resistant materials; putting electricity, communication networks and other water-sensitive installations on the first floor, or, at the least, not in a basement; enabling shutting off sensitive appliances in case of flooding. In existing buildings, potential measures to be taken, comprise refurnishing the ground floor in a more flood-proof way (e.g. with tiles instead of wood); mobile shading structures, preferably on the outside of the building; reducing heat producing equipment (LED lighting, passive lighting such as skylights, energy saving equipment; installing green roof or facade, which provides cooling through evaporation and limits uptake of solar radiation.

1.2.1.5. Energy

Expected impacts of climate change

Climate threats for the European energy system do already exist and are projected to increase. Explicitly affected by climate change is and will be even more the security of electricity supply for:

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14 Directive 2010/31/EU

15 As regards EIA, it is already being done as a part of an ongoing review of the EIA Directive.

- citizens and companies as energy consumers, whose activity is threatened by weather-induced black outs (threatened security in energy supply) in conjunction with
- TSOs and DSOs as the infrastructure (explicitly for the usually less robust distribution grid) is threatened by extreme events – sometimes in extremely critical conjunction with high demand (cf. black out 2003 in Italy and Switzerland as one example)
- Energy suppliers with a high share of vulnerable supplies – i.e. water intensive energy supply (i.e. for cooling thermal plants as well as for run-off plant-generated hydropower)

More intense and frequent heat waves will shift demand patterns to critical constellations in which supply is low due to i) decreased CARNOT efficiency (for thermal plants), ii) decreased cooling water supply, but demand is high due to i) increasing demand by air conditioning (private, office and storage of for example food and pharmaceutical products). Shifting patterns of precipitation will cause problems for energy supply. Higher magnitude and frequency of extreme weather events will cause threats for physical energy infrastructure (explicitly overhead transmission/distribution, but also other infrastructure – e.g. substations, transformers or fragile supply infrastructure).

Threats to the energy system might increase regional disparities with the EU with southern countries suffering from i) high electricity import dependency and thus relying on yet non-resilient transmission infrastructure and ii) projected impacts from gradual temperature increase, heat wave and drought frequency further threats to domestic supply aggravating import dependency.Meanwhile, northern countries show a more complex and uncertain picture of potential gains and losses for energy supply and security.

Policy context and current adaptation activities

All policies related to energy transmission could be potentially concerned. Fundamental are TEN-E Guidelines (1364/2006/EC), Connecting Europe Facility COM(2011) 665, Guidelines for trans-European energy infrastructure COM(2011) 658, Cohesion Fund COM(2011) 612 final, the smart grid technology platform, the European Electricity Grid Initiative (EEGI) and its implementation plan and the Internal Energy Market.On the supply part, important European policies are the Strategic Energy Technology Plan (SET plan), the communications Energy Roadmap 2050 as well as Energy 2020 – A strategy for a competitive, sustainable and secure energy.

Furthermore, policies aiming at decreasing demandalso have a potential to cut-off seasonal demand peaks, e.g. directive 2010/31 on the energy performance of buildings, directive 2006/32 on energy end-use efficiency and energy services and repealing Council Directive 93/76/EEC ("The Energy Services Directive")[16] or regulation (EC) No 106 on a Community energy-efficiency labeling programme for office equipment (Energy Star).

The EU's renewable energy policy is the current main driver of change to Europe's energy mix. This is accelerating Europe's adoption of low carbon energy, with the gradual introduction of renewable energy heating, cooling and power sources geared to local circumstances. Thus, emissions are being reduced (mitigation), and smaller scale, often distributed power genration is geared to local climatic circumstances (adaptation).

Main barriers to action

Current adaptation activities in the energy sector are basically taken place at different national levels, namely in member states with adaptation strategies already in place (e.g. Finland,

[16] The energy efficiency Directive has not yet been formally adopted at the time of completion of this IA report.

Netherlands, France and Germany). At European level, policies supporting to reach adaptation targets (e.g. cutting down seasonal demand peaks, Connecting Europe Facility, Smart Grids initiative, renewable energy development) are in place and emerging, although not named as such – thus having high mainstreaming potential. Adaptation to climate change is seen as additional burden to the ongoing shifts of the energy system towards the 20-20-20 goals. Mitigation is thus regarded as much greater challenge.

However, adaptation requires sufficient knowledge e.g. on: i) Vulnerable hot spots in the transmission and distribution grid, ii) Vulnerability assessment of energy supplies including explicitly nuclear, fossil fuel and renewable energy supplies and iii) Future climate-induced demand patterns. While iii is well-covered in many studies, projects and publications, i and ii still show significant knowledge gaps. Limited data access to damages of energy infrastructure as well as a lack of energy meteorological forecasts and data is an additional barrier to start action on adaptation in the energy system.

An ongoing challenge for TSOs and DSOs is the connection with newly built, remote or isolated energy supply infrastructure (e.g. mainly offshore wind parks or pumped storage power), which leaves less budget for the investment in hardening and adapting existing grid infrastructure. Increasing regional disparities in energy would become striking without further action. These would have significant economic impacts due to i) Endangered energy security explicitly in southern member states as well as ii) Price signals to companies and citizens in those countries with a high import dependency.

Potential examples of adaptation actions to increase resilience by 2020

Research policies should focus on detecting vulnerable hot spots and potential technical measures to increase the physical resilience as well as capacity at climatically triggered/demand-induced bottlenecks in the trans-European grid. Furthermore research investments should be further enlarged for alternative storage technologies. Research on the vulnerability of all energy sources' efficiency towards changing climate parameters is necessary as well as intensified efforts to support energy efficiency and sufficiency – along the preexisting policies described above.

Further adaptation measures could focus on installing underground cables to the degree possible, expand aisles in storm-prone areas, putting slope stability measures in place, set up/expand existing early warning systems among TSOs, relocate flood-prone transformers and substations, support 'isle solutions' for critical production or explicitly important facilities (thus enabling them to become independent from the grid).

Adaptation measures in import dependent countries should focus on extending the share of domestic supply or in the diversification of energy sources. Measures to safeguard electricity supply can be achieved by technical optimization of hydropower plants, enhance management in hydropower catchments to better control erosion/sedimentation processes, install capacities at suitable run-off regimes (e.g. glacial regimes for small-scaled facilities as buffers).

Improved assessment of changes to local climatic conditions (in the context of infrastucture and power generation planning) would increase the scope for local energy sources to be exploited in accordance with local climatic conditions, minimising risks to energy supply though avoiding disruptions from constraints on transmission infrastructure or fuel supply.

Measures to cut-off critical seasonal/climate-induced demand peaks could focus on installing further solar cooling (meant here: PV-powered), promote water-saving technologies to relief cooling water demand, further measures to increase efficiency/sufficiency focussing on 'high demand periods' and setting up regulations and contingency plans for extreme meteorological periods.

1.2.1.6. Insurance

Expected impacts of climate change

The probability of most types of extreme event is expected to change significantly, in many cases upwards, as a result of climate change (IPCC, 2012). Several national studies have interpreted the predictions for insurers; for example in the UK (ABI, 2005) and in France (FFSA, 2009). In fact the ongoing rapid changes make it hard to assess the future risk. The most dramatic and reliable changes are predicted for temperature; the historical 500 year heat wave event might become a 2 –yearly (biennial) event by the 2040s (Stott, Stone and Allen, 2004).

Current activities

Insurance can be a valuable tool for adaptation in three main ways: helping to manage climate change risks; providing incentives for risk prevention; and providing information on risk (Courbage and Stahel, 2012). Insurance should be seen as one of the possible options and tools available to government and individuals to respond to climate change risks and should be adopted in conjunction with other preventive and response measures.

The insurance sector is arguably the most advanced in evaluating risks and opportunities. Major adaptation initiatives in the insurance sector, to date, have focused around building institutional networks that address the common risks to the industry through collaboration. It is likely that the insurance sector leads in this area due to its vulnerability, but also because of its historical experience in risk management and climate-related risks.

How would the probblem evolve without further EU action?

In the short term, the effect of climate change on insurance might not be thought to be significant, as long as due allowance is made for the underlying trend For example, prices would rise gradually, and the market would absorb such changes without disruption. However, risk knowledge often advances in 'steps', which can lead to jumps in the price over a short period.

In the longer term, particularly in sectors or areas where insurance has not been customary, climate change could create or exacerbate issues with correct pricing and availability. In particular, sea level rise will become an issue for coastal and estuarine risks. The problem of drought for agriculture and livestock may also become more serious. Drought-related subsidence may also become a greater issue for the built environment in some regions where clay soil is sensitive to the absence of water (Swiss Re, 2011). Potential losses from storm and flood could also rise significantly (ABI, 2005; GDV, 2011), but the actual increase would be highly dependent on changes in exposure and vulnerability.

Potential actions by 2020 to increase resilience

As stated by stakeholders in the sector, the insurance sector should no longer be regarded solely as a provider of compensation for losses. The Insurance buffer function is of great importance for the economy since it allows insured parties to plan with more certainty by covering specific risks that could otherwise threaten business continuity. Yet, in adaptation too, the role of insurance goes much further. Insurance is an integral part of the whole risk-management cycle, from risk identification to risk transfer and recovery.

A Green Paper on the insurance and prevention of disasters is under preparation. It will be a first step for a better understanding of the role that insurance can play to promote adaptation.

1.2.1.7. Tourism

Expected impacts of climate change

Tourism is a major economic sector in Europe, with the current annual flow of tourists from Northern to Southern Europe accounting for one in every six tourist arrivals in the world. Climate change has the potential to radically alter tourism patterns in Europe by inducing changes in destinations and seasonal demand structure (Ciscar et al. 2009). There are a number of specific projected impacts on the tourism sector as a result of climate change and from increased risks of water scarcity, changes in winter/snowfall and temperature change. The biggest adverse impacts would appear to be from changes in summer tourism flows (in the Mediterranean region) and winter skiing (in the Central region). The likely effects of climate change on the tourism sector vary widely, depending on the location and the season (Altvater et al., 2011b).

High levels of economic dependence on the tourism industry in some southern countries will make these areas more vulnerabl to the impacts of climate change. Negative climatic consequences will have particularly serious effects if climate-sensitive tourism has major economic importance. Conversely, some benefits are to be expected in other areas, which may benefit from a shift in tourist flows.

How would the problem evolve?

The Tourism and Recreation sector appears to have a general idea of the risks that it will face in light of climate change. However, only firms in regions that are already affected (Northern Mountains and Tropical Destinations) are adapting to climate change using technical, managerial, financial, or behavioural adaptations. It is unclear how tourism in other areas will be affected by climate change, it appears that stable weather is an important determinant of destination attractiveness.

1.2.2. Environmental systems

1.2.2.1. Soil

Expected impacts of climate change

Both the agricultural and forestry sector are closely connected with soil and affected by soil degradation through soil carbon loss, erosion and salinization[17]. Around 45% of soils in Europe have a low or very low organic matter content (meaning 0-2% organic carbon) and 45% have a medium content (meaning 2-6% organic carbon). Soil organic matter plays a very important role not only for soil fertility, for maintaining soil structure, for buffering and water retention capacity and for soil biodiversity. It is also an important organic carbon stock, estimated to between 73 and 79 billion tonnes in the EU (some 1,500 billion tonnes at the global level – that is around twice the amount of carbon in the atmosphere and three times that to be found in vegetation). It is important to underline that the soil organic matter cycle is based on continually supplying carbon in the form of organic matter as a food source for microorganisms, the loss of some carbon as carbon dioxide, and the build-up of stable carbon in the soil. If the rate of assimilation is less than the rate of decomposition, soil organic matter will decline and, conversely if the rate of assimilation is greater than the rate of decomposition, soil organic matter will increase. Both the assimilation and decomposition processes occur concurrently, but are of a different order of magnitude – organic matter can be lost instantaneously (e.g. by fire) or very quickly (e.g. in case of grassland conversion to arable land), whereas its build-up is spread over several decades.

The northern latitudes are most affected by increased CO_2 and methane emissions from decomposition of organic matter in soil. Currently decomposition processes are limited by low temperatures and permafrost. Although the Mediterranean region is historically most

[17] COM(2006) 231 and COM(2012) 46.

severely affected by erosion there is growing evidence of significant erosion occurring in other parts of Europe as well (e.g. Austria, Czech Republic and the loess belt of Northern France and Belgium). Artificial salinization occurs in Portugal, Spain (Ebro valley), Italy (Sicily), France, Greece, Hungary, Slovakia and Romania. Coastal areas and irrigated agricultural land are sensitive to salinization. In Europe, 13 of the 27 EU member states have declared themselves affected under the UNCCD[18].

Climate change may aggravate erosion, decline in organic matter, salinization, soil biodiversity loss, landslides, and flooding. The effect of climate change on soil carbon storage can be related to changing atmospheric CO_2 concentrations, increased temperatures and changing precipitation patterns. Extreme precipitation events, fast melting of snow or ice, high river discharges and increased droughts are all climate related events which influence soil degradation. Deforestation, inappropriate agricultural practices, urbanization and other human activities (e.g. skiing) also play a role. Saline soils are expected to increase in coastal areas as a result of salt water intrusion from the seaside, because of rising sea levels and (periodically) low river discharges. Soil biodiversity is already under threat because of soil contamination, acidification, soil sealing and other human-induced impacts[19]. There is little information available on impacts of climate change on soil biodiversity. Landslides in Europe are most often the result of soil saturation with water from heavy rainfall events and snow melt in combination with inappropriate land use and land use changes (e.g. deforestation and building activities). Desertification often results from the overexploitation of vegetation cover leading to topsoil erosion and hence reduced productivity, or improper water use resulting in salinization. Desertification is aggravated by prolonged droughts.

The predicted increase in temperatures and decreases in summer precipitations could lead to higher soil moisture deficits, which area also likely happen earlier in spring affecting the growing season of crops and their water needs.

Some recent studies suggest that soil organic carbon in European agricultural land is decreasing. The EEA expects an increase in erosion risks of 80% in agricultural areas in Europe, especially in places where erosion is already severe. The 2006 Soil Thematic Strategy indicates that erosion is increasing in Europe; at that moment in time, 3.4% of the area (1.6 million hectares) of the 21 Member States covered in the assessment is at risk from erosion of more than 10 tonnes per hectare per year, and 18% (54 million ha) are at risk of losing soil above 1 tonne per hectare per year. As for soil sealing, in the European Union (EU) at least about 1,000 km² - an area larger than the city of Berlin - were subject to land take annually for new infrastructure - housing, industry, roads or recreational purposes - between 1990 and 2006.

Soil consumption due to land take (urbanization often decoupled from population growth) will contribute to climate change. The loss of water retention and evaporation potential is going to influence weather patterns and local climate conditions, in urban areas often expressed in overheating during summer periods. Due to sealing land is deprived of its function to act as a sink for atmospheric carbon, to be fixed as carbon in soil organic matter or vegetation. In order to maintain these ecosystem functions of soil the 2011 Roadmap for a Resource efficient Europa is promoting a zero-net land take rate in Europa by 2050.

Sealing of soil caused by built-up areas (not only but particularly on floodplains and water retention areas) impacts on the storage capacity of the floodplain, increasing the risk of

[18] Bulgaria, Cyprus, Greece, Hungary, Latvia, Italy, Malta, Portugal, Romania, Slovakia, Slovenia, and Spain

[19] See the European Atlas of Soil Biodiversity, particularly pp. 62-63 (http://eusoils.jrc.ec.europa.eu/library/maps/biodiversity_atlas/index.html).

flooding and flood damage. The increasing number of flooding events and their seriousness in these areas can be partly attributed to the reduction of open space (decreasing retention capacities of agricultural land, caused by compaction and low levels of organic matter, can be concurrent factors). For example, the costs of the summer floods in England in 2007, classified as a national disaster, have been estimated to be more than £ 3.2 billion (approximately €4.5 billion).

The Commission's services have recently published a working document containing Guidelines on Best Practice to Limit, Mitigate or Compensate Soil Sealing[20] informing about magnitude of soil sealing in the European Union, its impact on the environment – including the climatic aspects – and examples of best practice.

The 2012 implementation report on the Soil Thematic Strategy (COM(2012) 46) confirmed on-going and increasing soil degradation, highlighting the preservation of soil organic matter as one of the main challenges. Keeping terrestrial carbon stock is not only essential for food security but for the fulfilment of present and future emission reduction commitments.

There is a lack of data on the different degradation processes that makes it difficult to assess its full impacts and the development at European scale.

Policy context and current adaptation activities

The European Commission adopted a Soil Thematic Strategy (COM(2006) 231) and a proposal for a Soil Framework Directive (COM(2006) 232) on 22 September 2006 with the objective to protect soils across the EU. The strategy has four pillars, namely awareness raising, research, integration, and legislation. The framework would consist of a risk analysis by the Member States for erosion, organic matter, salinization, compaction and landslides.

Agriculture is a key sector for maintaining carbon stocks and soil fertility and avoiding deterioration due to erosion, salinization, compaction etc. The CAP has an important role in protecting soils, avoiding depletion of organic matter - especially on carbon rich soils (peat land, pastures) – and supporting agro-environmental measures aiming at carbon sequestration, and a better care of soils which sustain agricultural activities.

Current soil related activities at EU level involve:

- Work on the Soil Thematic Strategy, aiming at the implementation of an EU Soil Framework Directive;
- Activities of the JRC working group in the area of climate change and soil biodiversity;
- The European Soil Data Center as one of the ten environmental data centres in Europe and acting as the focal point for soil data at European level; its Soil Portal, contains soil data and provide links to national or global datasets. The website serves also as a vehicle to promote the activities of the European Soil Bureau Network.

Main barriers to action

Despite on-going degradation of soil resources in Europe and globally, as stated in the 2012 Commission report on the implementation of the Soil Thematic Strategy (COM(2012) 46), no agreement has been reached so far within the Council on the proposed Soil Framework Directive, due to a blocking minority. Further barriers relate to a lack of coherent and EU

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[20] European Commission [SWD(2012) 101] - *Guidelines on best practice to limit, mitigate or compensate soil sealing*. Available at http://ec.europa.eu/environment/soil/sealing_guidelines.htm

wide data on the different soil degradation processes as well as little information available on impacts of climate change on soil biodiversity.

How would the problem evolve by 2020 without further EU action?

Soil degradation in the European Union is accelerating due to inappropriate farming practices (erosion, organic matter decline), salinization (climate change impacts on water, irrigation), landslides (intensive land use), contamination (industry and mining) and soil sealing (urbanization). As neither most Member States nor the EU have an integrated soil protection policy in place, the degradation is likely to proceed. For example, in the eight years to the end of 2020 we can expect that an extra 8,000 km² of European fertile land will be lost to food production, around 4.5 billion tonnes of topsoil will have been washed away because of water erosion, more than 700 million tonnes of CO_2 will have entered the atmosphere as a result of soil organic matter losses from cropland, and 62% of the habitats and 52% of the species covered by the Habitats Directive would continue to be in an unfavourable conservation status[21].

Potential actions by 2020 to increase resilience

Knowledge (examples): Areas where the most basic knowledge is lacking include: i) the costs of climate change related to soils and land use; ii) soil biodiversity; iii) the social impacts related to soils and land use. Areas where aggregation of knowledge to the EU level is needed comprise: i) monitoring soil carbon storage; ii) soil erosion; iii) soil salinization; iv) landslides.

Technical options (examples): i/ Soil carbon storage: appropriate water management to preserve peat soils; ii/ Erosion: contour ploughing, terracing, improving vegetation cover, roughening of soil to slow down water flows, wood fibre matting and adding mulch to enhance water absorption by the soil; iii/ Prevent salinization with sustainable water management; iv/ Landslides may be prevented with proper land management, by taking care of the balance between soil and biotic structures; v/ Prevent soil sealing, limit soil sealing with semi permeable bricks or asphalt; to compensate for soil sealing in other areas.

1.2.2.2. Biodiversity

Expected impacts of climate change

There is clear evidence to show that biodiversity is already responding to climate change and will continue to do so. Species respond individualistically, with direct impacts including changes in phenology, species abundance and distribution, community composition, habitat structure and ecosystem processes. Climate change is also leading to indirect impacts on biodiversity through changes in the use of land and other resources. These may be more damaging than the direct impacts due to their scale, scope and speed and include: habitat fragmentation and loss; over-exploitation; pollution of air, water and soil; and spread of invasive species. They will further reduce the resilience of ecosystems to climate change and their capacity to deliver essential services, such as climate regulation, food, clean air and water, and control of floods or erosion.

Vulnerability assessments have been undertaken in relation to potential impacts of climate change on some species, habitats, ecosystems and ecosystem services and their adaptive capacity. Assessments show vulnerability primarily arises where species are constrained in colonising new areas with suitable climate. The vulnerability of habitats to climate change is also likely to be a problem for species, particularly habitat specialists already constrained by

[21] Annex 6 to the Impact Assessment on the proposal for a general Union Environment Action Programme 'Living well, within the limits of our planet', SWD(2012) 398, p. 30.

habitat availability and/or condition. Climate change is likely to exacerbate such threats, rather than create new opportunities.

Vulnerability assessments suggest that the majority of species studied are likely to be vulnerable. One study ranked the vulnerability of 64% of 212 species assessed as high, very high, critical or extremely critical under at least one future climate change scenario .

Policy context and current adaptation activities:

The EC White Paper on adapting to climate change has recognised the significance of climate change for biodiversity loss and has highlighted that it is important for the EU and Member States "To promote strategies which increase the resilience to climate change of health, property and the productive functions of land, inter alia, by improving the management of water resources and ecosystems". The new EU biodiversity strategy to 2020 goes on to state that "Ecosystem-based approaches to climate change mitigation and adaptation can offer cost-effective alternatives to technological solutions, while delivering multiple benefits beyond biodiversity conservation". It aims to restore degraded ecosystems and maintain and enhance ecosystem services by incorporating green infrastructure into spatial planning.

Other existing EU instruments (e.g. the Birds and Habitats Directives) explicitly address the implications of climate change for biodiversity. A set of seven overarching biodiversity adaptation principles have been identified for the Bern Convention. Each principle gives rise to a number of more detailed measures whose relative weight depends on each sector's: impacts and dependencies on biodiversity; threats and opportunities that could be addressed by integrated action; synergies with other sectors; and scale of activity (e.g. EU, Member State, local).explicitly address the implications of climate change for biodiversity. A set of seven overarching biodiversity adaptation principles have been identified for the Bern Convention . Each principle gives rise to a number of more detailed measures whose relative weight depends on each sector's: impacts and dependencies on biodiversity; threats and opportunities that could be addressed by integrated action; synergies with other sectors; and scale of activity (e.g. EU, Member State, local).

Ecosystem-based adaptation activities are currently mostly driven by the biodiversity sector. However, there is growing recognition of the importance of ecosystem-based approaches by other sectors, particularly in relation to coastal protection, urban planning and water management.

Main barriers to action

Successful adaptation requires that the conservation of biodiversity and ecosystem services is fully integrated with other land and water management and economic activities. Additionally, whilst Member State policies to tackle climate change adaptation at a national level are essential, the state of development of these across the EU is currently variable.

The EU 2020 biodiversity strategy recognised that, in addition to its intrinsic value, biodiversity and the services that ecosystems provide have significant economic value that is seldom captured by markets. Biodiversity often falls victim to competing claims on its use because it escapes pricing and is not reflected in society's accounts. The report on The Economics of Ecosystems and Biodiversity (TEEB) recommends that the economic value of biodiversity should be factored into decision-making and reflected in accounting and reporting systems. Quantifying links between biodiversity and ecosystem services and estimating their value is clearly an urgent requirement that currently remains far from completion. However, there is also a cultural barrier to broad uptake of ecosystem-based solutions, which are ready to hand, as many people, including decision-makers, believe

climate change is a technological problem that needs to be addressed by technological solutions.

How would the problem evolve by 2020 without further EU Action?

Delay in further EU action will result in more severe impacts on biodiversity and the delivery of essential ecosystem services, including climate regulation and adaptation, fewer available options and increased costs of damage and intervention to maintain these essential ecosystem services. This is mainly due to the length of time that it will take to implement adaptation actions and for biodiversity to respond to them.

Costs of inaction would be dwarfed by the costs to society of biodiversity loss, as many economic actors in sectors depend directly on ecosystem services. For example, insect pollination in the EU has an estimated value of € 15 billion per year. The continued decline of bees and other pollinators could have serious consequences for farmers. The TEEB report estimated that if nothing is done, the loss of terrestrial biodiversity alone could cost 7% of GDP by 2050, with loss of marine ecosystem services adding substantially more.

Potential actions by 2020 to increase resilience

Evidence needs, which should be identified and addressed with stakeholder participation across all sectors, include: identification of the impacts and dependencies of all sectors on biodiversity and ecosystem services, and estimates of their economic value; monitoring of direct impacts of climate change and, where possible, indirect impacts (e.g. associated with land-use change and underlying socio-economic drivers); vulnerability assessments of EU species and habitats (notably within the Natura 2000 network); establishing possible impacts of invasive alien species; scenario assessments and identification of 'no regrets' actions; piloting of new approaches through demonstration projects; assessing the effectiveness of adaptation actions and changes in management strategies.

Appropriate development of biodiversity adaptation indicators, involving stakeholders from across all policy areas, might do much to catalyse development and integration of policy objectives that promote ecosystem-based adaptation across sectors. Indicator development could bring cross-sectoral attention to the need for a wide range of EU policies to address sectoral impacts and dependencies on biodiversity, and the associated threats and opportunities that could be addressed by integrated actions, which not only support biodiversity but also achieve required sectoral outcomes.

Climate change highlights the need to adopt an increasingly dynamic approach to conserving biodiversity and ecosystem services. The movement of species needs facilitating by: enhancing the ecological quality of existing habitats, reducing external impacts (e.g. by establishing buffer zones and controlling pollutant emissions) and managing species populations (e.g. controlling exploitation and impacts of invasive alien species); increasing the area of available habitat by restoring degraded habitats and creating new habitat adjacent to existing sites; increasing/restoring habitat connectivity through landscape-scale conservation measures (e.g. restoring degraded habitats and creating new habitats as 'stepping stones' between existing habitat patches, enhancing the permeability of the wider matrix between habitat patches, and creating habitat corridors to physically link them).

Furthermore, ecosystem services and their valuation could be linked to a wide range of existing financial tools, such as carbon markets and eco-tourism fees, which attract a wider range of funders, including private finance. These payments, be they government or public, voluntary private or regulation-driven private, could be used to maintain and improve biodiversity and ecosystem services that support climate change adaptation across all sectors that make use of land and natural resources.

1.2.2.3. Inland water

Expected impacts of climate change

Potential actions by 2020 to increase resilience:Floods, Droughts and Water Scarcity have already affected large parts of the European Union and have an important impact on socio-economic developments. In the future, climate change is likely to change water availability and global warming will probably increase both the number and magnitude of hydrological extremes

Scenarios developed under the SCENES project estimated potential impacts of climate change. In western Europe, the energy sector in particular is extremely vulnerable to water scarcity and droughts under the EcF scenario conditions because of increased electricity production. Extreme flood events are expected to increase in eastern Europe, leading to loss of life and higher flood damages. For example, among the European countries, Hungary is likely to suffer from the highest costs in percent of GDP due to direct impacts of flooding. Flooding damages might decrease the Hungarian GDP by 0.09% in 2050. In southern Europe, agriculture is the major water use sector and could suffer significant economic losses if water scarcity and drought events are more frequent and severe under climate change. In northern Europe, water stress only occurs in a few places (e.g. BE) and only (locally) the thermoelectric sector may be at risk during low flow periods.

The recently completed ClimWatAdapt project investigated the future water situation and developments in the water sector in Europe until 2050 in terms of "vulnerability to water scarcity", "vulnerability to droughts", and "vulnerability to floods". The ClimWatAdapt project concludes that changes in future water scarcity are mainly driven by changes in water withdrawals. Under the EcF (Economy First) scenario, the percentage of area under severe water stress is expected to increase in all regions until 2050, with major changes in particular in eastern, western, and southern Europe. Increasing water withdrawals are the main cause in eastern and western Europe. In southern Europe a decrease in water availability due to climate change exacerbate the situation. Mostly, water stress will not occur in northern Europe, with some localized exceptions (e.g. the UK). In river basins under severe water stress, there will be strong competition for scarce water resources between households, industry, agriculture, and nature. Overall, this situation is most severe during summer when river flows are low and are becoming lower due to climate change. Additionally, the water demands are highest during the summer due irrigation demands and tourism water use.

Such stress on water resources would also impact on the energy sector, given the cooling needs of thermal power stations and the water flow needs of hydro-power stations.

Climate change will also affect drinking water supply from ground and surface water.[22] In particular changes in groundwater recharge and low flow conditions are the main issues. Most vulnerable areas include: i/ coastal aquifers, because of the combined effects of increasing sea levels, reduced recharge and often high abstraction pressures; ii/ Mountainous, permafrost and boreal areas, where increasing temperatures lead to changes in snow accumulation and melting, with resultant impacts on groundwater recharge and discharge; iii/ • Most small islands are especially vulnerable to future changes and distribution of rainfall because they have a limited water supply, and water resources; iv/ in the case of increasing frequency of flood events, combined with associated increased pollutant peaks (combined sewer overflows, pesticide runoff etc) all drinking water resources along rivers could be impacted as well as

[22] See second interim report to the study: "Literature review on the potential climate change effects on drinking water resources across the EU and the identification of priorities among different types of drinking water supplies – ADWICE project" contract DG ENV 070326/SER/2011/610284/D1

systems that use bank filtration. However it should be noted that additional pressure will arise from socio-economic pressures due to increased urbanisation, growing water demand in other sectors (in particular agriculture) and further loss of ecosystems.

Policy context and current adaptation activities:

The Water Framework Directive (WFD) commits the EU Member States to achieve good ecological status of all surface waters, including marine waters, and good chemical status of groundwater by 2015. The WFD does not explicitly refer to adaptation to climate change. However when drafting the guidance document No. 24 River Basin Management in a Changing Climate (EC 2009) it was agreed that from the second planning cycle onwards climate-related threats and adaptation planning should be incorporated in RBMPs. In order to address the issue of water scarcity and droughts in the EU, in 2007 the European Commission issued a Communication COM/2007/0414 final 'Addressing the challenge of water scarcity and droughts in the European Union'. The communication lists a set of policy options that are implementable as a concerted EU action to increase water efficiency and water savings, and to improve drought preparedness and risk management.

The Directive 2007/60/EC (Floods Directive) sets to prevent and limit floods and their damages on human health, the environment, infrastructure, cultural heritage and property. The Directive obliges the Member States to assess risks posed by each Member State's water courses and coast lines, and to produce maps of area subjected to floods of different intensity. Climate change should thereby considered.

The Rural Developmentstrand of the Common Agricultural Policy, also give support to climate adaptation measures in the field of water management by agricultural sector.

Main barriers to action:

Governance issues may prevent the uptake of innovative measures to achieve the WFD objectives, e.g. taking advantage of natural retention over hard flood defenses. and to work with a more integrated and comprehensive approach on sustainable land management and in this way overcome the sectoral compartmentalisation

As regard to adaptation measures there are several barriers preventing implementation such as i) lack of concrete rules or definitions for implementation of measures; ii) lack of coordination of measures across river basins or administration units; iii) lack of concrete financing sources in some cases; iv) measures are often voluntary;When the EU water directors endorsed the guidance document on climate change, they also agreed that climate change will be considered in the 2nd and 3rd implementation cycle of the WFD. However the assessment of the first river basin management plans showed that almost all Member States are working on the issue of climate change to a different extent. It is expected that these efforts will be strengthened with the adoption of the EU communication "Blueprint for Safeguarding Europe's Water' ." and the commitment made by the water directors. In order words it is expected that several more adaptation measures will be taken in the future to mitigate the impacts of floods and droughts.

How would the problem evolve by 2020 without further EU Action?

Many actions promoted by the forthcoming Blueprint will also be very relevant to tackle climate change adaptation issues.

1.2.3. Social issues

The table below summarises the socio-economic impacts of climate change.

Table 1: climate change challenges and their socio-economic impacts (Source: ILO, *Skills for green jobs* (2011))

Climate change major features	Major areas of impacts	Possible impacts on employment	Possible impacts on income
Rising average temperature	Health, food security, water, resources	√	√
Higher climate variability	Food security, water	√	√
High incidence of droughts and floods	Food security, population displacement, resources	√	√
Melting of glaciers	Food security, water	√	√
Rising of sea levels	Coastal areas	√	√
Loss of biodiversity	Food security, resources	√	√

1.2.3.1. Health

Expected impacts of climate change

Climate change will impact Europe citizen´s health, animal (livestock) and plant (food security, environment, agriculture) health as well as cause (damage) costs related to direct and indirect health impacts. Increases in the annual mean temperature projected for all regions, while stronger in the North, South Central and Mediterranean Europe. The numbers of frost days are decreasing. The annual mean number of summer days will be increasing in the Southern-central and Mediterranean Europe the strongest. Annual mean precipitation in winter months will be mostly increasing, especially in Northern Europe, but not in the Mediterranean. Annual mean precipitation in summer months will be mostly decreasing especially in Southern-central and Mediterranean Europe and heavy rainfall will be increasing in Northern-western and Northern Europe and decrease in Mediterranean Europe. A variety of impacts are projected for European countries. The most important effects on human health from future climate change are projected to include increases in summer heat related mortality (deaths) and morbidity (illness) (Watkiss et al., 2009; D`Amato et al., 2007); decreases in winter cold related mortality (deaths) and morbidity (illness); increases in the risk of accidents and wider well-being from extreme weather events (floods, fires and storms); changes in the disease burden e.g. from vector-, rodent-, water- or food-borne disease; and changes in the seasonal distribution of some allergenic pollen species, range of virus, pest and disease distribution.

The expected increase in heat/thermal stress is related to mortality from annual temperature increases and heat extremes. Additional human diseases will increasingly challenge EU public health. Allergen potency and atmospheric transport of pollen will become more intense. More extreme events such as floods, storms, droughts & wild fires are expected by recent climate projections. Also the increase of risks in relation to change in air quality and ozone are likely.

Climate change may impact on animals' living conditions and bring forth pathologies such as parasitic diseases, nutritional disorders, sunstroke or dehydration which can be very important for the farmers' economic situation.

The control of transmissible infectious animal diseases at EU and international level includes diseases considered to respond to climatic changes especially vector-borne diseases dependent on specific weather conditions and those transmitted by wildlife. Climate change is likely to have facilitated the expansion of Bluetongue in Europe (e.g. Martinuzzi, A. 2008[23]*)*

[23] DG SANCO (2008): Sustainability project, Synthesis Report;
Takken W., Knols B.G.J. (2007): Emerging pests and vector-borne diseases in Europe, Ecology and control of vector-borne diseases, Volume 1, *Wageningen Academic Publishers*.

Climate change may impact on plant health by allowing for the expansion of the range of pests that so far could not establish in the Union thanks to increased temperatures allowing them to survive wintertime and to have multiple generation cycles per year, and by increasing the susceptibility of crops and trees to new dangerous pests of plants from other continents. Climate change thus increases the vulnerability of plants while at the same time the globalisation of trade allows new pests to reach the Union. Large-scale outbreaks of new forest pests could change European forests from a carbon sink into a carbon source, as has happened in Canada (mountain pine beetle). The EU plant health regime is in place to protect the Union against the entry of such dangerous pests that so far do not occur in the Union.

Policy context and current adaptation activities:

Existing policies related to human, animal and plant health like the EU Health Programme 2007-2013, EU Ambient Air quality and Cleaner Air Directive, EU Animal Health Strategy (2007-2013) including the revision and consolidation of veterinary legislation by a New Animal Health Law, the review of the EU plant health legislation are good starting points for the inclusion of climate change adaptation aspects.

Current activities are related to the i) protection of people from health impacts (e.g. thermal stress, disasters) and diseases, ii) protection of animal health related to healthy food production and the well-being of European citizens, iii) protection of plant health for ensuring sustainable and competitive agriculture and forestry and for protecting the environment, public and private green; and iv) promotion of healthy lifestyles, and helping national authorities in the EU cooperate on health issues also related to climate change. Latest developments with regard to early warning systems (e.g. heat, flood, drought, forest fire, storms), European Centre for Disease prevention and control (ECDC) and Disease information systems and surveillance and strenghtening of the emergency response systems serve as proactive developments, support climate change adaptation activities.

Main barriers to action

Climate change impacts are already being taken into account by health authorities and relevant actors are aware of future challenges related to climate change. Nevertheless, there is a need to close existing knowledge gaps, which might be a barrier to action, like the lack of consistent and comparable epidemiological studies and analysis including urban effects of heat related impacts and additional impacts (heat waves). Also the possible interactions between climate and air pollution on ozone need to be analyzed in more detail. Also the analyses of food-borne disease, besides salmonella are a challenge. The national and sub-national (financial) capacities might not be sufficient to address health risks and might need financial support, especially in European areas, where health care services are not so well established.

How would the problem evolve by 2020 without further EU Action?

Temperature increase will, according to climate projections increase the number of heat related deaths. More than 70.000 excess human deaths were reported from 12 European countries in the hot summer of 2003. The mortality risk increases between 0.2 and 5.5 % for every 1°C increase above a location-specific threshold. Long heat waves (more than 5 days) have an impact 1.5 to 5 times greater than shorter events. The reduction of ability to work, resulting in a lower productivity e.g. shortening/ delaying delivery of products and services will impact European economy. 86.000 net extra deaths per year are projected for EU Member States (high-emissions scenario) with a global mean temperature increase of 3 °C in 2071–2100 relative to 1961–1990. Although the timeframe is longer than 2020, heatwave

plans like the one for England can be prepared by all Member States with EU support, also clearly clarifying the responsibilities for action.

The climate is becoming more suitable for certain disease carrier like e.g. the Asian tiger mosquito (Aedes albopictus). Europe will have to deal with certain human, animal and plant pests and diseases which were in the past very rare and were mostly imported via international trade or tourism. Climate change and globalisation are mutually reinforcing human/, animal and plant health problems.

Changes in weather/precipitation pattern and increases in extreme events are projected; therefore, more intense and frequent events are expected. Especially floods and storms are the most common natural disasters causing loss of life and economic damage in Europe. Already in the past 20 years, 953 disasters killed nearly 88,671 people in Europe, affected more than 29 million others and caused a total of 250 EUR billion of economic losses. Climate change related challenges might even increase these numbers in the future.

Potential actions by 2020 to increase resilience:

It is of great importance to identify research needs and gaps in order to develop a sound knowledge base. The project "The Sustainability of DG SANCO policies – New Consumption and Production Patterns" (DG SANCO, 2008) e.g. suggests developping "an adaptation tool box" in order to cope with most climate change related health challenges. There is potential in collecting more data on EU-level to achieve the best possible disease surveillance for the EU, and also raise awareness. Especially the communication of direct and indirect impacts of human, animal and plant health in a changing climate and a context of increasing globalisation of human movements and trade needs to be strengthened. Therefore a strong protective and more pro-active approach in the health sector is of importance.

There is a need for Member States and their regions to allocate the adequate financial resources for health within their EU Cohesion Policy programmes from 2014 onwards to deal with climate challenges and link forecasting tools (e.g. heat, floods, wild fires, storms) with the health sector on a cross-border scale.Early warning for air pollutants, especially ozone shall be closer connected to health services in order to effectively react & ensure in timely actions.

The EU Animal Health Strategy (2007-2013)[24]and its Action Plan[25]focuses on preventing rather than reacting to animal diseases including considering the influence of Climate Change on animal diseases. A new Animal Disease Information System (ADIS) is being developed to improve the gathering of epidemiological data. Stepping up animal disease surveillance and the establishment of further vaccine banks for certain animal diseases will enable risk managers to better respond to emerging disease situations. The proposal by the Commission of a new Animal Health Law is foreseen during 2012. It will consolidate the exhaustive existing animal health legislation and put emphasis on preventive measures such as surveillance activities. The rules will be flexible allowing quick adaptation of diseases control measures to changes in disease patterns including those resulting from climate change.

The EU Plant Health Regime is being reviewed so as to reinforce the protection of the Union against new and dangerous pests from outside Europe. Prevention will be strengthened by targeting high-risk commodities imported into the Union, and surveillance for outbreaks of new pests will be reinforced to ensure early detection and immediate eradication of those outbreaks. More and better instruments for eradicating pests are foreseen. Increased Union

[24] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2008:152:0001:0044:EN:PDF

[25]http://ec.europa.eu/food/animal/diseases/strategy/docs/COMM_PDF_COM_2008_0545_F_EN_AUTRE_PROC_LEG_NOUVELLE.pdf

financial support for these measures is considered. The proposal by the Commission of a new Plant Health Law is foreseen during 2012. It will replace the current basic acts by a single, transparent and flexible framework, suitable to address the increasing problems experienced with plant health.

Additionally, the upcoming EU Strategy on Invasive Species can support the monitoring (e.g. detection via early warning mechanisms and rapid eradication) and reporting procedure, monitor climate related changes on invasive species distribution, survival and spread, and foster the exchange of information on potential eradication strategies.

1.2.3.2. Employment

The impact of temperatures increase, changes in precipitation regimes and sea-level rise will affect – directly or indirectly – productivity and viability of nearly all economic sectors across all EU Member States.

Rising temperatures and erratic weather pattern will in many places reduce the land and natural capital productivity. More frequent and intense heat waves, and altered transmission seasons and geographic range of important vector-borne diseases will lower labour productivity. As a result of sea level rise and increased intensity of climate extremes, physical capital assets will be more frequently impaired and important lifelines disrupted with wide reaching economic and social consequences.

There is mounting evidence that climate policy driven transition towards low-carbon, resource efficient and green economy may positively affect employment market, and create opportunity for more environmentally-related and qualitatively better jobs. Significant efforts have been done by the Commission to better understand labour market challenges to developing a green economy, in terms of net job creation as well as in terms on the impacts on skills.[26]

Although there is no clear quantitative evidence yet of jobs created in an "adaptation" sector, it should also be underlined that it is sometimes difficult to make a clear distinction between adaptation and mitigation and thereby related employment. For instance, buildings' renovation supports both mitigation and adaptation. In addition, activities related to water management, waste water management and water supply are included in the Eurostat statistics on eco-industries, which provide information on employment related to activities with environmental purposes. The global market for eco-industries is estimated at roughly EUR 1.15 trillion a year (2010 figures for turnover) and there is a broad consensus that the global market could almost double, with the average estimate for 2020 being around EUR 2 trillion a year.[27] The average annual growth in employment in the eco-industries in 2000-2008 was 2.7%. Total numbers employed have grown from 2.4 million in 2000 and 3.0 million in 2008 and are forecast to reach 3.4 million in 2012.

Climate change adaptation contributes to **preserving existing** jobs through maintaining viability and resilience of existing businesses. Many adaptation measures will require substantial investments which can stimulate demand for labour. A recent study estimated the annual cost of adapting to global warming of modest level (+2°C compared to pre-industrial times) to between 70 and 100 billion worldwide between 2010 and 2050[28].

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[26] See Exploiting the employment potential of green growth, Commission Staff working document, SWD (2012) 92 final and source quoted.

[27] See Commission study *The number of jobs dependent on environmental and resource efficiency improvements,* 2012. .

[28] The World Bank 2010. The Economics of Adaptation to Climate Change: Synthesis Report. Washington DC, The World Bank

Climate adaptation is not only an instrument contributing to maintain the EU's macro-economic stability and growth, but it is also a growing market, with expected business opportunities for European firms on the EU and global markets. Thus, **adaptation will create new demand and market opportunities and increase need for innovation.** For instance, with increased water scarcity envisaged, the need for irrigation will continue. While innovations in irrigation appear to reduce downstream employment opportunities due to more efficient techniques, the European companies can grasp opportunities from selling water-efficient agricultural irrigation technologies worldwide. Approximately 28% of cropland is now under irrigation, with half of this located in Asia[29]. But European companies will need to improve their products and invest in R&D to compete to existing and forthcoming competitors from Asia.

However, not only the number of jobs generated matters. Attention will have to be paid to 'decent work and quality jobs'. Labour market and climate change adaptation policies must be approached hand in hand to make sure adaptation to climate change can contribute to economic transformation.

The results of the online consultation show that even though many stakeholders identify potential job creation in the medium term due to climate change adaptation action, only environmental NGOs seem to anticipate short-term benefits.

Modelling GDP impacts and sectoral shifts in economic activity due to climate change

In the context of the support to this project, a computable general equilibrium modelling exercise was undertaken on the potential economic implications of climate change. Impact types considered are those originated by: sea-level rise, changes of energy demand, of crops productivity, of fish stock productivity, of tourism flows, ecosystem losses, flooding and health.

Impacts are also economically assessed for a 2 °C and 4 °C warming scenarios, both are assumed to occur in 2050. The EU 27 as a whole experiences a GDP loss of the 0.16% and the -0.74% in the 2°C and 4°C cases respectively. The apparent low vulnerability of the EU hides important country specificities: the southern EU region is more severely hit with Greece top-loser (-1.76% and 6.24% of GDP in 2050 in the 2°C and 4°C temperature increase scenarios respectively), the Northern one gaining or remaining basically unaffected. Among impacts type, at the country level, agriculture clearly dominates, followed by tourism and ecosystem. These three impacts together build more than 70% of the final GDP result in the majority of the EU countries. Interesting is also country specific vulnerability. For instance, in Greece and Spain, agriculture and tourism impacts are by large the more concerning; agriculture is less of an issue in Italy, Belgium and Poland, where on the contrary tourism and ecosystem losses there appear to be more important.

The model used depicts a Walrasian, perfectly clearing/full employment labour market therefore unemployment is not modelled. Any shock on the labour market implies just a re-distribution of the labour forces from those sectors whose production, and factor prices, are declining in relative terms, toward those sectors where the opposite happens. This said, the redistribution of the labour force could indirectly provide some insights of possible tensions on the labour market that climate change may originate. In 2050, when the temperature increases 2°C, higher labour demand contractions are concentrated in the agricultural sector especially in Greece (-5.7%), Spain (-5.9%) and Portugal (-2.7%); in the fishing sector in Italy (-7.9%) and Spain (-4.5%); in the service sector in Hungary (-1.3%), Italy (-0.7%) and

[29] See Commission study *The number of jobs dependent on environmental and resource efficiency improvements,* 2012.

Portugal (-0.5%). Industrial labour demand declines particularly in Finland (-4%), Sweden (-1.6%) and Hungary (-1.4%); energy sectors tend also to expel labour force.

There has been some progress in better understanding labour market challenges to developing a green economy[30], yet there is still not enough quantitative evidence about how many new jobs can be created and what skills will be required as the communities and sectors turn better adapted and prepared to the likely impacts of climate change. Furthermore, it is difficult to disentangle climate adaptation activities from development and economic transformation driven by other factors. Hence, there is an urgent need for additional assessments on the long-term, indirect and induced effects of climate adaptation policies on labour patterns and markets

Literature review on employment implications of climate change adaptation

Climate adaptation will enable the economic sectors to better cope with the impacts of climate change and avoid to some extent economic and social disruptions. On the face of it, climate adaptation contributes to preserving existing jobs through maintaining viability and resilience of existing businesses. Many climate adaptation measures will require one-time investments which temporarily stimulate demand for labour. Long-term indirect and induced effects on employment on labour patterns and markets are difficult to demonstrate (Harsdorff et al. 2011). Up to date, most studies have focussed on employment generated by climate mitigation policies whereas the employment effects of climate adaptation are examined qualitatively or within a larger context of policies stimulating 'green' growth. We have found no comprehensive, analytical study shedding light on the employment aspects triggered by climate adaptation. The existing studies provide qualitative insights or anecdotal evidence (Anonymous 2008; Agrawala et al. 2011; Carraro et al. 2011; EEA 2011; EEA 2012d).

The few studies that address the relationships between climate change adaptation and jobs, proposes three different perspectives of analysis. The first analyses the amount of jobs exposed to climate change risk and then tries to assess the potential of adaptation to prevent, smooth or eliminate that risk, with the associated job saving potential. It either conducts an analysis at the sectoral level, or tries to compare the expected negative GDP effect of climate change (e.g. from the -4% to the -20% of world GDP as proposed by the 2006 Stern Review) with that of other crisis (e.g. the last financial crisis) to then make a parallelism between observed and expected job losses. The second thread of studies analyses the skills (new and old) that are, and will be increasingly required to develop appropriate climate change adaptation strategies. All economic sectors are expected to undertake some adaptive adjustments to climate change, but the most concerned appear to be agriculture, forestry, building and infrastructure. Technologies and therefore skills to develop good adaptation practices will be required (see e.g. Strietska-Ilina et al., 2011). Finally the third thread, drawing almost entirely qualitative conclusions, recognises that the development of adaptation technologies and the implementation of adaptation measures, like large irrigation programs, building insulation, landscape re-planning against hydro geological risk, land recovering after floods or drought may create additional jobs (Harsdorff et al. 2011).

In addition to the lack of quantitative studies, it is important to consider that: (a) the studies by a large address developing countries; (b) job creation potential of adaptation, if one excludes the technology-induced one, is likely to be short to medium term, that is it can be experienced mainly as long as the specific adaptation measures are being implemented; and (c) the investment needed to implement adaptation measures or to develop adaptation technologies

[30] See Exploiting the employment potential of green growth, Commission Staff working document, SWD (2012) 92 final.

could crowd out other kind of investments, therefore draining resources from other economic sectors or activities.

Climate change impacts and adaptation needs are rooted in site-specific patterns of resource availability and use, sensibility to climate risk, and ability to resist to, and cope with climate extremes. Moreover, it is difficult to disentangle climate adaptation activities from development and economic transformation driven by other factors. Climate adaptation is about preserving employment in sectors struggling with the impacts of the climate change, as well as about exploiting opportunities of shift in markets or new product markets (e.g. climate proofing materials and building designs) (Sussman& Randall Freed 2008).

1.2.3.3. Other social issues

Climate change impacts might affect people's daily lives in terms of employment, housing, health, water and energy access as well as the implementation of gender equality and other human rights. Thus, including the social dimension of climate change within future climate change adaptation efforts is of central importance and reflects one of the key challenges at EU and Member State level.

While not all climate change impacts will be negative, it is broadly accepted that the most vulnerable communities will bear a disproportionate share of the hardships associated with climate change (UNICEF, 2007; Adger et al., 2003; Mearns and Norton 2009; Verner, 2011, Worldbank, 2012). Negative impacts of climate change will especially affect *disadvantaged population groups* (especially those living in poverty) in least developed countries, but also within the EU Member States. Often people living in poverty depend highly on the very natural resources affected by climate change and have less capacity to protect themselves, adapt or recuperate losses (United Nations, 2011).

On a more abstract level research leads to the conclusion that the people most vulnerable to social impacts of climate change will be those (CAG Consultants, 2009): living in places at risk; already socially deprived (e.g. by poor health, low income, inadequate housing, lack of mobility); disempowered (by lack of awareness, adaptive capacity, support services and exclusion from decision-making).

Population ageing in Europe is significantly increasing a group of population especially vulnerable to climate change impacts. Moreover, the issue of social vulnerability is a further characteristic of many cities which must be considered in the context of climate change. Cities are often home to those with higher vulnerability to climate change hazards and limited adaptive capacity and assets to respond effectively to adverse climate impacts.

Regarding migration, migration decisions are multi-causal, and climate change is projected to have influence on several of the already existing causes of migration rather than being a driver in it. Recent evidence suggests that no significant increases of external immigration to Europe solely due to climate or other environmental changes can be expected.

Reduction of poverty increases people's adaptive capacity and reduces their vulnerability to climate change (better health, better housing, less homelessness etc.). Thus, the inclusion of fight against poverty and social exclusion in Europe 2020 strategy supports climate change adaptation efforts in the EU.

1.2.4. Territorial challenges

1.2.4.1. Coastal zones

Expected impacts of climate change

Climate models, confirmed by current observations, suggest that climate change will have a profound effect on coastal zones and marine areas through:

- Increases in sea level rise: In most Europea seas, sea-level has been rising in the last century. Even if in some areas of Europe, a fall of sea-level has been observed in the last centrury, IPCC projection estimating global average sea-levels to rise between 0.18m and 0.58m by the end of 21st century.
- Changes in ocean currents, specifically the thermohaline circulation, could affect Europe's seasons.
- Coastal erosion is already a serious problem in Europe with already 20,000km of coastline threatened in 2004. Coastal erosion could increase due to climate change through the above mentioned sea-level rise as well as increased frequency in storms.
- Sea Surface Temperatures (SST): In Europe, increases in SST have been greatest in the Baltic Sea and the North Sea, with lower rates identified in the Black Sea and the Mediterranean Sea. In the North Sea and the Baltic Sea values are over 0.06-0.07 °C/year. Over the past 60 years, the extent of the Arctic sea ice at the end of summer melt has declined at a rate of -7.8%/decade; the last 20 years have seen a trend of -9.1%/decade.
- Enhanced eutrophication: climate change could indirectly increase eutrophication problems in coastal waters through increased rainfall and its associated flooding loading rivers that discharge into coastal areas. Although in recent years nutrient concentrations have been decreasing in some areas, EEA (2011a) indicates an increase in nutrients in transitional, coastal and marine waters in parts of the Baltic (Denmark, Finland), the North Eastern Atlantic (Ireland) and the Mediterranean (Croatia).
- Ocean acidification: CO2 absorption by seawater decreases the pH of oceans, leading to acidification. The ocean's acidity could increase by 150% relative to the beginning of the industrial era under the IPCC A2 scenario, affecting aquatic species and reducing the ocean's ability to act as a carbon sink.

The potential changes to coastal zones and marine areas will not only affect aquatic flora and fauna, it will also affect coastal economic development and human well-being. Increases in sea-level have the potential to negatively impact economic growth as well as destroy physical infrastructure such as housing roads. Estimates of the economic costs of climate change impacts in coastal zones are still in the early stages of development.

Some studies estimate millions of Euros in losses by 2020 under both the A2 and B2 scenarios due to floods and saltwater intrusion. The loss of land along the coast as well as salt water intrusion could impact aquaculture production by eliminating farm locations. However, it is likely that aquaculture (which is not exclusively concentrated in coastal areas), in view of its resilience and adaptability and its cultivation of a wide array of species/species groups will be able to respond positively to climate change impacts. Fisheries could on one hand increase fish catches in some areas – for example a 24-45% increase in Scandinavia by 2055, but increasing temperatures could also destroy some fisheries and lead to serious decline in fish species as well as economic losses. Tourism may also be affected both positively and negatively: northern destinations may see a surge in visits, while in others increased storms and beach erosion may reduce tourism numbers and therefore money.

Green Infrastructure, soft coastal protection are often cost-efficient alternatives to traditionally engineered protection structures. In addition green infrastructure appears more effective when facing uncertainty and provides multiple benefits.

Policy context and current adaptation activities

Efforts to enhance more sustainable coastal development in Europe were promoted by the Recommendation on Integrated Coastal Zone Management (ICZM) in 2002). Right now the EU is assessing different policy options for future EU action to further develop ICZM. Complementary, the European Commission launched the OURCOAST initiative, a web-platform that gathers and disseminates case-studies and practical examples of coastal management practice in Europe. In 2010, the EU strengthened the legal framework for integrated coastal zone management in the Mediterranean by deciding to ratify the ICZM Protocol to the Barcelona Convention, which entered into force on 24th March 2011. Both the Recommendation as the Protocol recognise the the threat to coastal zones posed by climate change, which should be considered by implementing ICZM strategies or plans.

The EU Integrated Maritime Policy seeks to provide a more coherent approach to maritime issues, with increased coordination between different policy areas. It focuses on issues that do not fall under a single sector-based policy e.g. "blue growth" (economic growth based on different maritime sectors) and issues that require the coordination of different sectors and actors e.g. marine knowledge. One of the objectives there is to create a strategy to alleviate the consequences of climate change in coastal regions.

Another important policy is the Common Fisheries Policy (CFP) which (beside others) is laying down rules to ensure Europe's fisheries are sustainable and do not damage the marine environment. In order to do so potential impacts from climate change on the fish stocks have to be considered.

Main barriers to action

Stakeholders indicate that: i/ ICZM is a complex issue and including climate change makes it even more difficult; ii/ lack of awareness; and iii/ lack of funding for monitoring impacts and taking measures.

Expected developments

It is expected that due to the existing legal framework and increased awareness raising as well as further research under Horizon2020 by the Commission and the EEA more adaptation measures will be taken. The planned guidelines on ICZM and climate change adaptation will help Member States in taking action. So it is expected that the vulnerabilities will decrease over the next years. The current policy framework also triggers transboundary co-operation, so it is expected that adaptation will also be dealt in this manner.

At the moment, the European Commission is not considering to develop any actions to increase the resiliency of coastal and marine areas. However, the Commission initiative on Maritime Spatial Planning and Integrated Coastal Zone Management intends to identify climate change adaptation as an important element to consider for sustainable coastal management.

Knowledge gaps in relation to climate change adaptation for marine and costal issues are handled with in the context of the EU Adaptation Strategy under the Commission’s Green Paper on Marine Knowledge 2020.

1.2.4.2. Mountain regions

The increase in temperature is particularly high in mountain regions, where loss of glacier mass, reduced snow cover, thawing of permafrost and changing precipitation patterns including less precipitation falling as snow have been observed and are expected to increase further. This could lead to an increase in the frequency and intensity of natural hazards such as floods and rock falls that will impact people and the built environment. Key vulnerabilities include reduced winter tourism, less energy supply from hydropower, a shift in vegetation

zones, invasive alien species and extensive biodiversity loss. Plant and animal species face the risk of becoming extinct due to natural and artificial barriers not allowing them to move upwards or northwards to more suitable areas. The retreat of the vast majority of glaciers also affects water availability in downstream areas.

1.2.4.3. Cities and urban areas

Expected impacts of climate change

Around 70 % of the EU population – approximately 350 million people – currently lives in urban agglomerations of more than 5,000 inhabitants. Climate impacts on cities will directly affect those citizens that live in and visit urban areas, and indirectly affect those citizens that rely upon the services provided by urban areas.

The major threats to European cities are the impacts resulting from flooding, heatwaves, and water scarcity (or drought), coupled with coastal impacts for those cities in vulnerable locations. In addition, climate can magnify the pre-existing socio-economic challenges that cities face.

While urban areas will generally experience the same changes in climate as their surrounding region, the urban setting (physical form and socio-economic activity) can affect both exposure and sensitivity to weather events, and therefore the impacts felt at the local scale. For example, urbanisation of land can limit the land available for natural flood management and lead to higher peak run-off of rain and flood water (EEA, 2012c) thus magnifying the impact of high intensity rainfall projected to occur as a result of climate change. In addition, built-up areas can create unique microclimates in terms of temperatures, wind and precipitation.

It is likely that the length, frequency and/or intensity of warm spells, or heat waves, will increase. The impact of heatwaves is particularly strong in cities and towns because of the Urban Heat Island (UHI) effect. Impacts will also vary by region. Cities in northern Europe are potentially as much exposed to the human health effects of heat waves as are cities in southern Europe, given the different heat thresholds and levels of acclimatisation of local populations.

Flooding is a potential risk across all European regions and the extent of its impacts in urban areas is shaped not only by long term changes in climate but by topography, characteristics of the built environment, weather variability and extreme event occurrences. The nature of flood impacts is also the result of existing vulnerability within a particular city and the type of flooding. Climate change may act to change the both the frequency, type and severity of future flood events. For example, Some scenarios indicate that between 250,000 and 400,000 additional people per year in Europe by the 2080s will be affected by river flooding, most of them in cities

Water stress is already a serious issue for certain areas of Europe in the summer months, especially in Southern and Eastern Europe and projections suggest that the water stress will worsen, increasingly affecting more northerly latitudes. This increase in water scarcity, alongside a range of socio-economic drivers such as population growth, is likely to worsen water stress in cities.

Recent sea level rise projections taking into account the impact of artic ice melt suggest that increases of between 0.9 to 1.6 metres above the 1990 level could be expected by 2100. These increased sea levels have the potential to interact with storm surges to present a serious flood threat to Europe's coastal area, where large cities and urban centres are located. Cities along the coast of the Netherlands, Germany, Belgium and northern Italy are most likely to be affected.

Policy context and current adaptation activities

The number of Europeans living in urban areas is set to increase from the current figure of around 70% to around 80% in 2020. Therefore, even without climate change, it is increasingly important to enhance urban resilience to extreme weather events, but with projections for more frequent and more severe heatwaves, flash flooding and periods of water scarcity, and rising sea levels, the risks are also increasing.

Cities are affected by a large number of regional and sectoral policies. This includes cohesion policy, environmental, agriculture and rural development, transport and energy, industrial, employment, education and health policies. Of particular relevance are urban development activities funded under cohesion policy programmes, environmental policies targeting specific impacts (e.g. Flood directive (EC, 2007c), and certain sectoral policies (e.g. agricultural policies can provide upstream flood prevention measures or water management in water scarce regions). These policies will influence the vulnerability of urban regions, the resilience to climate impacts and the adaptive capacity.

Current adaptation activities are highly site specific; not all Member States have national climate change adaptation strategies which may hinder development of adaptation plans at lower spatial levels. In other countries, while there may be regulations at the national level for larger municipalities to develop adaptation plans, such regulations may not be strongly enforced. Adaptation remains a new policy area for many city administrations in Europe.

Main barriers to action

In terms of capacity for EU cities to adapt, there are a range of barriers, which include lack of awareness, lack of appropriate knowledge and data at city-level, lack of communication of good practice, little opportunity for cities to exchange experiences. Availability of resource within city administratations and in financial terms can be a barrier. The overarching multi-level governance framework to support urban adaptation is also lacking.

The EEA identifies a number of barriers to local, regional and Member State governance for adaptation in urban areas. These include the complexities of jurisdictional and economic boundaries compared to the scale and location at which effective interventions for adaptation may need to be implemented for increasing urban resilience. Lack of communication between planning and risk management departments may mean, for example, that whilst adaptation plans are developed by the municipalities, they do not filter into e.g. land use planning; thus adaptation may remain a separate, or additional issue, rather than becoming mainstream consideration. Another barrier is associated with the apparent gap between local adaptation action and national level strategies, and the fact that competition for resources between policy sectors at the national level can lead to the neglect of funding for urban adaptation.

How would the problem evolve by 2020 without further EU Action?

According to the EEA, it is clear that adaptation is progressing across Europe, but this is patchy, uncoordinated and of varied quality. The same is true for adaptation across Europe's cities (e.g. EEA, 2009b; CoR, 2011). Only a quarter (24%) of cities report that an adaptation strategy that has been adopted in their city, with only 8% stating that no work is planned or has begun on climate adaptation. Without new EU action the gaps in adaptive capacity and in the development of appropriate adaptation responses across Member States will remain or widen; the problem described above will remain.

Potential examples of adaptation actions by 2020 to increase resilience

The unique contribution of the EU level is an over-arching, framework-setting function is to enhance an integrated and multi-level governance approach to building climate resilience. In

terms of concrete actions, this would play out as mainstreaming into EU policies and budgets, facilitation of exchange of good practice, and coordinated development of the knowledge base relevant to urban adaptation. An extended Adaptation Steering Group involving a wider range of local/city-level representatives could support the implementation phase of the EU Adaptation Strategy providing links across the governance levels.

Given the large number of sectors requiring adaptation at city level, in different local contexts with differing vulnerability, a very wide range of technical measures for urban adaptation is available. The appropriate options are also dependent on the nature of local governance and its role / remit across affected sectors. At European level, the role is predominantly one of support, rather than implementation.

Urban adaptation could be facilitated by mainstreaming of adaptation into key EU policy areas, as well as the removal of potential policy conflicts at national and European levels. Areas identified as a high priority include: urban development policy, especially current Cohesion policy proposals; climate proofing for the EU budget for 2014–2020; climate proofing of Commission sectoral initiatives with urban dimension; procedural integration.

A number of specific opportunities include: exploiting both the increased urban emphasis and the new adaptation theme under Cohesion proposals to support urban adaptation, increasing the take up of urban adaptation projects under future Life+ programme, extending the urban section of Climate-Adapt and linking with other urban (sustainability) platforms.

There is strong potential for European action to provide resources and coordinated action for research to fill existing knowledge gaps in urban impacts and adaptation, and making use of the Climate-Adapt platform in dissemination, engagement and application of this knowledge base.

Knowledge exchange can play an important role in raising awareness and building adaptive capacity among cities, and the EU can facilitate such exchange, through support of networks and campaigns (such as UNISDR, Making Cities Resilient“), and/or through provision of a platform to promote exchange of experiences among cities.

1.2.4.4. Rural areas

In rural areas, which still make most of the EU's land area and represent an important share of employment, climatic risks are also likely to exacerbate the socio-economic challenges that these areas face (depopulation, economic viability, social services). Rural areas are exposed to a wide range of impacts from climatic variations, beyond those directly affecting agriculture and livestock. These include increased risk of flooding, particularly in Central and Northern regions, and risks for damage to infrastructure due to other extreme events. Increasing competition for water between different uses will also concern rural population and economies. Forest ecosystems and forestry are important in many rural areas. Climatic changes will lead to increased risk of disturbances through storms, fire, and outbreaks of pests and diseases with implications for forest growth and production.

The trend towards reduction of snow cover in mountainous areas will have negative consequences for winter tourism and on rural economies dependent on income from tourism. This can also be the case for areas facing water shortages, while a warmer climate can bring new tourism opportunities for rural areas in other parts of the EU.

The rural development policy for the period 2014-2020 will continue sustaining economic development in European rural areas.

1.2.4.5. Outermost regions

The outermost regions (OR) are amongst the regions of the EU most vulnerable to the impacts of climate change, most notably to: biodiversity loss, health impacts, negative impacts on agriculture, tourism stagnation and water scarcity. Studies have foreseen that the Caribbean islands and French Guiana will experience increased dryness, more intense cyclones and sea level rise, which will lead to coral bleaching, shoreline erosion and the degradation of tropical forests, mangroves, and freshwater ecosystems. Coral bleaching is a great reason for great concern, as the coral reefs provide essential protection against storm surges and waves. Loss of coral reefs will mean loss of livelihoods for many inhabitants of islands and coastal regions. Corals already weakened due to overexploitation and pollution are threatened through increased water temperature and ocean acidification. The current CO2 concentration in the atmosphere (393 ppm) is already above the viable limit for coral reefs, which according to current state of the art knowledge lies at 350 ppm. The Macaronesian islands will be particularly threatened by changes in wind and precipitation patterns that increase the risk of invasive species and the potential of desertification. In Reunion, rising temperatures, together with human induced impacts, drive coral bleaching, water scarcity problems, and the spread of invasive species and vector-borne diseases.

The geographic and economic differences between the OR and the rest of the EU make them special cases for the EU adaptation strategy in terms of the potential impacts and the adaptation options available. The OR are characterised by their remoteness, insularity, small size, difficult topography and climate, and economic dependence on a narrow range of goods and services, especially tourism and agriculture. Also they generally have poor economic growth and suffer from high unemployment. The habitats and species found in these regions are distinct from the rest of the EU and provide an important contribution to global biodiversity. These ecosystems are particularly sensitive to changes in climate and their deterioration poses significant health and socio-economic concerns.

These characteristics make them not only vulnerable to climate change but also likely to have limited capacity for adaptation without support. For example, the economy of Guadeloupe is highly dependent upon bananas and the economy of Réunion is dominated by sugarcane. Both require freshwater but sea level rise and saltwater intrusion into aquifers will put increased pressure on this limited resource, which is also under demand from domestic consumption and the tourism sector. The potential reduction in fisheries resources due to climate change also poses a significant threat for islands like Martinique. The OR are isolated, either due to their island nature or due to the characteristics of the territory (Amazon forest in French Guiana), most OR are mountainous and, as a result, urban areas are predominantly coastal making them potentially vulnerable to sea level rise and storms. Therefore, adaptations measures to minimise the effects of the deterioration of the shoreline - corals, mangroves, beaches- is paramount.

As they are already experiencing the impacts of climate change, activities to increase the knowledge of climate change impacts as well as the definition and implementation of adaptation strategies are key priorities in the OR. Moreover, these regions could serve as early demonstrations for the development of policy initiatives and technologies devoted to climate change adaptation. Activities under the BEST initiative could become a valuable contribution to the adaptation effort in OR. Lessons learnt can then be exported; tailored to neighbouring countries and adapted for the rest of the EU.

1.2.5. Cross-sectoral challenges

1.2.5.1. Linking disaster risk management and adaptation

One of the most important consequences of climate change will be the increase in the frequency and magnitude of extreme events such as floods, droughts, windstorms and heat waves. Climate change may also trigger other hazards in which climate or weather conditions play a fundamental role, such as snow avalanches, landslides and forest fires. The drivers and causes for disaster risk are:

- Population growth, leading to settlements in areas with a higher risk potential;
- Economic growth: economic risk will equally increase;
- Human technology and behaviour (nuclear plants, chemical industry, clear-cutting of forests, spilling freshwater resources, arson).

Risk is determined not only by the severity of the hazard but also by the concentration of people and assets in hazard-prone areas and their vulnerability to the hazard. Human fatalities tend to concentrate mostly in Eastern and Southern Europe. People who are generally more vulnerable are also more at risk when a natural disaster occurs: low income households, the elderly and infirmed.

With regard to human fatalities the most prominent natural hazard is heat waves. The summer 2003 claimed lives of a tremendous number of people on the continent, with over 70.000 excess deaths being reported in 12 Western and Central European countries. Flooding and storm events result the most significant amounts of economic losses relative to other types of disasters in the EU.

Climate change will lead to new disaster risk ‘landscapes’ and distribution of hot spots. In recent years, policies for disaster risk reduction and management have shifted from defence against hazards (mostly by structural measures) to a more comprehensive, integrated risk management approach.

Policy context and current adaptation activities

The European Union has already developed a set of instruments to address various aspects of disaster prevention, preparedness, response and recovery. These include, inter alia, the Community mechanism for civil protection (EC, 2001,2007), the implement of disaster risk management policy (COM(2009)82), the European Union Solidarity Fund (EUSF; EC, 2002)

The EU is developing an "Overview of the Major Risks the EU May Face in the Future", so as to potentially inform policy decisions at EU and MS level. The overview will be primarily based on national risk analyses drawn from the national risk assessments that Member States are now developing based on the 2010 Guidelines on risk assessment for disaster management. Other on-going activities at EU level include: i/supporting Member States in developing national risk assessments and risk management plans; ii/ overcoming the challenges of data sharing iii)develop incentives for prevention and innovative financing instruments iv) facilitate cooperation and exchange of good practices among Member States though training, exchange of experts, peer reviews, development on guidelines for good practices in disaster prevention etc, v) enhancing the level of preparedness though actions such as training, exercises, development of Early Warning Systems, scenario development and contingency planning.

On 20 December 2011 the European Commission adopted a proposal to revise the existing European Union's Civil Protection legislation in order to ensure more effective, efficient and coherent disaster management.. The prevention and disaster risk management activities are

thus incorporated into the legislative framework and form part of the integrated disaster management cycle.

The European Union Solidarity Fund (EUSF) was set up to respond to major natural disasters and express European solidarity to disaster-stricken regions within Europe. The Fund was created as a reaction to the severe floods in Central Europe in the summer of 2002.

The Floods Directive (FD) (2007/60/EC) was proposed by the European Commission in 2006, and was adopted by Council and Parliament in 2007. Its aim is to reduce and manage the risks that floods pose to human health, the environment, cultural heritage and economic activity. The FD requires Member States to first carry out a preliminary assessment by 2011 to identify the river basins and associated coastal areas at risk of flooding and come up with comprehensive flood risk management plans by 2015.

Disaster risk reduction is a well-established field in policy and research, and many technical measures have been developed. For example, the recently published Special Report of IPCC on disaster risk reduction (IPCC, 2012b) contains 140 pages on managing the risks at three levels (local, national and international), including technical measures such as warning systems, better land use management (through e.g. conservation zones, buffer zones, or land acquisition), ecosystem management and restoration (e.g. watershed rehabilitation and forest landscape restoration) and post-disaster recovery and reconstruction (preferably in ways that reduce future risk).

Such activities are coherent with international developments, such as the Hyogo Framework for action or the Rio +20 conference on sustainable development.

Indeed, in the field of preparedness, early warning systems have been recognised as an important element of disaster risk reduction as a means to protect lives and reduce losses. Also Rio+20 recognises the complementary added value of global and regional early warning systems for natural disasters to national systems in particular for trans-national hazards such as large riverine floods, droughts and storms. European and pan-European early warning and detection systems for weather-driven natural disasters exist such as the European Flood Awareness System (EFAS, COM(2002)-481), the European Forest Fire Information System (EFFIS) and the European Drought Observatory (EDO). They have been developed in close collaboration with Member States in view of an improved European crisis management for weather related natural disasters and contributed to the development of state-of-the art scientific and technical solutions that are shared with the Member States organization and scientific community. Furthermore, these systems foster the establishment of comprehensive, European data and information archives which are essential for planning and decision making up to 2020 across different sectors of environment, agriculture, transport, energy, water management and land-use planning.

Similarly, global systems such as the Global Flood Detection System (GFDS) and the Global Disaster Alert and Coordination System (GDACS) are developed in cooperation with the United Nations Organisation for the Coordination of Humanitarian Affairs (UNOCHA) to enhance preparedness and response to major international disasters requiring humanitarian assistance. These systems also can provide useful complementary information to systems and approaches used by national and regional authorities in Europe.

Main barriers to action

Need to strengthen the synergies to maximise the links between disaster risk reduction and climate change adaptation policies and communities

Sharing of data, observations, projections and good practices on climate change vulnerability methods and adaptation actions is so far limited.

Still an obstacle for successful cooperation between the DRR and the climate change adaptation community is the different terminology.

How would the problem evolve by 2020 without further EU Action?

Without new EU action the cross-cutting areas between climate change adaptation and disaster risk reduction will not be properly developed.

Potential actions by 2020 to increase resilience

Examples of potential action include:

- The assessment of exposure, vulnerability and adaptive capacity, taking current weather related disasters as a starting point.
- More robust regional climate change scenarios that better capture the occurrence of extreme events and improved assessments of their societal impacts are needed.
- Socio-economic scenarios for exposure, vulnerability and adaptive capacity to the more frequent and more intensive future extreme weather events. Addressing current risk levels, through actions such as retrofitting buildings, relocating human settlements and restoring ecosystems is more expensive than avoiding these risks in the first place.
- Linking national, European and global Early Warning Systems for a more effective management of trans-boundary disasters in Europe.

Coupled decadal climate predictions to early warning systems for floods, droughts and forest fires would be needed. Further, it is imperative to record local disaster data, particularly damage and loss at the local level for developing appropriate responses. In addition, it would be useful to explore case studies where adaptation and DRR have been linked and draw on lessons learned.

Further potential entry points for adaptation with regard to DRR and early warning and monitoring could be the Action Plan on GNSS Applications (COM(2010)308). In addition, Copernicus and the application of EGNOS and GALILEO could be explored further for early warning, monitoring wind speeds, spread of flooding etc.

Example 1: 2003 Heat wave in France

In 2003, France suffered the hottest summer in 50 years. That year, an exceptionally severe heat wave claimed more than 15,000 lives. After this tragedy, the public authorities established the national heat emergency plan, which is activated every year from 1 June to 31 August, in order to reduce the risk of deaths from heat waves. The French Red Cross, in its role as auxiliary to the public authorities and with its 45,000 volunteers and 556 health and social facilities, was mobilized in a large-scale operation in the summer of 2003 (helping vulnerable people, distributing water, assisting health facilities and emergency services). Since then, it has played an active part in implementing the national plan. Based on its own heat emergency guide and plan, it prepares and implements a series of actions in coordination with the public authorities and in accordance with local resources and needs.

The national heat emergency plan established by the Ministry of Health provides for French Red Cross intervention at various levels. It plays a vital role in strengthening solidarity and dealing with the problem of isolated vulnerable people, particularly those most at risk from the effects of a heat wave. It also mobilizes its volunteers to carry out specific activities, targeting the most vulnerable sectors of the population including elderly and disables people. in 2006 the French Red Cross mobilized its network to deal with the effects of extremely high temperatures (level 2 or 3), deploying over 3,500 volunteers.

Efforts focused primarily on assisting homeless people and isolated elderly people, supporting establishments and services, such as homes for the elderly and hospital emergency services, and providing first-aid teams. On 17 July 2006, the public authorities in western France activated level 2 of the heat emergency plan, where the local Red Cross branch started on its rounds of elderly people living on their own. The most problematic cases were to be dealt with on the first day, focusing on the most vulnerable sectors of the population, including those who are completely on their own, those who are no longer in full possession of their faculties and those who have serious medical conditions. On recognizing the Red Cross uniform, an elderly lady opened her door quickly. In the dim interior of her pleasant, impeccably kept apartment, 87-year-old Suzanne invited the volunteers to sit down for a moment in her living room. “I’m so happy to know that someone is thinking of me.

You can't imagine how hard it is and how much my heart is warmed by what you do," she said (Source Red Cross, 2009)

Example 2: 2010 Central European Floods
The 2010 Central European floods were a result of storms and unusually heavy precipitation events embedded in widespread and longer lasting rainfalls in May 2010. The resulting floods affected several Central European countries during May and June. In August another flood event hit the countries again. Poland was the worst affected but also Austria, Czech Republic, Germany, Hungary, Slovakia, Serbia and Ukraine were affected.
At least thirty-seven people died in the floods and approximately 23,000 people were evacuated. The estimated economic cost was 2.5 billion euros. According to Poland's Prime Minister Donald Tusk the 2010 flooding was "the worst natural disaster in the nation's history ... without precedent in the past 160 years". The situation became critical when the Vistula River broke its banks and flooding the town of Sandomierz where residents were stranded in their homes while power outages affected telecommunication. Not able to cope with the disaster with national resources, Poland triggered the European Civil Protection, the MIC, for aid. On 20 May, aid began arriving to Poland from several European Union countries.
Hungary triggered the MIC on the 26th May for support to strengthen its flood containment capacity and put in place additional temporary protection. A request for up to 2 million sandbags to strengthen its flood containment capacity was communicated to the European Civil Protection Network.
In 2010, for the first time, the MIC had received information on the possibility for upcoming floods through the European Flood Awareness System (EFAS) and therefore was prepared for the incoming requests which resulted in faster response to the requests. (Sources: Wikipedia and JRC internal information_

1.2.5.2. Adaptation actions and needs for the private sector

Expected impacts of climate change

The private sector is defined as privately owned or controlled companies, organisations and entities. Climate change will have a range of impacts on businesses Impacts are expected to fall disproportionately on SMEs including disrupting business operations, property damage, disruption to supply chains and infrastructure leading to increasing costs of maintenance and materials, and raising prices. The majority of the Global 500 companies (81%) report physical risks from climate change and the percentage of companies that view these risks as current has nearly quadrupled from 10% in 2010 to 37% in 2012. In the UK the Carbon disclosure project surveyed members of the FTSE 100 group of companies finding more than 80% identify substantive risks to their business from climate change. In other cases, climate change may also offer new business opportunities for products and services that would help people to adapt in the form of expanding market share and creating wealth in communities (innovation and job creation) and accessing new finance streams (increased public funding and financial products and services). New business opportunities might be as simple as increased demand for air conditioning or chilled drinks or as complex as new roofing materials or draining equipment suitable for changing weather conditions.

Climate change exposes businesses to a range of operation, profit and growth-related risks (such as flooding damage to production facilities or supply routes in and outside the EU). The impacts from these risks may be systemic (at the whole economy level), such as damage to major infrastructure, or they may be sector/industry-wide or company-specific, such as unavailability of an important feedstock.

The problem for the private sector can be seen as evolving alongside the evolution of climate scenarios. Increased precipitation in the north of Europe and increasing drought conditions in the south will increasingly impact on the organisation of the means of production. As weather patterns shift so too will patterns of demand and labour mobility. At present problems associated with failure to adapt can be illustrated by increasing incidence of insurance related weather events. However current experiences are a pre taste of much more significant

adaptation challenges in the years ahead including more frequent weather related damage to property, production facilities or logistical infrastructure.

Policy context and current adaptation activities

The Cohesion and Regional Development Fund both allow support for the development of strategies for adaptation to climate investment aimed at increasing adaptation to climate change including avoiding damage to the built environment and other infrastructure, investments and the development of tools to facilitate disaster prevention for large infrastructure projects, not businesses themselves.

The European Social Fund (ESF) and Horizon 2020 both also include funds that can be used in support of adaptation action for the private sector. The ESF aims to increase employment opportunities and ensuring the right skills are available and enhancing the competitiveness of small and medium-sized enterprises (SMEs) as well as the future funding programme COSME[31].

Firms are investing more to protect themselves. Much of this takes the form of updating business continuity plans, or upgrading risk trackers. But around one in four firms is either upgrading their existing physical assets, for example by weather-proofing buildings, or taking out new insurance policies. Around one in five businesses plan to adapt their operations better to deal with such changes, such as adopting new crop varieties or more water-efficient facilities (UK Trade & Investment, 2011).Other examples of action by private organisations include the following, which shows in particular how European companies can take action in other parts of the world (Source: PwC: Business leadership on climate change adaptation: Encouraging engagement and action, 2010).

Type of exposure	Type of response	Examples of companies who have taken action
Direct exposure	Identification of risks	Anglo American (mining/ natural resources) has commenced regional climate modelling exercises with UK Met Office, Imperial College of London and consultants to assess the long-term adaptation measures for operations and projects in South Africa, Brazil and Peru. A study of Peru's Tambo water basin will help enable the safeguarding of local assets, resources and communities.
	Change in operational strategy	ThamesWater (water utility) is embedding adaptation into its core operational strategy. The strategy is focused on water resources, sewer capacity and flood resilience. The company has also challenged their suppliers to consider its adaptation actions to ensure and maintain service levels in future.
Indirect exposure	Identification of risks	HSBC (financial services) is developing a detailed understanding of the physical risks of climate change to help the bank maximise the opportunities that arise. For example, the HSBC Climate Vulnerability Assessment, which maps risks for the G20 in 2020, looks at the impact of climate change on food production, water availability and health. An understanding of the scale of the issues helps the bank – and its clients - to focus on how best to respond.
Opportunity	New products and services	BASF (chemicals) has developed products that are helping coastal settlements protect local dikes by absorbing the force of breaking waves and slowing down water masses. BASF's researchers are also developing stress-tolerant plants that are more resistant to extreme weather conditions such as drought and superabsorbers are being trialed for a reforestation project in Brazil to increase water storage capacity.
		Allianz (insurance) offers micro-insurance products in six countries. With a highly established market in India, Allianz has extended its reach to Indonesia, Egypt, Cameroon, Senegal, and Colombia. Its first flood catastrophe bond is part of a EUR 1 billion programme to mitigate the risk of severe, regional floods across a global fund. Allianz's schemes are typically managed in partnership with others.
Disaster risk management	Disaster relief support	Deutsche Post (logistics) has identified Disaster Management as one area of their global CSR priorities, and has initiated a global humanitarian partnership with the United Nations and a global network of DHL Disaster Response Teams in three regions: Asia-Pacific, Middle East and Africa and

[31] The European Commission proposed a Programme for the Competitiveness of enterprises and SMEs(COSME) that will run from 2014 to 2020. http://ec.europa.eu/cip/cosme/index_en.htm

		Americas.

Main barriers for action

A number of barriers prevent the private sector from taking appropriate adaptation actions and future-proofing their business, among which the current economic conjuncture which is particularly adverse for long-term investments especially for SMEs. The lack of accurate, reliable information, networking and exchange of experience hinders the uptake of adaptation investment because of a lack of awareness of climate-change related risks e.g. there remains a large gap between businesses recognising current and future risks that climate change may pose to their operations, and engaging in activities to address these risks.

Companies' ability to finance adaptation can significantly affect their engagement – companies often state that cost is a reason for not implementing risk management e.g. with regard to the high costs of undertaking a climate risk assessment and the high cost of the adaptation options they have considered.

Some adaptive responses not only provide private benefits to those who have paid for them, they also provide benefits – or positive spill overs - to the wider economy e.g. positive externalities from the restoration of the environment, reduced water use are not fully captured by the organisation which invests in actions.

Insurance is currently not being used effectively to manage climate risk. Three categories of barriers to the widespread uptake of insurance for adaptation relate to: i/ Inadequate risk transfer conditions to the underlying risk e.g. price or premium, deductibles, exclusions and co-insurance; ii/ Insufficient insurance supply: The availability of insurance related to climate change remains limited e.g. due to 'covariate risk', i.e. many claims can occur simultaneously; iii/ Lack of demand: In general, insurance penetration is low in the EU e.g. lower income segments do not purchase insurance, and the farming sector has limited cover.

How would the problem evolve without further EU action?

In the absence of EU action there is an expectation that the gap between those organisations able and willing to take adaptation actions and those left behind will grow. Some of the largest trans-national corporations, and those in certain sectors, have begun to appreciate the potential threat and opportunity presented by climate change. However by 2020, in particular many small and medium sized enterprises will be unable to make the necessary adaptation measures making them increasingly vulnerable to the effects of unavoidable climate change. In the absence of measures from the EU this gap will widen – creating market obstacles for those left behind.

Examples of potential adaptation action by 2020 to increase resilience

A first element could be an increased awareness raising and business engagement in adaptation policy making and planning. To date, businesses engagement has been focused on issues related to mitigation rather than on adaptation. A specific strategy for mobilising private sector strengths and assets is needed. There is some untapped data and knowledge potential in the private sector which should be maximised.

Access to finance for the private sector can be achieved through the direct provision of grants by the EU and other private funding mechanisms including traditional loan finance and equity finance. The existing suite of grant schemes are set out within the proposed 2014-2020 Multi-annual Financial Framework and future MFFs to 2050 are seen as an opportunity to embed finance for adaptation measures. There are opportunities to further embed adaptation actions within existing EU programmes such as CAP, Cohesion funds, ERDF and ESF and Life.

There appears to be an important role for insurance to play in a cost effective balance of measures adopted within the public and private sectors. Market based instruments have the potential to drive behaviours and achieve outcomes with low cost e.g. unlike standards, which are applied uniformly, MBIs enable firms to adopt a cost-effective solution as they also encourage businesses to innovate and increase productivity.

1.2.5.3. Threats and opportunities for companies with respect to climate change

Finally, adaptation activities can offer profitable business opportunities across the economy, including for instance in the following sectors: environmental consulting services; agricultural technologies; ecosystem managemen, water management and technologies; construction; insurance.

Table 2: Threats and opportunities that companies could face with respect to climate change

	Threats (potential damage costs)	Opportunities (potential benefits)
Markets – changing demand for goods and services	Decreased or disappearing demand for present range of goods and services Access of customers to products and services could be undermined by extreme weather	Increasing demand for present range of goods and services but in a different market or demand for new products More extreme events create opportunities in sectors of maintenance, repair, localized operations (e.g. tourism, recreation)
Finance—implications for availability of credit, insurance, stakeholder reputation	Failure to adapt creates difficulties in securing affordable rates of insurance and financing Potential liabilities stemming from climate change related events are not factored into long-term business decisions	Rewards for better risk management in the form of reduced premiums Customers attracted to businesses that have demonstrated resilience against climate change related events
Logistics—vulnerability of the supply chain, utilities and transport arrangements)	Possible negative effects on the availability of some good and services (e.g. raw materials, components); upward pressures on commodity prices Disruption to supply of electricity, water, and sewerage and other utilities Disruption of transportation along the supply chain	Competitive advantage for businesses with flexible supply chains and delivery systems Competitive advantage for businesses with continuity planning and back-up utility facilities. Opportunities for businesses supplying local markets; marketing strategies based on regional differences and reduced product miles.
Premises or Assets (Impacts on building design, construction, maintenance and facilities management)	Vulnerability due to proximity to premises likely affected by climate change related events (e.g. river banks, coastal zones) Challenges to cope with temperature extremes at premises (cooling in the summer and warming in the winter without adding to GHG emissions)	Opportunities for businesses specializing in built environment for developing climate-related products (more efficient air-conditioning installations etc.) Depending on the region, maintaining inside temperatures in winter might become less costly.
People (implications for the workforce and customers; changing lifestyles)	Threats to the health and travel arrangements for staff and clients due to extreme weather events related to climate change. Deterioration in internal work environment because of increased summer temperatures	Opportunities for improving public image by offering flexible working hours/travel arrangements, early warning systems Opportunities for businesses in tourism and recreational sectors
Process (impacts in production processes and service delivery)	Reduction in productivity or disruption to climate sensitive processes or activities, e.g. in the construction sector and agriculture	Opportunities for new products and innovations in the climate sensitive sectors

1.3. Likely impacts of policy initiatives

1.3.1. Likely impacts of policy initiatives on knowledge generation

1.3.1.1. No policy change

Major research efforts on climate change have been promoted and financed at the European level within the 7th Framework Programme and its predecessors. Such activities would continue and further expand, in line with the Commission's proposals on research under Horizon 2020. EU research projects should strive to provide coherent, integrated and exhaustive results. In many cases tailored linkages among projects will be beneficial. Although all the details have not been clarified yet, Horizon 2020 is expected to improve the coordination of research activities. However as no systematic mechanism of mapping knowledge gaps, screening of on-going research and support activities and prioritising along policy needs is proposed, some limitations in coordination and targeted close of knowledge gaps can be expected.

The Commission developed in the context of the PESETA and the JRC PESETA II projects[32] a multi-sectoral assessment of the impacts of climate change in Europe for the 2011-2040 and 2071-2100 time horizons. However, to get to a harmonized and agreed approach across the EU in modelling climate impacts would require further efforts. There are various on-going activities for model comparison and model combination. In the "impact and adaptation" area probably the most important is the on-going and abovementioned IPCC RCPs action. All of these show that comparability is indeed possible also in a multi model approach once the assumptions and structure of the models are transparently communicated. In addition an important recent global initiative is ISI-MIP Inter-Sectoral Impact Model Intercomparison Project[33]. This is the first global activity aimed at providing cross-sectoral global impact assessments, based on the newly developed climate Representative Concentration Pathways (RCPs) and socio-economic Shared Socio-Economic Pathways (SSPs).

Various ways can be used to disseminate information. In particular, the use of web-platforms as well as of science-policy interfaces can be efficient tools to disseminate information. The paragraphs below describe the expected developments by 2020 without further EU Action.

Under the no policy change scenario it is assumed that Climate-ADAPT will be further financed and that the EEA (supported by European Topic Centre on Climate Change adaptation[34]) will ensure regular maintenance and updating of Climate-ADAPT. This includes ensuring inclusion of this work within the EEA annual management plans and in the annual ETC CCA implementation plans. It also includes regular reporting on progress, e.g. through the EEA (and ETC CCA) progress reporting. EEA (with ETC CCA) will organise regular training sessions and meetings but also develop information and publicity material such as a newsletter and a tutorial video. The inclusion of the results from the Joint Programming Initiative "Connecting Climate Knowledge for Europe' (JPI Climate) is expected to take place from 2014 onwards. Beyond 2014 it remains unclear how Climate-ADAPT will further develop and which dissemination activities will be carried out.

An important additional element which is now being implemented is the obligation for EU-funded projects under the last FP7 Call to report to Climate-ADAPT on any climate change adaptation related findings from the research project. Under the no-policy change scenario, it

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[32] Projection of Economic impacts of climate change in Sectors of the European Union based on boTtom-up Analysis: http://peseta.jrc.ec.europa.eu/

[33] http://www.pik-potsdam.de/research/climate-impacts-and-vulnerabilities/projects/Externally_RD2/isi-mip

[34] http://cca.eionet.europa.eu/

is expected that these requirements will be included to EU-funded projects under Horizon 2020. This could entail some costs, both on the project side and on the Climate-ADAPT management side, to ensure quality assurance and quality control.

In relation to data sets some progress has been made,[35] which is concurring in creating a wide and reliable data and information base. Their linkage and an integrated use of the data stored however remains an unsolved issue.

While there are some science-policy interface (SPI) research projects and expert groups that include climate change adaptation as one of the main fields to focus on, many SPIs have not yet taken up the issues of climate change adaptation into their work. It is not expected that the situation would change dramatically without further EU intervention.

Only six (AT, DE, DK, FI, SE, UK) Member States have until now developed broad national web-portals on climate change adaptation. If other portals will be soon developed, it is unlikely that without EU intervention, all Member States would have a national web-portal by 2020.

Knowledge Gaps: some indications on recent progress

In a 2008 commission staff working[36] document, the need to evaluate the impacts and costs and benefits of adaptation measures and to encourage innovation. Some progress has been made, but the evaluation of climate change and adaptation efforts remains a challenge. The following sections structure the main knowledge gaps along environmental, social and economic issues, comparing them to the status of 2008.

Environmental issues

Knowledge gaps highlighted in 2008	Initiatives	Remaining gaps
Need to integrate medium and long-term uncertainties in climate change projections	The CIRCLE-2 (FP7) project promotes a joint initiative on dealing with and communicating climate uncertainties[37] that will produce a special issue peer-review journal and a final publication for decision-makers during 2013.	Uncertainties related to climate developments, impacts of adaptation measures and socio-economic developments however remain a main issue
- lack of regional climate change information - confidence in projections is not the same for all the variables, space-scale and periods - need of a better understanding of coupled system processes and their feedbacks	The AQWA[38], CIRCLE-2[39] MOUNTain[40] and CIRCLE-2 MED[41] Impact2c[42] projects should help close some gaps in the field of lack of data and information in the water sector. The CARBO-EXTREME[43] project should	Climatic model limitations (e.g. huge variation in predictions between different climate models, lack of local data, lack of models for certain regions i.e. modeling sea level rise in the Black Sea) and a lack of understanding natural processes (e.g. anthropogenic forcing, the carbon cycle, lack of epidemiological studies) still exist.

[35] Data bases such as Climate-ADAPT, INSPIRE, WISE, CORDIS, OURCOAST Copernicus services, WSDiS, EEA WQ Waterbase, JRC EDO, Water Accounts, Research and Regional programmes have been further developed or new ones have been set up.

[36] European Commission (2008): Commission staff working document: Integrated climate change research following the release of the 4th Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) and most recent research developments http://ec.europa.eu/research/environment/pdf/commission_working_doc.pdf

[37] http://www.circle-era.eu/np4/CARAUncertainties.html

[38] http://www.acqwa.ch/

[39] http://www.circle-era.eu/np4/home.html

[40] http://www.circle-era.eu/np4/CARAmountain1.html

[41] http://www.circle-med.net/

[42] http://www.hzg.de/mw/impact2c/030467/index_0030467.html.en

[43] http://www.carbo-extreme.eu/

- need to strengthen climate observations and maintain long term records in order to understand key processes and their feedbacks (also in mountain regions) - need for a dedicated computing infrastructure to meet current and emerging research needs - need of a better understanding of the carbon cycle - need to better understand the links between the Arctic Ocean and the climate system	improve knowledge about carbon-cycle. ECLISE[44] should help for the coastal areas. Further there are several sectoral ongoing projects	
Need to better understand vulnerability in relation to land use		This issue still remains and there is a need to identify more precisely the vulnerable areas and the vulnerability of the different sectors in relation to spatial planning (e.g. different transport modes, climate sensitivity of renewable energy supply).
- need to better address the impacts of climate change on water quality - need of more efforts on the assessment of impacts in the area of health - need to have more information about floods and droughts impacts in the water sector and about the impacts of extreme events - need to better understand the impacts of ocean acidification.	Over the last years some progress has been made in particular in relation to floods and droughts (e.g. by PESETA[45], CLIMWATADAPT[46], LISFLOOD[47]) and health (results of the not yet published CEHAPIS[48] study (results are expected for autumn 2012) will partly close the knowledge gaps, but also identifies areas where more research and effort is needed)	Some knowledge gaps remain: especially the improvement of existing early warning systems for heat waves, floods, droughts and forest fires can be an added value and advantage in knowledge, reducing impacts from extreme events and weather pattern. In the field of climatic drivers, there is a need to better develop projections, especially in terms of sea level rise in the Black Sea. There are also quite some uncertainties about ice melting and related impacts to temperature and sea level rise
Need of a better estimation of impacts at finer spatial scales and shorter timeframes for agriculture and forestry		There is still a lack of broad scale knowledge in the forest sector in particular about the regional or local level
Lack of information about impacts of climate change on most vulnerable ecosystems	The CLIMSAVE[49] project is trying to address the issue of the indirect impacts of the different sectors on Biodiversity	Climate change impacts on ecosystem services are still a gap. An integration and coupling of land-use and climate change scenarios would provide better insights into future vulnerable ecosystem hot spots. limited information about indirect impacts (e.g. biodiversity, health sector (traumata after flood events, reduced working ability, workdays and productivity as a result of more severe weather events) or secondary impacts (e.g. deterioration of ecosystem has secondary impacts on employments and labor demand)

Social issues

Knowledge gaps highlighted in 2008	Initiatives	Remaining gaps

[44] http://www.eclise-project.eu/
[45] http://peseta.jrc.ec.europa.eu/
[46] http://www.climwatadapt.eu/
[47] http://floods.jrc.ec.europa.eu/lisflood-model
[48] Climate, Environment and Health Action Plan Information System
[49] http://www.climsave.eu/climsave/index.html

Need to take account of the social scenarios in the assessment of climate change impacts for the sectors of agriculture and forestry, and health		In general much more attention should be paid to socio-economic pathways and policies (with and without adaptation) that determine which kind of Europe (which exposures, which sensitivities and adaptive capacities) will be hit by climate change in the forthcoming decades. Presently some general gaps in this knowledge have been identified, namely: - Land use developments, - Changes in demographic development, - Migrations developments. Missing information about population and land cover in the sector of coastal zone.
- need of research on social impacts - need to better quantify the impacts of climate change in vulnerable world regions - need of studies related to urban adaptation	Several studies dealing with adaptation in urban areas have been carried out. The RAMSES project deals with the analysis of climate change impacts, vulnerabilities and adaptation in EU and international cities, as well as with the full economic costs of adaptation in the particular contexts. Progress has been made on global impacts, mainly under the work performed by the IPCC.	- lack of information on how EU can be affected by the rest of the world (e.g. impacts of climate change and increase of population on food security) - lack of information about impacts in the fields of soil, drinking water supply and land use change - need to identify vulnerable groups and sub-regions, evaluate the inequality in adaptive capacities and how vulnerable are the most vulnerable, assess the impacts on poverty rates - adaptation measures themselves have unequal costs and benefits, which might increase social or regional disparities and which need to be further addressed
	- Work of CIRCLE-2 in the field of adaptation strategies[50] especially related to transnational knowledge sharing and collaboration - Work in the RESPONSES[51] and MEDIATION[52], CLIMSAVE projects on multilevel governance and mal-adaptation avoidance - Initiated work in the BASE project on assessing and combining bottom-up adaptation needs with top-down strategic assessments in 20 diverse Case Studies. - Initiated work in the ToPDad project on the development and application of state-of-the-art socio-economic methods and tools for integrated assessment of climate change impacts and regional adaptation decision-making, with particular emphasis on the Energy, Transport, Tourism sectors.	- lack of knowledge on long-term adaptation in some sectors and on how adaptation decision-making processes deal with climate change uncertainties - need of research on how adaptive management can be supported by the regulatory system and how the adaptation process can be monitored and evaluated

Economic issues

Our future world will be impacted by the direct effects of climate change but also by the evolution of the economic context. It is thus important to have a good knowledge of the economic scenarios to evaluate their impacts on the different sectors.

Knowledge gaps highlighted in 2008	Initiatives	Remaining gaps
need of development of high resolution climate change impacts studies and large scale quantitative modeling		- agriculture: need to find methods to predict long term agricultural land-use - coastal zones: missing information about economy and land cover - transport: possible impacts from the competitive contracts for infrastructure maintenance that may lead to a delay in responses to extreme climate events (need to study the effects of performance type contracts) - energy: in the field of estimating

[50] http://www.circle-era.eu/np4/CARAadaptationstrategies.html
[51] http://www.responsesproject.eu/
[52] http://mediation-project.eu/

		energy demand (demand peaks during extreme periods and cooling demand for urban agglomerations) - job/employment: difficulty to have appropriate scenarios due to its governance by a multitude of elements (e.g. technology development, economic development, demographics)
need of more information about costs of climate change and adaptation, and about inter-sector linkages (need of development of high resolution climate change impacts studies and large scale quantitative modeling to obtain this information)	- ClimateCost[53] works on costs of inaction and costs and benefits of adaptation - The costs of damages in the sector of water are currently studied by the ACQWA project (expected outcomes by mid-2013). In the sector of transport, they are studied by the project WEATHER[54] and EWENT[55], and in the sector of Health by the project PESETA (updated in 2012) and CEHAPIS (results are expected for autumn 2012) - Adaptation of ecosystems are currently studied by the EcoSpace[56] project, and coastal technology options via the THESEUS project	- missing information on disaggregated and sectoral costs of inaction (direct damage costs and indirect costs due to disturbed/interrupted economic activities of system failures) - need of an elaboration on cost-sensitive climate triggers in all relevant sectors, a better assessment on the exposure of assets and economic activities, their projection and impacts of extreme events - need to better estimate the economic value of interdependencies between the different sectors - need to have a better knowledge of the impacts of some measures and policies on different sectors - need to evaluate adaptation costs and benefits and the costs of residual damages, and to take into account the changes in practices (e.g. CAP reform for the farmers)
lack of information about the role of the financial flows in the insurance sector, the distribution of damage and repair costs between the different parties affected (focused research on coastal protection and monitoring activities recommended)	This issue is currently studied by THESEUS[57] (final results for Nov 2013)	

Crosscutting issues

The Commission staff working document also mentions the need to develop multi-sectorial analysis. Presently some general knowledge gaps have been identified, namely: i) Land use developments, ii) Changes in demographic development, iii) Changes in technology and technological development, iv) Economic developments, v) Migration developments. With ESPON-CLIMATE[58] and PESETA some progress has been made to develop such multi-sectorial analysis. However, still only a few sectors can be covered at the same time. A major issue in this context is a lack of data availability (e.g. soil characteristics not available for all regions and ecosystems, cross-sectoral data). The CLIMSAVE project could help closing some gaps as it develops linkages between key sectors under different climate and socio-economic scenarios.

1.3.1.2. Option 1A: Developing a common climate vulnerability assessment

Currently several climate vulnerability assessments have been or are carried out on the European level. Often they use different SRES scenarios (e.g. the initial PESETA project used the A2 and B2 SRES scenarios as references; more recently the FP6 CIRCE[59] project and the

[53] http://www.climatecost.cc/
[54] http://www.weather-project.eu/weather/index.php
[55] http://www.weather-project.eu/weather/inhalte/research-network/ewent.php
[56] http://cordis.europa.eu/projects/rcn/96752_en.html
[57] http://www.theseusproject.eu/
[58] http://www.espon.eu/main/Menu_Projects/Menu_AppliedResearch/climate.html
[59] http://www.circeproject.eu/

FP7 CLIMATECOST[60] project used the A1B SRES scenario as reference; the FP6 ENSEMBLES[61] project even focused on an ad hoc non SRES stabilization scenario: E1). More importantly they apply different models or combination of models.

Efforts have been undertaken by the Commission to use a consistent approach, initially based on the PESETA – and now JRC PESETA II – project as a basis for its vulnerability assessment. This approach has the merit of being the first attempt to provide a comprehensive (multisector and EU wide) and integrated (internally consistent and comparable) impact assessment exercise.

Improving the coordination of research efforts, the comparability of research methodologies and outputs, and the consistency of policy messages is of utmost importance. However, these goals are not achievable imposing the use of one single climate scenario, one single social economic scenario, not to mention a single evaluation tool. This is so because of the following reasons:

Current activities, such as the recent global initiative ISI-MIP Inter-Sectoral Impact Model Intercomparison Project can already help achieve a better understanding of differences between impact model results relevant globally and for Europe.

Both scenarios and models are continuously improved by a dedicated science community. Proposing one standard would lock the current state-of-the-art, and might hinder improvements and unconventional solutions. Moreover, different models can be better suited to answer different sets of questions. Accordingly, it would be important to exploit rather than limit this richness.

Using a broader set of scenarios, models and data sets allow quantifying and better communicating the uncertainty. For example so called multi-model ensemble is used to sample uncertainties in model formulation. Initial condition ensemble runs can be used to estimate the uncertainty in the projections of future climate change due to the incomplete knowledge of the present state of the climate system[62]. The different spatial resolution of these assessments allows serving different specific purposes. This is particularly relevant when adaptation is addressed, as different measures are effective at very different spatial scales.

The IPCC is currently developing new scenarios for a possible use in its AR5[63]. Europe should link its assessment to this global work, for scientific, but also for cost saving reasons. The 2009 White Paper already stated that vulnerability should be assessed against a wide range of climate scenarios and on different geographical scales to facilitate the definition of adaptation measures.

To improve the comparability of results, in particular out of the future Horizon2020 EC funded projects, the Commission could still prescribe which emissions scenarios shall be used (based on the EU mitigation goals), but then leave flexibility in the choice of the environmental, social economic impact assessment tools to apply. In addition the Commission could mention good practice examples of such assessments in the context of Climate-ADAPT.

Finally, this initiative might lead to the fact that some of the research groups not following such a European approach might suffer from lack of funding. This might hamper the development of alternative approaches.

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60 http://www.climatecost.cc/

61 http://www.ensembles-eu.org/

62 http://ensembles-eu.metoffice.com/tech_reports/ETR_3_vn0.pdf

63 See http://sedac.ciesin.columbia.edu/ddc/ar5_scenario_process/index.html for further details

1.3.1.3. Option 1B: Adopting a knowledge gap strategy

This option would result in administrative costs for the Commission, but mainly for Member States for collecting the information e.g. via a questionnaire or dedicated meetings, analysing and assessing the results, organising and hosting a working group (for instance similar to the Working Group on Knowledge base created to favour discussions among stakeholders and Member States when Climate-ADAPT was being prepared) and writing a list of priorities. The administrative costs for Member States and stakeholders would differ depending on the format the information is collected (e.g. filling in a questionnaire is more time consuming than just writing an informal letter) and the fragmentation of information available at Member States level. For example if structures that coordinate research activities are already in place, fewer efforts are necessary than in cases where various research institutions have their own independent agenda and no overall coordination exists.

Regarding potential benefits, indirect economic, social and environmental impacts exist in as much as prioritising research activities can allow for filling knowledge gaps more quickly. No quantitative evidence exists of such impacts but a survey among researchers and research institutes showed that there is a widespread support for a higher participation of stakeholders in European Research Area processes (where Horizon 2020 is a part), mainly through dedicated working groups[64]. Falconi (1999)[65] identified several positive social impacts if priority setting in research is done in a participatory mode. They refer to:

- the more efficient resource allocations (reducing the risk of potential double funding) and allocating them in a more transparent and unambiguous way,
- better achievement of a consensus of the research agenda due to allowing different staff levels to participate in the process as well as discussing a broader set of alternatives in a transparent way,
- Strengthened credibility of an institution or program and helps it to take a proactive role in soliciting government and donor support for crucial areas to research.

In January 2012 the European Commission published the summary and analysis of the response to the ERA Framework Public Consultation[66]:

- Joint Programming Initiatives and Alliances between research institutes are considered appropriate mechanisms for cross-border research. As climate change has wide-spread effects and can potentially cause interdependencies between countries, this initiative will most likely strengthen cross-border cooperation for issues of common interest.
- Lack of political commitment is considered to be the major difficulty for transnationally coordinated research. The agreement on common priorities by the European Commission and Member States in the field of research on climate change adaptation could be seen as a way of increasing the political commitment.
- Ensuring a closer cooperation and coordination in policy development and implementation is considered to contribute to reducing the research and innovation deficit and inefficiency in the EU.

A more tangible benefit relates to a better use of EU funds. There are currently examples of research streams being conducted in parallel. Would a better coordination of research

[64] http://ec.europa.eu/research/era/pdf/era-summary-report-2012_en.pdf

[65] Falconi, C.A (1999): 'Methods for Priority Setting in Agricultural Biotechnology Research', Chapter 4 of *Managing Agricultural Biotechnology Addressing Research Program Needs and Policy Implications* (ed. J.I. Cohen), CAB International. Available at ftp://192.156.137.116/isnar/IBS/II_04.pdf

[66] Consultation on the ERA Framework: Areas of untapped potential for the development of the European Research Area (ERA) http://ec.europa.eu/research/consultations/era/consultation_en.htm

activities, at EU and Member States level, have been in place, EU-funding could be better rationalised.

The results of the public consultation of the EU Adaptation Strategy confirm enhanced support for research initiatives. When asked which actions could improve the use of EU funding for projects, respondents rated 'coordination among research projects' and 'strengthening the science-policy interface' as having medium to high potential (55% and 81% of respondents, respectively). Moreover, 76.4% of respondents agreed that 'supporting pan-European discussion fora on adaptation to share experiences and good practices' would help to facilitate dissemination.

However there is also the risk, that with such a priority setting process certain issues will be overlooked (e.g. risk exists that the priorities may concentrate too much on diagnosis and improving the understanding without arriving at testable solutions). This risk can be reduced due to the development of a list of key questions against the priorities assessed. Further, knowledge gaps are closely correlated with decision-making needs and adaptation governance. While research for climate change had a strong focus on assessing vulnerabilities, a shift towards more research activities on adaptation actions is already noticeable. When listing knowledge gaps, it needs to be acknowledged that the compilation will need to be regularly checked and updated reflecting demands for adaptation policy processes.

1.3.1.4. Option 1C: Promoting interactions between Climate-ADAPT and other services

This initiative has a three-fold objective: producing guidance on better linking climate-ADAPT to other relevant databases, promoting the inclusion, when available, of the Copernicus Climate services under Climate-ADAPT and ensuring the provision of more detailed information on climate change adaptation at local level.

Climate-ADAPT already experienced a very high web use/traffic during and immediately after the launch, ranking high compared to launches of other EEA products (see Figure 7).

Figure 7: Main statistics for Climate-ADAPT for the period 23 March – 23 August 2012

The costs to develop this guidance are estimated to range between 50.000 and 100.000 euros for writing the guidance and about 20 man days for one to two expert meetings[67]. The wider economic benefits of this initiative is clearly depending on the extent to which the guidance will be applied and therefore a quantification in monetary terms is currently not possible. At this stage only the types of benefits can be listed, namely:

- Avoided costs for data integration into Climate-ADAPT at a later stage on an individual database level. This covers the development of an integration approach, but also all technical works to ensure interoperability (e.g. manual transformation of

[67] based on expert judgment

dataset, or the programming of automatic software that converts the data). These cost savings would occur on both the EEA side but also on the side of those who want to link to Climate-ADAPT.

- Reduced costs for the end users in compiling and processing data due to increased data availability ("one-stop-shop" principle). For certain needs/policy requirements data from different sources might need to be compiled and processed by the end user. However these policy needs might occur several times across Europe and without interoperability each end user has to develop its own solution. Interoperability at the EU scale might reduce the need for singe solutions and might allow the development of a single tool that can be used by different end users. The main benefits from a "one stop shop" approach are an improvement of communication within the authority and with the developers and better working relationships between the different agencies. For the end user, it is a gage of efficiency and quality as it increases the speed of access to information from validated sources and reduces the need for matching information. (Department for Communities and Local Government (2008)
- Reduced costs might also occur due to better quality control of data in-put, more coherence as regards input of data categories and improved user-friendliness.
- Guidance for database interfaces makes the application development faster and easier and therefor cheaper.

In the case of public funded databases all mentioned above will allow a more efficient use of tax payers money.

Using this guidance, there would be reduced barriers between institutions (e.g. EEA and others) cooperating and better collaborating. This might improve the working relationship as well as lead to a better structured and coordinated information infrastructure for climate change adaptation in Europe.

Efficient sharing of data and methods is vital on the track towards more comprehensive and reliable assessments in environmental decision problems (Kokkonen, et al 2003).

In addition, a second strand of work would focus on ensuring that the information provided by Copernicus Climate services, when available, is properly disseminated, in a pedagogical manner, to potential users. The Copernicus (Global Monitoring for Environment and Security) Climate Service will be based on satellite and in-situ monitoring data, modelling of the entire Earth system, including model reanalysis and data assimilation. Although not an adaptation option per se, additional data availability, if properly disseminated, will facilitate adaptation policy making. It will allow a better assessment of local vulnerabilities, and therefore providing additional data for proper climate risk assessments. This would have economic, social and environmental positive impacts, however yet impossible to quantify.

A third strand of work would be dedicated to promoting specific efforts to ensure a better linkage with adaptation at local level. The urban section of Climate-Adapt is currently rather limited, but a stronger presentation of city-relevant material will be provided following the conclusion of the Adaptation Strategies for European Cities' project. This could potentially include increased functionality to support networking or even "adaptation twinning" may be appropriate. ERDF proposals under plans for future Cohesion Policy identify the intention for an "urban development platform" with a focus on networking and knowledge exchange on urban policy related to sustainable urban development. There is good potential for this to be able to support exchange of experience on adaptation.

The additional costs for this option would be rather limited compared to the no-policy change scenario, as the currently funded adaptation strategies for European cities already includes in

its core tasks the development of a platform. The additional work for linking the two platforms would have to be assessed towards the completion date of the project (mid-2013).Engagement with the platform by city stakeholders would be entirely voluntary and therefore no direct fee for involvement. However, there would likely be indirect costs, for staff time and travel to engage via the platform and potentially in exchange visits, etc. Ultimately, the platform would hope to encourage investment by city stakeholders in adaptation activities in their local areas, but it is not possible to estimate the range or scale of those indirect costs.

1.3.1.5. Option 1D: Supporting exchange between science and policy in the field of adaptation

What are Science-Policy Interfaces?

Science-policy interfaces (SPIs), which aim to bridge between the two actors, can be defined as "social processes which encompass relations between scientists and other actors in the policy process, and which allow for exchanges, co-evolution, and joint construction of knowledge with the aim of enriching decision-making" . To achieve their aim, SPIs use a range of tools to facilitate exchange such as publications, working group meetings, conferences and web-based platforms that centrally house knowledge and research material. SPIs can be found at all levels of government, including the EU level. They often are sector-specific. At the EU level, a number of SPIs already exist for the following sectors. A non-exhaustive list includes

- Agriculture and rural development: SEAMLESS "System for Environmental and Agricultural Modelling, Linking European Science and Society (www.seamless-ip.org)
- Biodiversity: Alter-net "A long-term Biodiversity, Ecosystem and Awareness Research Network (www.alter-net.eu); SPIRAL "Interfacing biodiversity and Policy" (www.spiral-project.eu); BISE "Biodiversity Information System for Europe".
- Transport: EPTS "European Platform of Transport Sciences"; EFP "European Foresight Platform supporting forward looking decision making (www.foresight-platform.eu)
- Water: SPI-Water "Science-Policy interfacing in Water Management" (www.spi-water.eu); STREAM "Water research meets policy and industry"; Step-Wise "Science, Technology and Policy using WIDE-RTD; WaterDiss2.0 "Dissemination and uptake of FP water research results" (www.waterdiss.eu); WISE "Water Information System for Europe"; Common Implementation Strategy under the WFD
- PSI-Connect "Connecting Policy and Science through Innovative Knowledge Brokering in the field of Water Management and Climate Change",
- Circle-2 "Climate Impact Research and Response Coordination for a Larger Europe,
- Mediation "Methodology for Effective Decision-making on Impacts and Adaptation".

In addition to the EU funded projects, there are a large number of regional and national level initiatives taking place (e.g. BaltCICA "Climate Change Impacts Costs and Adaptation in the Baltic Sea Region, Knowledge Transfer Network from England covering many topics including Industry, Energy, Environmental Sustainability etc.).

Increasing interaction between scientists and end users (policy makers, representatives, consumers) has the potential to improve the critical evaluation and the integration of research findings, clarify expectations of different stakeholders and SPIs provide a platform where questions can be raised and positions clarified. For instance, the SPI group for the Water Framework Directive carried out a prioritisation exercise regarding research needs between

2010 and 2012 to support the work of the other working and expert groups, leading to the identification of 59 priority research areas and 180 specific research issues[68]. Another important outcome of science-policy interfaces is that they promote the dissemination of already available research outputs to avoid repeating research that has already been done.

While there are some science-policy interface (SPI) research projects and expert groups that include climate change adaptation as one of the main fields to focus on, many SPIs have not yet taken up the issues of climate change adaptation into their work. To remedy this, SPI research projects could take two approaches: 1) they could include specific work packages dedicated to climate change adaptation and 2) research projects could "climate check" their results and recommendations ex-ante to identify where climate change adaptation would be needed.

As the intention of this initiative is to piggy back on existing SPIs, the individual economic impact of including climate change considerations into SPIs would be rather low. Extending existing meetings could result in some additional costs of renting meetings rooms for another half day but the impact would be low. The administrative burden would therefore be limited. Incorporating adaptation into research projects is a more costly option, although this depends on how it is included. An additional work package under a FP7 project, for example, could increase a project's budget by an additional 50-100,000€ depending on the size; the additional costs would be justified as the research outputs would be tangible and beneficial to the climate change adaptation community.

Increasing interaction between scientists and end users (policy makers, representatives, consumers) has the potential to improve the critical evaluation and the integration of research findings, clarify expectations of different stakeholders and SPIs provide a platform where questions can be raised and positions clarified (Totlandsdal, A., et al, 2007). The benefits of SPIs rest on how often stakeholders meeting and the proper dissemination of research materials. For example, the development of the AIRNET Thematic Network (SPI on air pollution) was found to have facilitated the development of new networks within and across the various scientific disciplines and policy-makers by establishing sub working groups, publishing papers including non-technical summaries and organising meetings (ibid).

SPI working groups can also help to better structure future research needs. The SPI group for the Water Framework Directive carried out a prioritisation exercise regarding research needs between 2010 and 2012 to support the work of the other working and expert groups in the CIS process of the WFD. This exercise brought together 150 participants from 15 MS, of with 35% were from the scientific community and 65% from the WFD "end-users", leading to the identification of 59 priority research areas and 180 specific research issues . Another important outcome of science-policy interfaces is that they promote the dissemination of already available research outputs to avoid repeating research that has already been done. Under the mandate of the SPI for the implementation of the WFD, the group carried out an inventory of knowledge related to the topics initially prioritised. Scientific research projects can occur in isolation of other projects, so SPIs can bring together the experiences and knowledge to other researchers and policy-makers to ensure that research is better taken up and not "forgotten".

[68] Science-Policy Interface (SPI) activity on priorisation of research needs, knowledge availability and dissemination for the Working Group E (Chemical Aspects) 2010-2012. Available at: https://circabc.europa.eu/

1.3.1.6. Option 1E: Proposal for mandatory set up of national adaptation platforms

In addition to the initiatives presented above, this initiative also considers the request for Member States to develop national adaptation platforms.

Seven Member States (AT, DE, DK, FI, FR, and NL, UK) have already developed national adaptation platforms. Existing portals are already web-linked to Climate-ADAPT and it is expected that the new ones would do the same.

National adaptation platforms have a clear benefit in bringing together national information and providing it together with guidance for national, regional and local planners. In cases where national platforms already provide IT-based analytical tools or databases for impact, vulnerability and adaptation assessment, benefits could result from the fact that climate change information is taken into account at an early stage of the planning process. Such platforms on the national level can also avoid competition and duplication of efforts and enhance complementarities between the various systems. This is in particular an important issue in countries with decentralised research activities or federal structures. In the Nordic countries the development of national platforms was driven by the fact that apart from projects and networks, very little cooperation has taken place between national authorities due to the lack of an identified focal point for climate change adaptation[69]. Such platforms could strengthen national cooperation. Finally the information can be made available in the national language and therefore reach a broader range of stakeholders.

Such platforms are costly to develop and financial and administrative barriers may hamper their effective development. One of the reasons for developing Climate-ADAPT was the lack of financial resources in Member States[70]. Another crucial issue is the agreement on common quality standards across MS and ensuring that the national and EU level information is following them. The request from the EU to develop such platforms may therefore not be sufficient to ensure their effective implementation.

1.3.2. Likely impacts of policy initiatives aiming at increasing the resilience of the EU territory

1.3.2.1. No policy change

Although most Member States are to some extent active in terms of adaptation, as of January 2013, almost half of Member States have not yet adopted an adaptation strategy. Without additional action, the barriers currently preventing national, regional or local authorities from developing their own adaptation strategies are likely to remain in place, be it in terms of human or financial resources. Yet, such adaptation strategies will likely vary in terms of scope, level of ambition and agreed financing of adaptation measures. Also the timeframe for adaptation will differ. Some countries might develop sectoral approaches only, covering only certain sectors, others might include adaptation in existing management plans such as biomass action plan, sustainable development plans, etc.)

The persistent financial and economic crisis makes it difficult to confer necessary financial resources to developing adaptation strategies. This may be in particular the case in Southern and Central European Countries with high sovereign debt. In most cases these counties are very likely to face significant impacts of human induced climate change earlier than elsewhere in Europe. From among these countries; Cyprus, Greece, Bulgaria, Slovenia and Romania appear to not have started yet the development of a comprehensive adaptation strategy; whereas Italy, Slovakia and Czech Republic are expected to finalise planning

[69] See http://www.nordregio.se/en/Metameny/About-Nordregio/Research--Development/Geographical-scope-we-cover/Norden/Addressing-climate-change-adaptation-at-the-Nordic-level/

[70] See http://ec.europa.eu/clima/tenders/2011/208209/clearinghouse_concept_note_en.pdf

processes in 2013 or later in the next year (s) (Venturini et al, in press[71]). Other countries may need to significantly revise their existing adaptation strategies to account for the fast growing body of evidence about the likely impacts of climate change.

Such a decentralised approach would increase already existing disparities within the EU with respect to the potential vulnerabilities to climate change. Communities, regions will develop their own approaches, leading to a heterogeneous pattern of adaptation efforts. This might lead to greater economic, social and territorial disparities counteracting with the community objectives on cohesion.

Trans-boundary issues will remain a gap in most of the strategies. Trans-boundary issues are more complex than issues mainly affecting national and sub-national issues because procedures, laws, etc. might vary from country to country. A lack of coordination on trans-boundary issues could potentially lead to conflicting adaptation responses and would not provide for an effective approach to tackle common risks. Under the no policy change scenario, mainly the water sector would develop transboundary cooperation further as the legal framework and the existing efforts would further be strengthened. Adaptation therefore would be further included in the river basin management plans.

It is difficult to estimate what these developments would mean in terms of social, environmental and economic impacts, but the following examples illustrate that better preparedness can reduce damage costs and that impacts are often cross-border.

- During the summer 2010, mean temperatures were between 4 and 8°C above normal during July and the two first weeks of August in Western Russia and Eastern Europe. It was the most extreme heat wave in the instrumental record of 1880-present for that region. The extreme heat and the absence of rain led to the worst drought conditions in more than 100 years and also to the worst wildfires in decades. Munich Re estimated 56,000 people died from the effects of this heat wave. This heat wave also led indirectly to an increase in the price of staple goods like pasta and bread all over Europe because Russia's wheat crops failed .
- In November 2005, Western Europe was hit by an ice storm which causes the death of 2 persons in Belgium, 800 km of traffic jam in the Netherlands and a train derailment in Scotland. It also broke 70 transmission towers and prevented 200.000 people from electricity for four days for some of them in Germany. In France, 20.000 people were out of electricity and many roads were blocked (Broström and. Söder, 2007; Météo World, 2005).
- In February 2010, the storm Xynthia hit the French Atlantic coast. Its combination with the high tide and large waves caused the fail of flood defenses, which led to the flooding of more than 50 000 ha. 53 people died because of the storm itself or the flooding and the cost of the damages is estimated around 2.5 billion €. Infrastructures and tourism also suffered from the storm but the cost is hard to estimate. Many flood defenses that failed presented maintenance delay partly because maintenance responsibility was not always clear. In term of management, population warning should have been improved. People were aware about the risks of wind burst but the information about flooding was not clear enough and thus people were not prepared to it. (Slomp, et all, 2010).
- Major funding has also been put into increasing the capacity to combat forest fires in Europe. For example, Italy has Europe's largest fleet of aircraft and helicopters, and has on several occasions loaned out its planes to France and Spain. The high level of preparedness requires significant resources, but has shown good results: the year 2000 saw 6,600 fires destroy 58,000 hectares of forest, while almost the same number of fires in

[71] Source to be added when available. ,

2006 only destroyed 16,000 hectares (Swedish Commission on Climate and Vulnerability, 2007).

1.3.2.2. Option 2A: EU guidelines for adaptation policies

Description of the option

The guidance aims to support EU countries with national adaptation policy processes. It intends to provide a framework for generating the information needed to prepare, implement and evaluate a national adaptation policy. It shall foster a common understanding of key aspects relevant to any adaptation process and provides clear terms of references. Thus, it aims to deliver a common basis for cooperative adaptation activities between different actors/stakeholders concerned with climate change which deems necessary to avoid conflicts and make use of existing synergies.

Although there is no “one-size-fits-all” framework for adaptation in place, certain aspects of good adaptation are in common. The guidance shall highlight these key issues to give direction on how successful adaptation policy processes should be carried out. In addition, it will present various adaptation approaches as good practice examples taken by European countries in order to foster knowledge transfer and lessons learnt. To allow wide uptake of the guidance among European policy and decision makers, a pragmatic approach for adaptation will be presented.

Taking into account that a number of European countries have their national adaptation strategies and action plans already in place, the guidance also puts emphasis on providing support for the implementation and monitoring and evaluation stage as well as on showing how the EU can support national adaptation processes. Further, it provides the link to activities carried out in the area of disaster risk reduction (DRR).

"real-world” policy making is not a linear step-by-step process, but is rather characterized by process development phases that are closely interlinked and influencing each other. This mirrors the understanding that adaptation policy making at national level is to be seen as a process that is not finalised with having a national adaptation strategy and/or action plan in place. Moreover, adaptation decisions set out in an adaptation strategy and/or action plan should be periodically re-considered taking account of emerging knowledge, changing risks and new policies. This can apply to issues of all phases that could need to be adjusted over time when implementing an adaptation policy.

Assessment of the option

The development of the guidance for national adaptation policies takes stock of on-going adaptation activities in EU Member States and beyond, draws on lessons learnt and experiences and specific exchange with stakeholders on certain issues of common interest.

Linking to the above mentioned understanding of adaptation policy making at national level as a process, recommendations presented are relevant for all EU Member States, independent from their state of adaptation efforts. Those countries, which already have a National Adaptation Strategy in place, will be finding information on how to tackle implementation challenges (e.g. such as financing, assigning clear responsibilities) and setting up appropriate mechanisms for monitoring and evaluation. Member States further advanced with adaptation might be already in the stage to learn from the implementation (e.g. FI) and start revising their adaptation strategy accordingly. This might be opening up key issues to re-consider throughout all phases of the policy process where the guidance provides recommendations (e.g. one conclusion could be that there is a need to involve more stakeholders by setting up a broader stakeholder process; another conclusion might be that with evolving adaptation knowledge more and/or different adaptation responses might be needed). Other countries,

which are still in the course of developing a national adaptation policy, will get support for current "state-of-the-art" key issues and the given examples to consider when preparing the ground for adaptation and policy development.

Thus, the guidance will allow all Member States to prepare, implement and evaluate their adaptation policy in a cost-effective way as they will find detailed information on the process of adaptation as well as on methods and tools for reaching good adaptation. Practical examples on adaptation across Europe included in the guidance for all phases of the adaptation process strengthen the share of expertise and good practice. Compiling a set of recommendations for all phases of an adaptation process will also help to avoid "re-inventing the wheel", learn from (good and bad) practices, exchange on potential barriers and how to tackle them. Tacking stock of "state-of-the-art" adaptation knowledge and giving comprehensive recommendations for key issues to consider reduce time and resource intensive efforts that each Member State would have to invest otherwise to gather all relevant information. It became clear from the workshops organised with Member States to exchange on national adaptation policy processes that all face similar barriers and learning from each other can substantially reduce individual efforts and thus costs. Even only getting to know about activities and approaches addressing issues of common concern reduces time and financial efforts needed for single Member States. However, highlighting key issues and presenting various tools to approach them in the guidance cannot substitute personal exchange of knowledge and experience. Nevertheless, making use of the guidance will better inform policy makers about promising approaches throughout the policy process, where to find useful information and whom to contact for further details, based on the examples or references given. Cost savings for each Member State are thus mainly to be expected by proving a comprehensive compilation of all issues needed to be addressed for national adaptation policy making complemented with various tools and information sources..

Furthermore, if recommendations from the guidance are taken up by Member States to develop, implement and evaluate national adaptation policies cost-efficiency can also be expected by addressing negative impacts from climate change before they even occur (cf. examples under the "no policy change" scenario). Preparing for a range of risks that are to be anticipated with climatic changes and developing preventive response actions will increase coping capacity and reduce potential damage costs. The more detailed a national adaptation policy is being developed considering a broad variety of key issues as highlighted in the guidance, the better a Member State is prepared for future challenges due to climate change. Furthermore, more efforts invested in a comprehensive adaptation policy will ease the implementation thereof and prepare all necessary mechanisms for monitoring and evaluation in advance, thus reducing costs at a later stage of the policy process.

Cost-efficiency can also be expected to be increased by sharing financial burdens of implementing adaptation measures as joint activities in a cross-border context.

Giving advice on linking adaptation efforts better to Disaster Risk Reduction will furthermore facilitate joint activities with natural hazard management and thus share financial efforts for preventive approaches to extreme events.

The above highlighted cost savings for Member States and potentially further stakeholders that make use of the guidance clearly outweighs the investment to develop the guidance, which is estimated to be between 50.000 and 90.000 Euros[72]:

[72] Figures are based on the contracts No ENV.G.1/ETU/2008/0093R and CLIMA.C.3/SER/2011/0026

In terms of social implications, the guidance can assist in enhancing the preparedness of Member States and the adaptive capacity of society, especially of those population groups that are most affected. Assuming that suggestions in the guidance would be followed by Member States, large-scale impacts caused e.g. through extreme events such as heat waves that would highly affect vulnerable groups (e.g. children, elderly) can be reduced or even avoided. Social issues can be best tackled by involving stakeholders from all potential affected population groups throughout the adaptation policy development process. Taking into account recommendations from the guidance for stakeholder involvement can thus ensure that no potential risks will be overlooked and social implications of climate change are dealt with in a preventive manner. Further, potential political conflicts over un-coordinated responses could be prevented when mechanisms are established to engage in cross-border cooperation. Exchange of good practices in dealing with climate change impacts would be fostered and brought to attention to a larger community. Emerging themes such as awareness raising and climate change adaptation communication are important to all Member States when it comes to taking up the national responsibility for enhancing adaptive capacity, especially for those population groups that are socially deprived.

Environmental impacts of providing guidance for national adaptation policy processes and thus following common approaches are to be expected merely positive. By introducing a comprehensive process when setting up a national adaptation policy a variety of environmental issues need to be assessed. Climate change as a cross-cutting issue unfolds various effects on a number of environmental systems (such as water, soil, biodiversity). Through dealing with all those issues an integrative manner, thus ensuring that cross-cutting issues and interdependencies are thoroughly assessed and developing appropriate adaptation responses it can be assumed that this would long-term enhance the adaptive capacity of environmental systems.

As an outcome of the public consultation for the EU Adaptation Strategy respondents felt that ‘guidance on developing national adaptation strategies’ would have the most value added (60.25%) when asked to select which type of instruments would bring the most added-value in national adaptation strategies. Further 63.35% of replies considered that ‘Enhance awareness and develop guidance on the transboundary adverse effects of climate change’ was an action EU should consider. However, this option was less often chosen compared to ‘Facilitating cooperation among countries’ and ‘providing EU funding to address transboundary adverse effects of climate change’ (respectively 82.61% and 76.4% of the answers). This underlines, inter alia, that guidance can provide an important framework for national adaptation policy making but does not substitute additional exchange of knowledge and experiences on a personal basis.

Representatives from Member States also widely agreed that the development of guidance for national adaptation policy making would be of added value. They suggested that the guidance should be generic to cover differences among Member States (e.g. different governance structures) but also specific in providing tools and recommendations. The guidance document should also provide support to the process of setting up national adaptation policies but also on key issues to be considered when implementing and monitoring/evaluating. The proposed structure of the guidance document (cf. explanations above) and the presentation of good practice examples across Europe were broadly welcomed.

1.3.2.3. Option 2B: Using Life+ funding for supporting the preparation of adaptation strategies and for lighthouse projects on adaptation

Article 15(c) of the Commission's proposal for a Regulation on the establishment of a Programme for the Environment and Climate Action (LIFE) includes among objectives of the

climate action sub-programme the development of adaptation strategies and action plans at local, regional or national level. It offers the possibility to develop a proposal that involves knowledge transfer and capacity building across Member States.

Building upon experience and knowledge from other countries where comprehensive adaptation strategies have already been adopted and are being implemented can reduce the time and resources needed. Staff exchange schemes are beneficial both for outgoing- and incoming partner institutions. Projects under this scheme can contribute to building new or strengthen existing networks and collaborations between Member States and associated countries and other third countries.

This will be associated with some administrative costs, which may be reduced by creating a roster of experts with required competences. The development of such a roster is eligible under activities listed under the Article 22 of the proposed LIFE 2014-2020 regulation. Past experiences from the staff exchange schemes in other fields such as the Community Mechanism for Civil Protection, the International Research Staff Exchange Scheme, and Twinning projects show high added value in terms of achieved outcomes, best practices sharing, and networking (EC 2011, CEI 2011) .

The eligibility of the LIFE funding for the development of adaptation strategies and action plans can include obligation to apply good practices and guidance; cover all important sectors and ensure compatibility with the EU environmental policies; and foster transnational collaboration and cooperative problem solving.

The Commission proposal for a Regulation on the establishment of a Programme for the Environment and Climate Action (LIFE; EC, 2011u) encourages projects sets to develop, testing and demonstrate policy or management approaches, best practices, and solutions, for climate change adaptation in, but not limited to, *transboundary* areas (Art. 15a). Demonstration, pilot or lighthouse projects are a common form of best practice development/sharing and exploration of innovative solutions to intricate problems.

The development of such lighthouse cross-sectoral and cross-border projects can also make use of a new innovation in the proposed Regulation, namely integrated projects (IP). A typical IP would receive funding from several sources – Community, public and private – not only the LIFE programme. The IP are best suited to serve as demonstration (lighthouse) projects, even if major break-through may be sometimes achieved in smaller projects. The IP will operate on a large regional or sub-regional scale or cross-sector manner. These projects could be tackling pressing issues of mutual concern in many EU countries and develop innovative solutions.

Among the topics that are suitable for lighthouse projects, the following ones have been identified as particularly relevant to address climate change adaptation issues. These suggestions are notably based on the identification of knowledge gaps discussed above.

- *Cross-border management of floods:* The funded project should foster collaborative agreements based on the EU Floods Directive and the UNECE Model Provisions on Transboundary Flood Management. The assessment results should provide input into the envisaged European Flood Impact Database currently explored by the European Environmental Agency. Best practice example from the deployment of market based instruments to reduce or transfer risk could be developed.
- *Trans-boundary coastal management*: The funded projects should improve risk and vulnerability assessment and projections of future coastal change due to climate and other drivers, building upon the existing field observations, models and pilot experiments. Interdisciplinary research is required to analyse complex natural-human

sub-system interactions. Emphasis should be given to vulnerable and densely populated deltas and coastal cities. As several project for the Baltic and North Sea region exist, the focus should be on other regions. In-depth assessment of coastal adaptation options and knowledge/experience sharing should be promoted across the coastal regions[73].

- *Key infrastructure protection*: The funded projects should explore alternative diagnostic stress-test approaches that identify conditions which may lead to a failure or disruption of key infrastructure systems and explore a combination of hazards that may produce such conditions. Innovative risk and vulnerability assessment methods should draw on the recent advancement in disaster economics and take into account the full social welfare impacts of critical infrastructure failure. The projects should typically focus on a combination of critical infrastructures, including transnational and Pan-European transportation corridors, water and energy networks, information and communication systems, government services, banking and finance, health structures, food supply, and ecological and social networks whose disruption may lead to significant effects on vital social function, health, safety, security, economic or social well-being of people. The project could inform the European Programme for Critical Infrastructure Protection (EPCIP), the Directive 2008/114/EC, and the EU Strategy for Integrated European Infrastructures.
- *Adaptation to climate change in urban areas*: The transfer of experiences from "early adapters" to other cities can be greatly facilitated by LIFE+ Lighthouse projects, the more so if cross-border co-operations between urban authorities is encouraged and cities are supported in their attempts to elaborate shared adaptation strategies that should include ecosystem services of urban green and blue areas, exchange experiences and build commitment for sustainable adaptation strategies. The funded projects may encourage knowledge and experience sharing in the areas of risk and vulnerability assessment and implementation of pilot adaptation measures, mainstreaming of adaptation planning into urban land use planning, building layouts, public procurement practices, natural resources management (green areas, water and wastewater management, improvement of air quality), and disaster risk reduction. Good practice examples should comprise both strategic approaches to assessment and implementation, including innovative strategies for conservation of green areas from urbanization and planning and implementation of innovative solutions, including, inter alia, the maximization of urban ecosystem services and the creation of win-win solutions with regards to the reduction of greenhouse gas (GHG) emissions.
- *Forest management*: The funded projects should elaborate ways and approaches to mainstream adaptation to climate change into forest management considering the aspects set by the new forest strategy. The project should include different objectives of forest management (e.g. timber production, protection, nature conservation) and should bring together different types of forest owns (private and public). Furthermore, the projects should overcome barriers in the integrated assessment research to advance analysis on forest fires particularly in the Mediterranean.

The economic costs and benefits of the lighthouse projects depend on the size and number of the projects and whether a critical mass for a significant change will be established. It has been proposed that the IPs should be equipped with substantial contribution from the LIFE programme. Medhurst et al. (2011) suggested that the average budged of the projects should be around 13 million Euros and the IPs should account for at least 50% of the expenditure.

[73] The research priorities draw on the recommendations in the IPCC (2007a) 4AR – Parry et al.

Thus one may deduce that around 5 IPs of the above size may be funded annually in the Climate Action sub-programme alone.

1.3.2.4. Option 2C: Commission's proposal on the adoption of adaptation strategies for all Member States by 2017

Developing a comprehensive Adaptation Strategy needs commitment. Its drafting alone entails efforts estimated as follows: some three full-time employees on average over the course of two years or more, supported by consultants, depending on the level of ambition of the vulnerability and risk assessments conducted. Total costs depend on how detailed the adaptation strategy/action plan is, how many sectors are addressed, whether concrete actions are specified or not and the number of conducted stakeholder consultations. Experience in the EU Member States and regions puts the cost of developing an adaptation strategy between 1 million euro and 48 million euro, depending on the number of studies commissioned, modelling done, etc.

Based on the scope of existing strategies and their estimated cost by Member States, rough **cost estimates suggest that around €3 million would be needed** for the development of an adaptation strategy in line with the considered EU guidelines (**option 2A**, assessed above), not counting the elaboration of implementation action plans where these are not included already in the adaptation strategies. The cost implications for those Member States who need to revise their adaptation strategies will not be higher than €3 million.

Although not easily quantifiable, there are benefits to be expected from the adoption of an adaptation strategy, whose type relates to the ones **described in detail in the assessment of policy option 2A – guidelines on preparing adaptation strategies**. The extent of the benefits would however vary. The main advantage in an additional stimulus is in the use of the suggestions made in the guidelines, which would translate in a consistent and comprehensive treatment of climate change adaptation considerations by 2020 in all Member States, taking account of local and sectoral differences.

It would also ensure an adequate coverage of **transboundary** issues, currently overlooked. Cost-efficiency will be increased by sharing financial burdens of implementing adaptation measures as joint activities in a cross-border context. Furthermore, large-scale impacts causes e.g. through extreme events that would highly affect low-income groups can be reduced or even avoided. Further, potential un-coordinated responses could be avoided. Exchange of good practices in dealing with climate change impacts will be fostered. An inclusion of transboundary considerations in all adaptation strategies would enhance in the long-term the adaptive capacity of environmental systems, in particular with regard to water, biodiversity and soil.

Without a systematic overview of climate risks – which needs to be regularly adapted as more knowledge is obtained –the impacts of climate change will likely be addressed mostly reactively and randomly, which would be significantly more costly than considering, in an orderly way, whether and how public authorities, the private sector and citizens should adapt. Moreover, this would prevent some of the negative impacts identified under the baseline scenario from unfolding and avoid the greater costs of inaction.

Option 2C – Commission's proposal on the adoption of national adaptation strategies is composed of three alternative approaches. The effectiveness, efficiency, and coherence of the three approaches – no legal requirement, legislation later, and legislation now – must be considered in conjunction with the implementation of option 2A – guidelines and option 2B – presented above. In that respect, the positive impacts to be expected from option 2C mainly relate to the stimulus that the Commission would give for actions at national level.

The **non-legal approach** is a continuation of the approach presented in the 2009 White Paper. The additional effectiveness of this approach, compared to implementing options 2A and 2B alone, is expected to be small. Therefore, if the guidelines plus the availability of Life+ funding opportunities are not enough to provide the necessary political visibility to climate change adaptation, there is no guarantee that the second objective of the Strategy will be met. However, it would be uncontroversial, from a Member State's perspective.

Legislation later will give Member States the chance to make use of the guidelines and of LIFE+ funding in designing their adaptation strategy would be more acceptable than a 'legislation now' scenario by Member States reluctant to EU legislation on this issue. It would also provide additional political incentives for adaptation action, in particular to speed up the process in those Member States that are currently undertaking climate change adaptation action. The risk is that for those Member States who have not started any action on adaptation, the political incentive would be insufficient to undertake adaptation action now, de facto delaying the necessary action to meet the objectives of the Strategy to beyond 2017.

Combining a **legislative proposal now** with the adoption of the guidelines and the availability of Life+ funding opportunities could increase the likelihood that all Member States have developed an adaptation strategy by 2017, thus raising coherence of EU action and bringing Member States to a similar pace. The Commission could help deal with some of the compliance costs for Member States by providing funding opportunities and the necessary framework for experience transfer and capacity building.

However, some of the Member States which have already an Adaptation Strategy have expressed their **opposition** to the use of a legal instrument, arguing that legislative approaches would be premature, given that Member States are already in the process of developing programmes of work, and putting in place domestic programmes of action. This is also true for a minority of Member States which have not adopted an adaptation strategy and for a large part of the stakeholders that have answered the public consultation. Conversely, a large majority of **environmental NGOs** who answered the public consultation **support a legislative proposal**.

1.3.2.5. Option 2D: Promoting the UNISDR “Making Cities Resilient” cities campaign

The “Making Cities Resilient” campaign is one opportunity for cities to be encouraged to take their own actions in adaptation and urban resilience, and to take advantage of networks and partnerships which are appropriate to their political character and context. This campaign’s focus on disaster risk reduction brings both advantages and disadvantages in relation to building urban adaptation specifically. The advantage is that adaptation is mainstreamed into the broader disaster risk reduction field, and so disaster risk reduction policy, tools and networks can potentially be adapted to address climate impacts. The disadvantage is that some of the unique challenges and characteristics of climate change adaptation may be diluted or overlooked within this broader context. For example, the need to plan on longer timescales and for the potential of larger, more extreme climate change events will likely be underplayed in a disaster risk reduction context. Currently, 1067 cities worldwide are signed up and involved, including around 330 from the EU27 (most of it from Austria).

All participants to the “Making Cities Resilient” campaign are expected to be self-supporting as they organize awareness-raising events, convene meetings and engage in planning on campaign objectives. So there will be a cost to city stakeholders who engage in the campaign. It is not possible to put exact figures on this since the cost will be determined by the actions that each individual city chooses to take.

The wider economic benefits of this initiative are in terms of stimulating adaptation and disaster risk reduction planning at city level, which while it may require some investment in the short term, should result in the avoidance of much larger damage costs in the future, when extreme weather events are experienced. In addition, sharing of good practice and engagement in the international network could drive innovation in urban adaptation measures across a broad spectrum of sectors, potentially supporting creation of jobs and increasing EU market share in adaptation technologies. There will be opportunity costs as staff devoting more time to campaign activities and other work is not undertaken.

There are multiple potential social benefits associated with participation in international networks and campaigns. These include individual, collective and organisational learning, leading to changes in organisational practices and culture, improvements in managerial styles, better communication and co-ordination. The opportunity to exchange learning experiences between cities might result in more efficient adaptation decision-making at city level.

The potential risks relate to the absence of budget for this initiative. In that respect, there could be a low level of up-take by EU cities unwilling to commit budget to additional activities. In addition, a signature of commitment to the campaign is not a guarantee that cities will be actively involved or that their activities will result in enhanced climate resilience. From an EU perspective, there is also a potential lack of control over direction of independent UN campaigns to support EU policy priorities directly. Finally, the campaign is only scheduled to last until 2015, although UNSIDR expects to go beyond that date. It could thus create some uncertainties on the possibility to use this campaign for the duration of the EU Adaptation Strategy.

1.3.2.6. Option 2E: Inclusion of adaptation into the Covenant of Mayors Framework

Background

Following the Adoption of the EU Climate and Energy package in 2008, the Covenant of Mayor was set up to support the efforts of local authorities in the implementation of sustainable climate and energy policies.

Since then, this initiative has met large international success: 2,108 cities from 41 countries had signed political commitments by November 2012. The database "benchmarks of excellence" is a repository of solutions implemented at local level available via the web. In many cases, mitigation goes hand in hand with adaptation and needs to be coordinated at local levels. Including adaptation to the Covenant framework underlines the interlinkage between the two lines of actions and helps to increase the overall efficiency and effectiveness of integrated climate action.

The approach of ensuring voluntary, local political commitment for EU policy objectives was replicated in two other cases: i/ enlargement of the approach to cities in the Eastern Partnership and Central Asia; ii/ the Green Digital Charter commits cities to work together to deliver on the EU climate objectives using digital technologies. Both projects are linked to the Covenant of Mayors, as the same partners are in charge of implementation. They are implemented through separate service contracts.

Implementing climate adaptation related actions alongside existing initiatives can help meet the objectives and reach cost-effectiveness. For example, in the UK, the Nottingham

Declaration[74] was successfully extended from covering only climate mitigation to include adaptation, and then further developed to provide action packs and supporting guidance.

Discussion

This initiative aims at launching a new voluntary commitment for cities to adopt local adaptation strategies as well as to inform about their implementation.

In order to offer operational support to such a commitment funding from the European Commission needs to be provided to an office to administrate and steer the initiative. This has been estimated at around **500.000 Euro a year,** plus additional 200.000 Euro for the bottom-up design process of the initiative and promotional activities**.** In addition, initial funds to design and set up the support package including a monitoring and evaluation mechanism will be needed.

The new commitment will be purely voluntary. Hence the adhesion is fully free of charge for the cities; however there are costs to cities to follow up on pledges they sign up for. Using evidence from the DG CLIMA study on Adaptation Strategies for European Cities[75], completing an initial pledge to move one step further with adaptation in their city cost an average of €50,000, which was based on a daily average cost of €500 for 40 days for the cities time plus on potential consultancy costs of €27.200. However, numerous studies have proven the cost of inaction to exceed the cost of action. Furthermore, urban adaptation - if done well – forms part of integrated urban development and supports the upgrading of the urban fabrique.

Given the important role cities have to play in increasing Europe's resilience to climate change, the positive economic impacts would stem from ensuring cities are still a good place to live if not a better place to live, like wise invest and ensure economic growth. Stimulating adaptation planning at city level requires some investment in the short term, but will result in the avoidance of much larger damage costs in the future, when extreme weather events are experienced. Cities that are signed up to the revised pledge should ensure greater sustainability of action than those going alone, so longevity of action should have increasing postive economic impacts.

There are multiple potential social benefits associated with participation in international networks and campaigns. These include individual, collective and organisational learning, leading to changes in organisational practices and culture, improvements in managerial styles, better communication and co-ordination. The opportunity to exchange learning experiences between cities might result in more efficient adaptation decision-making at city level. The facilitation of peer-to-peer learning will enhance the necessary skills for the successful implementation of international frameworks in the local setting and sharing of good practice can lead to improvements in the quality and performance of decision-making. However, in practice, engagement in initiatives, provision of tools and guidance, or city exchanges do not automatically lead to their intended outcomes due to outside factors that cannot be controlled. The potential impact of this initiative on adaptation being incorporated into urban governance and decision-making is not guaranteed. The initiative would support job creation to deliver the adaptation pledge by the cities as well as additional jobs in the supporting office.

[74] The Nottingham Declaration has been succeeded in 2012 by the Climate Local initiative which supports carbon reduction and climate resilience. http://www.local.gov.uk/web/guest/the-lga-and-climate-change/-/journal_content/56/10171/3574359/ARTICLE-TEMPLATE

[75] http://eucities-adapt.eu/cms/

In the longer term, the initiative should have positive environmental benefits since training and toolkit align with principles of sustainable urbanisation and the supports and links to mitigation action will help further reducing CO_2 emissions.

A risk is on the delivery side, as the signature to the pledge is voluntary and does guarantee that cities will actually invest and implement in additional activities and that urban adaptation will be enhanced.

However, the effectiveness of the Covenant of Mayors' model has already been assessed when it comes to the greenhouse gas mitigation objectives. From an analysis of a sample of commitments, it is expected that the Covenant Signatories will reduce their Greenhouse Gas (GHG) emissions by 28% by 2020, well in line with the objective of the Signatories which aim at reducing emissions by more than 20% by 2020. This confirms the potential effectiveness of such an instrument.

1.3.3. Likely impacts of policy initiatives aiming at increasing the resilience in key vulnerable sectors

1.3.3.1. No policy change

To allow synergies and decrease the costs of adaptation, the EU has already recognized the need to foster mainstreaming into all EU sectoral policies Mainstreaming adaptation at EU level has so far benefitted from two strands of initiatives: the initiatives dealing with the implementation phase of the 2009 White Paper, and the Commission's proposal for the next Multi-Annual Financial Framework.

Regarding the former, the implementation phase of the White Paper can be considered as successful. Most actions have been implemented and in some cases, EU initiatives went beyond the White Paper's recommendations (see Annex 1.4.1 for details). Yet, among the number of EU policies that are or will gradually be affected by the adverse effects of climate change, some still do not sufficiently take into consideration the need to adapt to those negative effects. Moreover, in some cases (e.g. energy policy), a lot of attention has been paid to the greenhouse gas mitigation objectives while not necessarily integrating in the EU policy discussion on vulnerability to climate change or adaptation options to reduce vulnerability.In addition, in many sectors, adaptation considerations have been addressed on ad hoc basis, and insufficient attention has been given to the implementing measures accompanying broad policy objectives.

In particular, clear requirements in the CAP and Cohesion Policy proposals allow for serious consideration of climate change impacts in Cohesion Policy and Common Agricultural Policy for 2014-2020. At the same time, these requirements are flexible in nature, and allow for a great deal of interpretation by both the Member States and the Commission in their practical implementation.

Without further EU action, mainstreaming adaptation would simply mean for Commission initiatives to address in their related Impact Assessment the potential impacts of climate change on the effectiveness of the initiative. It would also mean that no steer would be given on the priority initiatives that would require ambitious and/or immedtiate mainstreaming. The mainstreaming of adaptation in national policies would also be hampered for those policies directly affected by policy intervention at EU level.

The European Union is a major investor in public infrastructure projects. European, investment-based development policies such as EU cohesion policy, TEN-T and TEN-E, help overcoming gaps in infrastructure needs, especially in Convergence regions. Combining

several EU sources, it is estimated that some EUR 400 billion have been invested in the TEN-T network projects since 1986 – almost a third coming from EU sources, much of it from the Cohesion Fund.[76]

Due to the long life spans of infrastructure and their great economic value, their preparedness for current and future impacts of climate change is critical. Hence, an assessment of a project's risk-exposure and vulnerability to climate change impacts is vital to guarantee its long-term sustainability. Accordingly, for some EU policy areas, climate resilience has already been taken up as a parameter in obligatory cost-benefit analyses during the project development phase.[77]

However, there is no common requirement to do so. There is also no common methodology or guidelines in place which could help project promoters to systematically assess the climate resilience of infrastructure projects and improve their sustainability and liability in changing climate conditions. Evidence[78] also suggests that there is a certain lack of awareness of project promoters for climate issues and insufficient knowlegde on how to conduct the climate resilience checks for projects, especially private sector-driven projects.

The Environmental Impact Assessment (EIA) Directive[79]requires that Member States ensure that, before development consent is given, projects likely to have significant effects on the environment by virtue, *inter alia*, of their nature, size or location are made subject to an assessment of the environmental effects. Climate change may affect all major developments subject to EIA but the EIA Directive does not explicitly address the future climatic pressures and impacts. Additional guidance is under way, and the EIA Directive is under revision and clearer provisions relevant for climate change are likely to be proposed. Similar issues apply in the context of the Strategic Environmental Assessment (SEA) Directive[80]. It requires the environmental effects of a broad range of plans and programmes to be assessed so they can be taken into account while plans are actually being developed, and in due course adopted. Here again, guidance is being prepared, but no revision is scheduled for the time being.

Having the above in mind, the Commission proposal for guidelines for the development of the trans-European transport and trans-European energy infrastructure[81] include general considerations on the need to climate-proof those investments. However, it remains unclear how this aim can be achieved in technical means and there is a risk that definition of common approaches will take quite some time. It should also be noted that the application for projects is voluntary for Member States and it cannot be ensured that all relevant infrastructure will be made climate resilient in the next decades.

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[76] 5the cohesion report

[77] For example, the proposal for 'guidelines for trans-European energy infrastructure' COM(2011)658 includes, in annex V, the 'system resilience, including disaster and climate resilience, and system security, notably for European critical infrastructure as defined in Directive 2008/114/EC' as an aspect to be considered for cost-benefit analyses for electricity transmission and storage.

[78] OECD 2011 (http://www.oecd-ilibrary.org/docserver/download/fulltext/5kg221jkf1g7.pdf?expires=1346855082&id=id&accname=guest&checksum=68799770483309BDDCBF3A8CF2E3C218)

[79] Directive 2011/92/EU of the European Parliament and of the Council of 13 December 2011 on the assessment of the effects of certain public and private projects on the environment [codification] OJ L 26, 28.1.2012, p.1.

[80] Directive 2001/42/EC of the European Parliament and of the Council of 27 June 2001 on the assessment of the effects of certain plans and programmes on the environment, OJ L 197, 21.7.2001, p.30.

[81] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2011:0658:FIN:EN:PDF

Green infrastructure to address natural hazards is governed by various EU policies. The evolution of how these policies address green infrastructure in the coming years will have a significant impact regarding its growth or stagnation. For instance, the WFD encourages Member States to implement measures targeting land use but on a voluntary basis. Many Member States have decided to wait to implement supplementary measures. The forthcoming adoption of the Green Paper on green infrastructure should provide additional elements on the way ecosystem based approaches issues could be addressed at EU level to better capture their potential for climate change adaptation purposes.

At EU level, the inclusion of climate change adaptation considerations in the design of buildings has just started. As already announced in the 2009 White Paper, a mandate has been adopted which would require standardisation organisations to consider, in the context of their work to update Eurocodes, developing a technical report analysing and providing guidance for potential amendments for Eurocodes with regard relevant impacts of future climate change. Eurocodes are a set of harmonized technical rules developed by the European Committee for Standardisation for the structural design of construction works in the European Union. The Eurocodes therefore replace the existing national technical standards, published by national standard bodies, although many countries had a period of co-existence. They provide a common approach for the design of buildings and other civil engineering works. They cover earthquake resistance, but not yet climate proofing. Since March 2010 the Eurocodes have to be accepted in all public tenders as means of calculating structural design and are de-facto standard for the private sector.
A consultation among national standardisation bodies led us to conclude that only limited efforts have been undertaken at national level to further climate-proof design standards. Denmark seems to have done some pioneer work on this issue. Road regulations and railway standards are being/will be reviewed and revised with consideration of expected climate changes. The standardisation body in the UK is also active, with specific emphasis on climate change adaptation measures in their standardization work with the construction sector (i.e. standards on water supply, flooding and the like); risk/resilience standardization (project underway to explore the role of risk/resilience standardization in the context of climate change adaptation), and more recently, their biodiversity work (where climate change adaptation is currently considered within the context of the UK planning regime). Other national standardisation bodies active include the ones in BE, DE and NL.

In the absence of EU action there is an expectation that the gap between those organisations able and willing to take adaptation actions and those left behind will grow. Some of the largest trans-national corporations, and those in certain sectors, have begun to appreciate the potential threat and opportunity presented by climate change. However by 2020 large sectors and a great many small and medium sized enterprises will be unable to make the necessary adaptation measures making them increasingly vulnerable to the effects of unavoidable climate change, and therefore less competitive. In the absence of measures from the EU this gap will widen – creating market obstacles for those left behind.

There is evidence of on-the-ground adaptation (e.g. PWC, 2010; UK Trade and Investment, 2011; OECD, 2011) but this is mainly from multi-national corporations and there is little evidence of adaptation in SMEs. Indeed only 24% of respondents to the consultation exercise indicated that EU action within the industry and SME sector was relevant or highly relevant to improve Europe's resilience to the adverse effects of climate change. 29% of respondents were neutral, 13% of respondents did not believe industry and SMEs were relevant and 10% had no opinion. This suggests that with no further action, multi-national companies rather than SMEs would continue to be the drivers of adaptation.

Firms are investing more to protect themselves. Much of this takes the form of updating business continuity plans, or upgrading risk trackers. But around one in four firms is either upgrading their existing physical assets, for example by weather-proofing buildings, or taking out new insurance policies. Around one in five businesses plan to adapt their operations better to deal with such changes, such as adopting new crop varieties or more water-efficient facilities (UK Trade & Investment, 2011).

In a review of existing European National Adaptation Strategies, there was very little consideration of the role of the private sector in adapting to climate change. Four of the nine adaptation strategies reviewed included discussion on the role of insurance, but this was limited. Only the adaptation strategy for Malta contained a concrete action relating to the role of insurance: "the Malta Resources Authority will steward discussion amongst stakeholders to identify suitable mechanisms and instruments that will ensure that the insurance market remains sustainable in the event of increasing unpredictability of climate change impacts on various sectors in Malta."

In light of this, it is likely that Member States require further guidance and assistance from the EU on how to stimulate the private sector into action on adaptation; combined with help to engage the finance and insurance sectors on adaptation. Without further action, progress among Member States is likely to be slow and fragmented. With no (new) action, large businesses are likely to continue with a piecemeal approach to adaptation and SMEs are not likely to step up their adaptation action. The impact of climate change on Europe and the rest of the world will accelerate and businesses will not be ready and able to reduce their vulnerability and seize the opportunities that adaptation presents.

1.3.3.2. Option 3A: Guidance on how to climate proof Cohesion Policy and CAP

Interactions with Member States and stakeholders have confirmed that there is a great deal of uncertainty on how the cross-cutting adaptation objectives can be implemented on the ground.

The guidance document will provide advice, methods, and examples aiming at ensuring that climate adaptation objectives are understood, fully addressed, and integrated into Member States' Rural Development Programmes (RDP) and Operational Programmes for the next programming period (2014-2020). The guidance is intended to be used by Managing Authorities as well as other actors participating in programme development, consultation, and evaluation including climate experts and external stakeholders involved in the process.

Providing further guidance would therefore support the European Commission and Member States in their efforts to achieve optimal integration of climate change adaptation into the Common Agricultural Policy (CAP) and into the Cohesion and regional policy. The costs of developing the guidance are estimated at **€200,000, to be supported by the Commission**[82].

A mix of "grey" (as related to infrastructure), "green" (as related to the environment/ecosystems/green infrastructure), and "soft" (as related to human capital and adaptive capacities) **adaptation options** need to be promoted in future Cohesion Policy and the CAP. The set of implemented options will yet vary throughout the EU. These will depend on the nature and severity of the climate change threats as well as on regional circumstances, including adaptive capacity.

Adaptation options can have high benefit-cost ratios, although the cost- benefit largely depend on the national and regional context and the assumed climate scenarios. Preliminary work has identified the following adaptation actions as potentially worth for funding by the European Agricultural Fund for Rural Development (EAFRD): buffer strips for agricultural land, storm

[82] Figures are based on the contract CLIMA/C3/SER/2011/0011

retention reservoirs, on-farm water storage, measures to adapt to river and coastal flooding. Other cost-effective options include: floodplain management, the planting of winter cover to prevent soil erosion, improvement of animal rearing conditions and high-efficiency ventilation. As regards Cohesion Policy, cost-effective actions are: early warning systems, adapting rail tracks to higher temperatures and adapting electricity grids.

There will be competition between different thematic objectives in Cohesion Policy. It is, therefore, important to promote climate change expenditure in a smart way. Where possible, priority should be given to options that realise important synergies with climate change mitigation or bring about co-benefits for other sectors such as industry, transport, water management and social inclusion. This would help to promote climate adaptation under different thematic objectives.

In addition to producing the guidance, additional costs may be expected if training events are organised, at EU but also national and regional level, targeting the main actors of the sectors. It is difficult to provide a good estimate of such a widespread training exercise, but additional costs of hundreds of thousand euros can be expected. These costs would be shared between the Commission, Member States, managing authorities and relevant stakeholders. Under both Cohesion Policy and CAP, various areas of expenditure are likely to be sensitive to climate change related impacts from threats, such as flooding, storms, and extreme temperatures.

Of course, the effectiveness and efficiency of such guidelance depend on their uptake. In that context, the capacity building strategy, although generating additional costs, could prove a key determinant to ensure the effective dissemination of the information available in the guidelines.

A focus on SMEs

There are two steps to the awareness process that have to be taken to avoid potential losses to the industry from climate change events. The first step is for private enterprises to be aware that climate change will have certain impacts specific to their activities beyond general impacts that are increasingly becoming common knowledge in the public domain. The second step is to carry out an assessment and be aware of what specific impacts are likely to occur to their enterprise.

Business sector entities might not be aware of climate change impacts particular to their activities and therefore choose not to allocate resources to find out how climate change will affect their business. An awareness-campaign could provide detailed enough information to private stakeholders (beyond common knowledge of overall climate events) as part of the first step to convince them that they need to take the second step (autonomous analysis of climate change impacts specific to their business) to ensure that their enterprise remains competitive and is not at risk from climate change events.

The need for public intervention and awareness raising might differ significantly among industry sectors and Member States, and might be most crucial in Member States where climate change effects are not yet apparent but are likely to have a significant impact on the private sector in the future. Presumably a private sector entity will be aware of climate change impacts, and public sector-driven awareness raising campaign will not be needed, if there are evident climate change effects already affecting the business, or if there is relevant, easily accessible and digestible information already available.

This initiative might be particularly relevant for SMEs and could be implemented in the context of the "Enhancing the competitiveness of small and medium-sized enterprises (SMEs)" objective of the Cohesion Policy Legislative Proposals for the 2014-2020 programming period.

There are no quantified benefit data available on awareness-raising benefits for companies that would consider the whole range of possible climate related damage costs specific to the industry. One indicative figure is the following—the damage costs reported for river flooding indicate that the damage to industrial and commercial activities accounts for around 12% of total damage costs, valued at some €2.5 billion per year (2010 prices) by the 2020s, based on the A1B climate scenario (Feyen and Watkiss, 2011).

1.3.3.3. Option 3B: Listing mainstreaming priorities in EU policies and engaging with key stakeholders

Description of the option

The aim of this policy initiative is to propose a strategic approach for mainstreaming climate change adaptation into EU legislation. This initiative would provide a list of priority initiatives until 2020 for mainstreaming and how to reduce vulnerabilities and thus enhance climate resilience. This would set out a plan for the political and structural change needed up to 2020. Areas where policy action can make a real difference are of particular focus. Based on the assessment described in the problem description the priority initiatives in mainstreaming should focus on the following priority areas and actions:

- Transport: Ensuring that transport related infrastructure is made more climate resilient
- Energy: Ensuring that energy related infrastructure is made more climate resilient
- Construction of buildings: Ensuring that energy related infrastructure is made more climate resilient
- Health: Early warning should be improved and an EU wide integration should take place. Also surveillance mechanism and periodic monitoring should be improved. This requires better cooperation among regions and Member States.
- Social issues: Particular focus should be spent on vulnerable groups (e.g. older people), but also on how to make use of gender issues for strengthening adaptation efforts.
- Insurance: With the Lamfalussy process a system has been set up that enables the Solvency II and IMD 2 regimes to keep up-to-date with future market and technological developments. This can be used as a starting point for mainstreaming.
- Coastal zone management and marine issues: Climate change needs to be considered within planning activities. This also requires increased awareness and better cooperation among the different stakeholders involved.

Mainstreaming should not only focus on introducing adaptation to climate change into legal actions or developing guidance. There is also the need to tackle specific bottlenecks like inconsistencies in policy (e.g. renewable energy) and market. These priority initiatives should prevent failures to ensure that policies are all going in the same direction. Cross-cutting themes such as social policies are also addressed. The roadmap provides a framework in which future actions can be designed and implemented coherently. It sets out a vision for the political and structural change needed up to 2020, with milestones to be reached by 2017. These milestones illustrate what will be needed to put Europe on a path to mainstream climate change adaptation into all EU policies.

Assessment of the option

The direct costs for listing mainstreaming priorities are seen to be marginal. When amending or developing new EU legislation, a dedicated impact assessment will have to consider the implications from a climate change adaptation point of view. It requires mapping the current status of adaptation efforts in EU legislation (Directives, Regulations and Commission Decisions) and other policy documents.

Listing priority initiatives for further mainstreaming will further raise awareness of the need to integrate climate change considerations in key EU policy areas beyond the recommendations of the White Paper on adapting to climate change. It will foster a dialogue with respective Commission services, but also with Member States and other stakeholders.

For this initiative as such, it can be assumed that the overall benefits relate to a clear commitment to act at EU level to integrate climate change considerations in all relevant EU policies in a coordinated and well-planned manner. It will further increase awareness of the necessity to address climate change adaptation in various policy areas projected to be affected by climate change impacts. Furthermore it can be expected that agreeing on these priorities would allow to anticipating and allocating better European Commission resources.

Further, listing mainstreaming priorities in EU legislation and policies allows for greater transparency for Member States. They would be able to prepare better for respective implementation in various sectors. Anticipatory policy making on Member States level can save costs, while avoiding potential overlaps in mainstreaming efforts at national level. Furthermore, processes to develop national adaptation policies can be better informed by a roadmap for upcoming EU level mainstreaming efforts.

A roadmap will also clearly outline potential conflicting policy objectives as well as highlight synergies that can be achieved through aligning mainstreaming efforts in several EU policy areas.

Assuming that the above mentioned priority areas and actions will form the core of the option the following more detailed impacts can be assumed:

For the transport, energy and construction sector climate resilience will be improved. There are several existing EU policies that may serve as entry points to include climate change considerations in particular with a view to taking into account future climatic conditions. Most policies take due account of climate mitigation issues, but not yet of assessing risks posed by future climate change and developing appropriate adaptation responses.

For the transport sector this applies to all transport modes where climate change impacts are expected to pose increased pressure on the infrastructure in the future, also in economic terms. This is of particular importance considering the long-term investments (e.g. major transport routes, bridges, tunnels, urban transport). Taking account of future climatic conditions is thus of high importance to both prevent potential damage costs and safeguard the functioning of European transport systems. Identifying and listing related policies that serve as entry points for mainstreaming adaptation are relevant for both existing infrastructure (such as e.g. safety management for roads) and new infrastructure to ensure that any investment is "climate-proofed".

For the energy sector EU policies helping to reach adaptation targets (e.g. cutting down seasonal demand peaks, Connecting Europe Facility, Smart Grids initiative) are in place and emerging, although not named as such – thus having high mainstreaming potential. Anticipated threats on the European energy system such as (i) aggravated extreme events, ii) increasing interconnection of grid-dependent European internal energy market and thus increasing amounts of transmitted energy/less domestic supply in many regions, iii) projected further shift towards increasing electricity demands and according shifts in primary energy consumption and iv) increasing share of renewable energy generation that will entail a more complex picture of climate threats (e.g. increasing dependency from solar irradiation, wind velocities, river run-off regimes) will need to be taken into consideration in various related policies. Listing those with high mainstreaming potential and assuring a coherent approach will allow to take preventive action to address the above highlighted threats.

For the construction sector EUROCODES as a set of unified international codes of practice for designing buildings and civil engineering structures are regarded as having high mainstreaming potential, however so far do not incorporate aspects of future changes of climatic conditions (for more details cf. option under problem 5). .

In the case of mainstreaming in the health sector, integration of future climate change risks is expected to improve, inter alia, the following:

- Less heat related deaths through improved surveillance mechanisms and contingency planning taking due account of potentially more frequent and extreme weather events due to climate change
- Foster preventive actions to reduce the risk of spreading of pests and diseases considering changes in certain disease carriers (e.g. by the Asian tiger mosquito)
- Safeguard adequate financial resources for health in the EU Cohesion Policy from 2014 onwards to deal with climate challenges and link forecasting tools (e.g. for heat, floods, wild fires, storms) with the health sector on a cross-border scale
- Connect early warning for air pollutants, especially ozone, closer to health services in order to effectively react and ensure timely actions
- Support the monitoring (e.g. detection via early warning mechanisms and rapid eradication) and reporting procedure, monitor climate related changes on invasive species distribution, survival and spread, and foster the exchange of information on potential eradication strategies.

Even if there are quite some uncertainties related to mainstreaming adaptation into the EU social policies, doing so could mitigate growing disparities in society due to climate change. Social harmony which is a cornerstone of the EU will also be secured. The mainstreaming of adaptation to climate change in social policies might not always involve direct additions or edits of the texts of current legislation and other policy documents, however, it certainly does provide additional reasoning and importance for the development of EU social policies due to the fact that successful achievement of social policy aims is inseparably linked to successful strengthening of the adaptive capacity of societies. For example:

Reduction of forced climate migration (internal and external) through the development of adaptation policies in potential source countries and regions (including EU member states) could reduce the need for people moving away from marginal areas and supporting livelihoods that are more resilient.

Economic disparities lead to differences in adaptive capacity between man and women. Climate change should be used as a further argument to reduce these disparities and to reduce vulnerabilities in particular of women.

The IPCC recognises the elderly as a group of greater vulnerability, which is mainly due to people of older age being more sensitive to health impacts (IPCC, 2007a), especially caused by heat, as well as to stress associated with losses and physical damage during extreme weather events (CAG Consultants, 2009). They are also more likely to have reduced mobility and therefore reduced access to essential services. Additionally, older people are less likely to be willing to relocate away from exposed areas due to general reluctance to migrate, which rises sharply with age (Huber & Nowotny, 2008). Considering these aspects in the context of planning for adaptation could reduce the vulnerabilities of elder people.

Coastal zones are one of the high risk – but on the same side one of the most dynamic and developing areas – in the EU territory. Increased mainstreaming into this policy area could reduce this risk but could also contribute to a sustainable development in the future.

Engaging with the insurance sector

The probability of most types of extreme event is expected to change significantly, in many cases upwards, as a result of climate change. Several national studies have interpreted the predictions for insurers; for example in the UK and in France. In fact the ongoing rapid changes make it hard to assess the future risk. The most dramatic and reliable changes are predicted for temperature; the historical 500 year heat wave event might become a 2 – yearly (biennial) event by the 2040's (Stott et al., 2004). There is now strong evidence that extreme high temperature and precipitation events are more common in many regions.

Similar projections for other extremes are less available. For several major European rivers, e.g. Odra, Elbe, Po, Loire, Danube, what used to be a 100-year flood might by 2100 become a one in 50 year or even one in 20 years event (Dankers and Feyen, 2008). The main underlying cause is rainfall; the return period for an event of annual maximum 24-hour precipitation with a 20-year return period in the late-20th-century is projected to be about 5-15 years by the end of the 21st century (IPCC, 2012). A study of extreme rainfall in London found that daily rainfall with a 100- year return period prior to 1960 has a 10-year return period now (Lloyd's, 2010).

On the reverse side, there is a projected increase of duration and intensity of drought in the Mediterranean region and central Europe, but this is not well-quantified (IPCC, 2012). For storms, the outlook is less clear still, but the consensus is a gradually increasing risk for north-west Europe (IPCC, 2012).

As a result climate change can affect the functioning of insurance markets. The impacts are likely to be in the same areas where the disaster insurance markets already experience difficulties. These may intensify as a result of climate change. Three main areas are identified that might be affected by potential impacts:

- Risk transfer conditions (price / coverage): An increase in the event probability and severity would lead to price increases. In the short term (under 5 years say), the effect of climate change on insurance might not be thought to be significant, as long as due allowance is made for the underlying trend[83]. In the longer term, particularly in sectors or areas where insurance has not been customary, climate change could create or exacerbate issues with correct pricing and availability. In particular, sea level rise will become an issue for coastal and estuarine risks. The problem of drought for agriculture and livestock may also become more serious. Potential losses from storm and flood could also rise significantly (ABI, 2005; GDV, 2011), but the actual increase would be highly dependent on changes in exposure and vulnerability. At the same time, changes in the underlying pattern of extreme events would increase the uncertainty of estimation, which would mean an additional increase in price to provide a greater safety margin.
- Availability: As a result of increasing risks, insurance might become unavailable in certain areas. It is widely accepted that natural events that are less frequent than 1 in 75 years are readily insurable. Swiss RE indicates that for risks with a 100 to 200 years return period (0.5% to 1.0% probability), the risk premium is 3.5% of the value of the assets. For more extreme risks, the premium therefore becomes too high as an

[83] The point is that regulators and insurers must allow for the trend, not simply use the historical averages, which will be somewhat lagging behind, and so will always produce an incorrect response

annual charge. Practice in the UK broadly confirms this – the limit for an insurable flood risk when there is no adverse selection, and the risk is bundled with other hazards is a 75 year frequency, i.e. 1.3% probability (ABI, 2005).

- Demand: It might be expected that climate change will increase the demand for insurance, due to higher risk. However, the increasing stresses may divert disposable income to other purposes, as well as creating greater calls for public relief after disasters. Furthermore, if not addressed, climate change could lead to insurance becoming less affordable or unaffordable, particularly for lower income population.

Insurance can be used as an instrument for adaptation to climate change in at least three ways

- Managing climate change risks: Insurance should be part of strategic risk management e.g. state policy for agriculture and forestry, and for energy which is weather-dependent. It is important to remember that climate risk management needs to be observed for existing assets and activities, as well as new ones. It is also important that stakeholders are aware of the available insurance products for their climate risk management portfolio.
- Providing incentives for climate change risk prevention: In order to give incentives for risk prevention, insurance prices have to be risk based and adequately adjusted according to risk prevention efforts taken by customers. In principle, if insurance prices and conditions were related to the risk, that would send a clear signal to the purchaser, about the economic implications of the present exposure and risk management. In practice this often does not happen, because such measures are voluntary and not common. 'Regulatory framework mandating or codifying risk resilience would encourage price differentiation.
- Disseminating information on climate change risks and risk prevention measures: Insurance sector organisations are among the entities which could provide climate change risk related information to clients, since they are already involved in the business of risk management. It could be argued that it is in insurers' interest to divulge information on risk, so that clients make appropriate preparations to deal with climate hazards, and so reduce the scale of potential losses.

It is premature at this stage to identify the detailed policy options that could be implemented on insurance, both as a sector and as an instrument for adaptation. However, it seems essential to start a process of consultations with stakeholders on the prevention and insurance of natural disasters. This process in itself will not provide detailed implications but it will allow identifying good practice in the EU and detailing the need for additional information at EU level.

Engaging with commercial banks

The Finance and Investment sectors' broad economic participation make them exceptionally vulnerable to climate change. The sectors have investments, portfolios, assets, debtors, and collateral across the world and across sectors, any of which may be adversely affected as the climate changes. At the same time, the Finance and Investment sectors can greatly influence adaptation measures by financing adaptation projects in all other sectors, and providing risk assessment services to other sectors.

Investors in infrastructure include banks, hedge funds, insurance companies, sovereign wealth funds, investment/development banks and public and private pension funds. Time frames range from investors looking for a return within 5 to 10 years to those long-term investors looking for a continual rate of return on their investment over 20 years or more. For long-term

investors in infrastructure in particular, climate change impacts present a risk, e.g. to the continuity of rates of return. Therefore, some long-term investors can see the potential benefits of incorporating climate risk into their decision making and adapting their infrastructure assets as this will help to lower the risk to their financial returns.

Investors have an important role in making investments more resilient by

- Demanding greater disclosure of climate risks and adaptation actions by companies to increase awareness, understanding and action.
- Incorporating within their own 'due diligence' processes an assessment of vulnerability to climate change and how this is planned to be addressed over an asset's proposed lifetime.
- Developing financial models to incentivise infrastructure to be planned, designed, built and operated with both current and future climate risks in mind.

Addressing access to finance issues was identified as a significant issue by 63% of respondents to the consultation exercise. 62% of respondents also said that lack of available funding for adaptation measures was a significant or very significant barrier preventing the economy from becoming more climate resilient.

While there is evidence on the role of public investment banks (e.g. European Investment Bank) on adaptation to climate change, less is known about the role of commercial banks. Therefore this initiative seeks to engage directly with commercial banks to a) review what adaptation-related actions are currently being taken, if any; b) review existing structures for risk assessment, e.g. is climate change risk and adaptation taken into account when applying for a loan; c) raise awareness of adaptation and initiate dialogue with stakeholders and facilitate cross-organisation working where possible; and d) motivate commercial banks to consider mobilising funds and sharing best practice with other commercial banks (where it does not compromise banks' competitive edge). The longer-term goal of engagement is to build relationships and facilitate cross-organisation working.

The impacts of the initiative are impossible to quantify at this stage. They will also be difficult to establish because they would mostly be indirect (i.e. they would result from the investments enabled by the initiative). However, some qualitative analysis of the main impacts is possible and presented next.

If effective the policy would improve access to finance through a more adequate offer of financial instruments on EU market, in relation to climate adaptation. This in turn would improve the understanding of the costs and benefits related to adaptation investments and ultimately enable investments that increase climate resilience and innovation in EU businesses. This initiative may also give EU financial institutions a leading edge in climate-related investments and instruments. In addition, through engagement with financial institutions the Commission will demonstrate a strong policy and financial commitment to adaptation, thereby increasing the likelihood of climate resilient investment

Small businesses face the biggest constraints limiting the type and scale of adaptation actions they can take (as do many businesses in developing countries)[84]. Engaging with financial institutions and the banking sector to promote climate resilient investments is likely to help SMEs to overcome financial barriers by allowing SMEs to adapt their operations and/or respond to new market demands by investing in product / service development. It is also important to bear in mind that adaptation measures should not increase red tape for SMEs.

[84] PWC (2010) Business leadership on climate change adaptation: Encouraging engagement and action

Preparing guidelines on disaster prevention

Regarding disaster risk reduction, the Commission would prepare **guidelines on disaster prevention.** In order to achieve climate change adaptation and disaster prevention objectives (see COM (2009)82), there should be a greater knowledge of good practices of disaster prevention by Member States. This can then be disseminated to other Member States policy makers, and relevant institutions to promote sharing of experiences and mutual learning.

The Council Conclusions from November 2009 on a Community Framework on disaster prevention within the Union asked the Commission to prepare together with Member States Guidelines on minimum standards for disaster prevention in particular for risks shared by several Member States on the basis of good practices in disaster prevention.

The preparatory work has included the collection and analysis of more than 400 examples of good practice from over 35 countries including all countries participating in the Civil Protection Mechanism plus Turkey, Australia, New Zealand, USA and Switzerland. A non-exhaustive inventory was established covering practices across various sectors, including horizontal measures, earthquakes and tsunami, flood and storms, heat waves, drought and forest fires, industrial accidents.

To shortlist good practices from the broader inventories per theme, selection criteria were used based on the Effectiveness, Efficiency, Transferability, Sustainability, and Coherence of the practices. Dedicated interviews, stakeholder meetings (April-May 2012) and follow up consultations with expert groups from the Member States helped verify the inventory and shortlist the practices that could feed into the Guidelines on good practice prevention standards.

Throughout the consultation process, it was generally agreed that the Guidance should be of a voluntary nature and centred on multi-hazard or horizontal and cross cutting themes that could be in line with the 4 prevention priorities under the "Hyogo Framework for Action".

Potential topics to be covered include:

- Governance –inter alia cooperation and coordination at different levels of governance and across different authorities and stakeholders, cross border cooperation, monitoring, evaluation and implementation of existing legislation, cooperation with the business sector and voluntary organisations, community resilience actions, coherence with other policies including climate change adaptation;
- Planning – including development and promotion of multi-hazard and cross sectoral risk assessments as well as specific risk assessment and mapping at national, regional and local level which should be further integrated into risk management plans, recovery, capability and response planning as well as long-term sustainable development strategies and policies (e.g. land-use planning, infrastructure) and financial mechanisms;
- Disaster data – including recommendations and good practices on collection, analysis and sharing of data and its use for policy-making;
- Risk communication, information-sharing and awareness raising – including use of social media, mechanisms for effective exchange of information before, during and after a disaster, creation of one information portal on risks, vulnerabilities and preventive actions, tailored risk communication to target local and vulnerable population, education and awareness raising activities;
- Research and technology transfer – including use of new technologies for prevention and risk management, development of multi-hazard early warning systems, extract

value out of research and implement into practice and underpin scientifically based decision-making;

The identified topics and practices will be complemented with findings from parallel activities, in particular EU-US workshops organised on disaster data (28 Sept 2012) and a 'Peer Review' programme to help transfer good practice on prevention and preparedness on the basis of the Hyogo Framework for Action Monitoring tool .

On this basis by the end of 2012, the Commission will prepare a discussion paper on the potential scope and content of the Guidance for discussion in the risk assessment expert group before discussion in the Civil Protection Committee in early 2013.

Consideration on costs

The provision of disaster prevention guidelines would have a very limited cost on the EU budget (less than 400 000 euros). A study carried out by an external consultant to be finalised before end of 2012 has already been conducted under the civil protection financial instrument budget (cost € 359 900) and will provide the Commission with both an inventory and assessment of good practices in disaster prevention and draft guidelines for minimum standards

The output of the study will also be made available through Climate-ADAPT.

Such guidelines, contributing to the knowledge objective of the adaptation strategy are expected to promote the sharing of valuable experiences and the take up of good practices by Member States: as supported by Member States in several council conclusions, sharing experiences and good practices is an essential component of prevention policy, as well as developing a prevention culture that is shared by all actors. They will also help inform policy decisions and actions at EU and Member State level.

In addition, if recommendations from the guidelines document are taken up by Member States and implemented cost-efficiency can be expected: the prevention level will increase (for targeted areas) resulting in lower cost impact of disasters. Furthermore, investing in prevention and disaster resilience makes strong economic sense the rate of return on every Euro invested in prevention is between 4 and 7 times, especially as demonstrated by the World Bank. Cost efficiency can also be expected from the implementation of joint cross-border actions.

1.3.3.4. Option 3C: Setting new calendar for revision of key EU legislation as part of the mainstreaming exercise

This initiative would define priority legislation whose timelines should be revised so that climate change adaptation can be inserted into legislation. By prioritising legislation, the Commission would carry out a process under which legislation would be screened for their links to climate change adaptation.

The main advantage would be that climate change adaptation issues would be brought to the forefront sooner. It may be advantageous to do so in the context of the Europe 2020 Strategy, where ambitious objectives have also been agreed regarding the current and future of the EU to climate change.

This initiative may be difficult to carry out given its political nature. Certain revision dates have been subject to long political negotiations between the EU, the Council and the Commission with input from the Member States. Changing this timing could cause political conflicts. Furthermore, there is a possibility that moving the legislative revision forward might result in the introduction of other (hidden) political agendas.

Moreover, as highlighted by the developments in water policy in the EU, voluntary action can pre-empt the need for causing legislation to be revised at an earlier stage. Climate change action is not required under the Water Framework Directive, but in 2009 the Water Directors agreed to follow a common implementation strategy guidance on how to climate check river basin management plans.

Nonetheless, the added value of moving up the review deadline for policies where it is possible is that climate change adaptation issues will be brought to the forefront sooner. It may be advantageous to do so in the context of the Europe 2020 Strategy, where ambitious objectives have also been agreed regarding the current and future of the EU to climate change. On the other hand, there is no guarantee - given the varied political interests across the EU - that moving up the review would ensure that adaptation is included in articles. The impact of this initiative, therefore, is not certain and could face a lot of resistance.

1.3.3.5. Option 3D: Guidelines for project developers for climate proofing vulnerable investments

This option would help developers of physical assets and infrastructure to incorporate resilience to current climate variability and future climate change within their projects. The estimated **cost** of developping these guidelines is slightly above €100.000[85], to be supported by the Commission. The Climate-ADAPT platform as well as additional publicity measures can be used to increase the up-take.

Climate proofing can be expected to slightly increase costs for infrastructure projects. A World Bank study[86] found that the net cost of adapting infrastructure to climate change is no more than 1-2% of the total cost of providing that infrastructure. However, at the same time, climate resilience may decrease costs over a longer period as it helps preventing damages to and interruptions of infrastructure.

Altvater et al. (2011b) assessed the economic costs and benefits of certain adaptation options in the energy and transport sector. The study highlights various uncertainties in relation to the assessments but concludes the following:

Adaptation measures due to electricity demand triggered by supplemental cooling to enhance the energy infrastructure in the EU and make it more resilient towards storm damages and demand-induced overloads in transmission lines are expected to be at some € 500 to 650 million per year until 2020[87]. The benefits are estimated at € 130 million to € 6,5 billion per year, with a best-guess estimate of € 870 million per year.

The investment costs for better heat-resistant asphalt have been estimated between 2.9 and 8.9 billion Euros per year for public roads. The highest investment costs are assessed for Germany, France, United Kingdom and Poland. The benefits are estimated between 1.8 and 2.5 billion Euros per year for passenger travel and approximately 183 million Euros per year for freight transport. In comparison to the benefits, this implies that, if the costs are at the lower end of the estimated range, benefits and costs would be almost equal. It is more likely though that the costs of the measure would exceed the estimated benefits. It has to be kept in mind that the estimated benefits only measure the benefits of avoided delays and detours in terms of saved travel time. Thus, they only represent a share of the overall benefits: for

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[85] Figures based on on-going consultancy contract for developing "Climate resilience guidelines for project managers' (DG CLIMA, 2011-2012)

[86] Worldbank (2009a): The Costs of Adapting to Climate Change for Infrastructure – http://siteresources.worldbank.org/EXTCC/Resources/407863-1229101582229/DCCDP_2Infrastructure.pdf

[87] Cost estimations are based on the IPCC emission scenarios A1FI and B1

instance, the avoided costs of road accidents have not been counted, and neither have the avoided maintenance and repair costs for fixing heat-induced damages to the road surface.

The investment costs of better drainage systems with a higher capacity are between 50 and 240 million Euros per year for public roads. The highest costs are assessed for France, Germany and United Kingdom. The benefits of this measure are estimated between 19 and 57 million Euros per year. Keeping in mind that the benefit estimate only captures part of the overall benefits, there is no guarantee that the benefits of the measure will exceed its costs. If the costs are at the lower end of the estimated range, and the benefits at the upper end, there is a chance that the measure will deliver a net benefit. If the costs are at the upper end of the estimated range, they will exceed the benefits – at least that share of the benefits that was quantified above.

The estimated operating costs for rail track buckling in the form of costs induced by speed restriction that could prevent derailments. The operating costs for speed restrictions due to track buckling are estimated to range from 59 million to 260 million Euros per year for EU-27 according to different values for delay minutes. The benefits are estimated to fall within a range of 90 million to 537 million Euros per year. It is therefore likely, but not certain that the benefits of the measure would exceed the costs. If the total costs are at the higher end of the projected range, but the benefits at the lower end, it is also possible that benefits may exceed the total cost.

Major effects on employment would not be expected from the measure, if it is assumed that the upgrading of infrastructures (e.g. heat resistant asphalt or improved drainage capacity) is integrated into the regular reinvestment cycle. In this case, there would be no substantial effects, since the required labour input does not differ. This would be different if existing infrastructure was retrofitted before the end of its economic life span; but this would also incur significantly higher cost than anticipated in this estimation.

The development and construction of new, more robust pylons and overhead lines, but also the development of more resilient grid layouts can help to promote the diffusion of European technologies. The EU industry is a main producer of technologies for energy infrastructure (EC, 2010m). Many countries outside the EU are also facing the challenge of installing electricity networks that are better-adapted to climate change and that meet the needs of changing generation patterns, which potentially increases the demand for European technologies and expertise in the world market. The investment need in this sector would have also a positive impact on small and medium enterprises (SMEs) in the fields of construction, mechanical engineering and business services (EC, 2010n).

Negative environmental impacts during the construction phase are not anticipated: compared to normal renewing works, the construction of heat-resistant road surfaces or increased drainage capacity does not create significantly different environmental impacts. Retrofitting transmission lines can affect agricultural activities including irrigation, aerial spraying, wind breaks and future land development. The placement of pylons on agricultural land can create problems for turning field machinery, lead to the compaction of soils, damage drain tiles, obstruct moving irrigation systems and interfere with a future consolidation of farm fields (PSCW, 2009; BDEW, 2011; Vattenfall Europe, 2005). For underground cables, a corridor of at least four metres width is required, with only low vegetation and without trees. Extensive excavation work and soil movement occurs during the construction of underground cables (BDEW, 2011; Schering, 2009). The excavation work is followed by long-term impacts on soil. Since underground cables produce heat, they may exacerbate droughts in drying out the soil, with adverse effects on the vegetation and agriculture (Vattenfall Europe, 2005; Gouda, et al, 1997). The costs of underground cabling exceeds the costs of overhead lines by a factor

of 5 to 21 (highly dependent from local circumstances)[88] and it is thus not feasible to replace overhead lines in the high voltage transmission grid to a large extend. However, the low and medium voltage distribution grid in urban areas is already underground to a large extend in most cities of western and central Europe, which has improved the resilience of urban distribution grids.

Alternatively, it could also be considered **not to make mandatory** these guidelines. To ensure a minimum up-take and application by project promoters, the European level could encourage Member States and regions to use it by including a reference into EU documents on cost-benefit-analysis and ex-ante project assessments for various policy areas, notably for projects under EU structural funds, TEN-T and TEN-E. However, the decision whether to apply the guidelines or not would remain with the project promoters or involved financial partners. The non-binding character of the guidelines means lower impact on project promoters, thus on infrastructure projects. However, it avoids an 'over-regulation' of projects as well as a reduced administrative burden. Public-private partnerships can be encouraged with a view to the sharing of investment, risk, reward and responsibilities between the public and private sectors in the delivery of adaptation action, in particular for investments in infrastructure.

1.3.3.6. Option 3E: Promote inclusion of climate change adaptation considerations in relevant infrastructure standards

Infrastructure is usually subject to strong regulation, in particular for safety reasons, and standards may therefore provide a particularly useful tool for the adaptation to climate change. The built environment is characterized by long investment cycles and thus prone to climate change. When revising existing or building new structures, standards are used in every phase during the lifetime cycle. They can apply during the planning phase, the construction phase and the maintenance phase. Thus standards have the potential to significantly impact the resilience of products, processes and constructions. The use of standards may be particularly relevant for transport and energy infrastructure, and for buildings. Yet, current design standards or standard development guides, across the whole scope described above, are not yet climate-proofed.

The Commission can use European standardisation as a policy tool to support implementation of Union's legislation and policies. European standardisation and use of European standards as a policy tool are regulated by Regulation on European Standardisation, Reg.(EU) No 1025/2012[89]. European standardisation may supports important Union policies such as consumer welfare, energy efficiency environmental protection, trade and the single market. The Commission has, since the mid-1980s, made an increasing use of European standards in support of Union policies and legislation. A standard is voluntary in application and established by all interested parties. Standards are build bottom-up but the Commission can request the recognised European standardisation organisation (CEN, CENELEC and ETSI) via a mandate[90] to develop European standard(s) on a certain topic. CENELEC operates on electrotechnical field, ETSI on telecommunications and CEN covers all other domains For buildings, the Eurocodes[91] are a series of European Standards (EN), providing a common approach for the design of buildings and other civil engineering works and construction products. They are meant to lead to more uniform levels of safety in construction in Europe, and to become the reference design codes replacing national codes. They cover earthquake

[88] See https://online.tugraz.at/tug_online/voe_main2.getvolltext?pCurrPk=33553

[89] OJ L 316, 14.11.2012, p. 12.

[90] Article 10 of Reg. (EU) No 1025/2012

[91] http://eurocodes.jrc.ec.europa.eu/showpage.php?id=1

resistance, but not yet climate change resistance. Concretely, three strands of initiatives can be considered to include climate change adaptation considerations in standard-design.

Amending the environmental guide of CEN

Originally, an ISO Guide 64 'Guide for addressing environmental issues in product standards' was developed. Following its publication, CEN decided to adopt it as a CEN Guide 4. This initiative would consider issuing an official request to CEN to integrate adaptation in the CEN guide 4 - Environmental Guide. The Environmental guide supports to assess sustainability during the development and amendment of standards. It assesses the impact from a product/process on its environment following a life cycle approach. For adaptation/climate proofing to be covered by the guide, it should also assess the impact of the environment on a product/process. Life-cycle thinking currently applied would also be relevant for adaptation, as that would prescribe consideration of climate change risks in all product development cycles from initial product development to raw material sources, to production processes to use and disposal options.

The use of the CEN-CENELEC guide 4 - Environmental Guide is voluntary. Due to the voluntary nature of the guidance, the application cannot be guaranteed, even if the current version of the guidance document is highly accepted by the sector.

Mapping relevant CEN-CENELEC standards in view of revising them to make them more climate resilient

Second, this initiative considers the possibility of mapping relevant standards and identifying the ones than would need to be revised to be made more climate resilient. As already set out for the Eurocodes initiative, the majority of the administrative burden for guidance falls at EU level and involved Member States. Mapping and prioritising relevant standards for transport infrastructure, energy infrastructure and buildings will require a considerable effort. According to CEN/CENELEC, indicatively 500-1000 relevant transport standards need to be mapped. The time for carrying out this mapping exercise is assumed to take at least 1-2 years[92]. For the energy sector, no figures of potential standards to be reviewed have been found/given, but this initiative would have to take into considerations the on-going work on standards for energy efficiency in the context of the Energy Performance of Buildings Directive. While acceptance of Eurocodes is mandatory in certain areas (public tendering), the use of European Standards is mostly voluntary. This means that there is no automatic legal obligation to apply them. However, laws and regulations may refer to standards and even make compliance with them compulsory.

For all three parts of the initiative the majority of the work has to be shared between EU level and Member States. A detailed cost estimate to carry out this work could not be undertaken but main costs would relate to working time for dozens of national experts from EU 27 to be involved over several years. Uncertainty in climate modelling and potential lack of data/information on climate impacts for specific regions may complicate the amendment of the concerned standards. Developing this guidance will likely trigger the need for innovation and research, which in turn will stimulate the creation or maintenance of jobs in the area of research. However, the number of generated jobs cannot be estimated at this stage. Due to the processes required for carrying out this initiative increased awareness of climate change within the standardisation bodies could be expected. This might lead to a more detailed discussion when reviewing standards or developing new ones. This might also trigger mainstreaming climate change adaptation for standards which are at the national level.

[92] Based on discussions with actors of the sector

Overall, climate proofing of design-standards will also be a necessary step in the way of achieving the objectives set out in the proposed TEN-E and TEN-T guidelines.

Some respondents of the public consultation stated that 'Adaptation should be included in relevant national building codes and Eurocodes to ensure that future constructions resist the consequences of climate change. In addition, standards for assessment of sustainability of buildings such as standards developed by the technical committee CEN/TC 350 "Sustainability of construction works" standards could take into account adaptation to climate change as an aspect of sustainability'. Also from the stakeholder workshops, the stakeholders involved supported an EU approach on adaptation in order to integrate adaptation into existing key standards concerning long life cycles.

1.3.3.7. Option 3F: Proposal on mandatory requirements for climate resilience of infrastructure projects

A legal proposal could be launched which obliges infrastructure developers in Europe to take into account certain climate scenarios when retrofitting or building new infrastructure. This legal proposal could include mandatory requirements that have to be adhered to when building roads and energy infrastructure. The legal proposal would also force Member States to retrofit existing transport and energy infrastructure until 2040.

Given the important role of the EU in Europe's infrastructure investment, a mandatory requirement will not only help in ensuring greater sustainability of action but also in promoting climate change adaptation as a EU policy priority.

The implementation of this option may however reveal difficult. First, this may induce increased project costs (short-term) due to additional investment for adaptation solutions, which could have negative impacts on the short-term competitiveness of European firms. Second, the uncertainty in climate modelling and potential lack of data/information in climate impacts for specific project sites may make the guidelines difficult to apply in practice. Third, the climate proofing of projects would create additional administrative burden for project promoters and for financing institutions to include it in cost-benefit analysis, in particular when such institutions have already their own approaches for climate proofing vulnerable investments, as currently the case for the EIB.

The uncertainty in climate projections and regional impacts are still quite high. Therefore, the level of adaptation and in some cases also the direction of adaptation (more floods, less floods) cannot be clearly estimated. Considering the low awareness on climate change issues, the acceptance of this initiative is considered to be relatively limited.

1.4. EU initiatives on adaptation:

1.4.1. State of play implementation of the 2009 White Paper

This Annex presents the latest evidence regarding the implementation of the measures announced in the 2009 White Paper. Approximately half of them have been successfully implemented. In other cases, much more remains to be achieved for the initial objective of the White Paper to be successfully implemented. This is mainly due to the factors:

- First, in some cases, although the EU has contributed to the implementation of the White Paper by undertaking a dedicated action (policy initiative, research funding, …), this has not yet been followed up at Member State level. Hence, additional actions will be needed in those areas.
- Second, it is also the case that the initial issue could not be comprehensively addressed by the actions mentioned in the White Paper. This refers to knowledge generation and

dissemination, or to mainstreaming for instance. In such cases, additional action will be needed at EU level to increase the EU's resilience.

In two cases, more efforts are still needed before the White Paper's proposed actions can be considered as implemented.

On knowledge gaps. Further EU-funded and national research is needed to fill gaps on methods, models, data sets and forecasting tools, in order to improve the understanding of current and expected climate impacts, vulnerabilities and adaptation options. For instance, there are significant data gaps on the development of systems for measuring and monitoring the impacts of climate change. When available, data are often non-standardised and non-comparable, have limited accessibility (non-centralised) or present other problems that make them difficult to use. This is particularly relevant when dealing with data and impacts across boundaries. Developing indices for vulnerability, exposure and adaptation practice and results is essential for monitoring impacts. Progress in developing indicators systems that are policy relevant is insufficient and slow. For many sectors, methodologies and tools for outlining adaptation are not yet available, and there is a need for sector-specific data and information for the assessment of vulnerability.

On assessing the **cost and benefit of adaptation options,** some progress has been made at microeconomic level, but important gaps remain on the macroeconomic approach to model adaptation and assess their implications. Further work could include a database on adaptation measures, to be integrated into Climate-ADAPT, in order to gather information available from existing FP7 projects and other relevant on-going projects. A methodological study has been launched that will conduct an extensive review of available information on costs of adaptation on adaptation measures within the EU and a review of existing methodologies for identifying these costs. It will also assess and compare such methodologies, identify the methodological and data challenges associated with calculating the expenditure on adaptation.

No detailed assessment is available yet on the impacts of climate change and adaptation policies on **employment and on the well-being of vulnerable social groups,** though some progress has been made in the context of the recently adopted employment strategy, especially through work on green jobs.

On ensuring that adaptation in coastal and marine areas is taken into account in the framework of the **Integrated Maritime Policy**, in the implementation of the **Marine Strategy Framework Directive** and in the reform of the **Common Fisheries Policy**, some progress has been made, but additional efforts are needed at Member State level. European guidelines on adaptation in coastal and marine areas are still to be developed. Knowledge gaps in relation to climate change adaptation for marine and costal issues are handled with in the context of the EU Adaptation Strategy under the Commission’s Green Paper on Marine Knowledge 2020. A similar situation exists when it comes to ensuring that climate change is taken into account in the implementation of the **Floods Directive**.

Mainstreaming adaptation into the EU **energy policy** needs to be further advanced and reconsidered in the context of the Strategic Energy Review process and the Energy Roadmap towards 2050 adopted in 2011.

Further work is needed on **climate-proofing infrastructure** projects and on how to incorporate pragmatically and usefully climate change adaptation considerations in the TEN-E and TEN-T guidelines.

The inclusion of climate proofing as a horizontal condition for all investments is being considered in the discussions on the future **Cohesion Policy**. Including climate proofing

provisions in EU co-financed programmes could be exemplary for national and local public investments and for private sector take-up.

On the potential for **insurance and other financial products** to complement adaptation measures and to function as risk sharing instruments , a study on applying economic instruments for adaptation to climate change was finalised in 2011 which explored the application of the following instruments: Risk Management Instruments, Market Based Instruments, Public Private Partnerships. Further mainstreaming and interaction is necessary, and we have identified engaging with targeted stakeholders (insurance companies and commercial banks) as a first priority. An important milestone will be the forthcoming Green Paper on the prevention and insurance of disasters, planned for early 2013.

Action (EU and Member States)	Status	Explanations
Take the necessary steps to establish by 2011 a Clearing House Mechanism		Climate-ADAPT, a web-based tool which will help decision makers at national, regional and local level to establish adaptation strategies, has been launched on March 23rd 2012. Climate-ADAPT is presently hosted and managed by the EEA and is publicly accessible here: http://Climate-ADAPT.eea.europa.eu/
Develop methods, models, data sets and prediction tools by 2011		Progress has been made but there are still some knowledge gaps Under the EU's 7th Framework Program for Research / FP7 (2007-2013) climate change remains a key priority including research on climate change adaptation. A number of projects funded under FP 7 have and will continue to contribute to the improvement of the assessment framework by improvement of the understanding of the climate system and its processes, the quantification of climate change impacts on human and natural systems (including extreme events), and to the identification and assessment of mitigation and adaptation options including their costs. These research projects also serve as a knowledge basis for the development and support of international climate policies as well as policies on e.g. disaster reduction (including hydrometeorological hazards). Most relevant FP7projects: ClimateCost: *Full costs of inaction and adaptation of climate change;* CLIMSAVE:*Climate change integrated assessment methodology for cross-sectoral adaptation and vulnerability*; RESPONSES:*European responses to climate change: deep emission reductions and mainstreaming of mitigation and adaptation*; MEDIATION: *Methodology for effective decision-making on impacts and adaptation;* CCTAME: *Climate change, Terrestrial adaptation and mitigation;* ClimateWater: *Bridging the gap between adaptation strategies of climate change impacts and European water policies;* ACQWA: *Assessing climatic change and impacts on the quality and quantity of water;* IMPRINTS: *Improving preparedness and risk management for flash floods and debris flow events;* CLIWASEC: Cluster - *Climate-Water-Security;* IMPACT2C: *Quantifying projected impacts under 2°C warming;* ArcRisk: *Impacts on health in the Arctic and Europe owing to climate-induced changes in contaminant cycling;* CLEAR*: Climate change, environmental contaminants and reproductive health* Viroclime: *Impact of Climate Change on the Transport, Fate and Risk Management of Viral Pathogens in Water;* EDENext: *Biology and control of vector-borne diseases in Europe;* DROUGHT-R&SPI: *Fostering European Drought Research and Science-Policy Interfacing;* KULTURISK*: Knowledge-based approach to develop a culture of risk prevention;* STEP*: assessing potential effects of phonological changes and extreme weather events on honeybees and wild bees and bee-pollinated plants,* SOILSERVICE: *Assessing effects of extreme weather events and climate change on gas excahne (soil ecosystem service;* BIOFRESH*: examines how climate change and other stressors affect freshwater biodiversity;* DG R&I has organised two workshops Adapting to Climate Change: A dialogue between research and policy in 2010 and 2011) involving FP7 research projects and policy DGs. The information on national expenditure related to climate change adaptation can be useful in evaluating the measures taken by Member States to address adaptation. Eurostat is investigating the feasibility of

		identifying such information on the basis of existing statistical classifications and administrative data in environmental protection expenditure accounts. The results of the study are to be used as a basis for further elaborating the precise statistical methodology for setting up an account on adaptation expenditure.
Develop indicators to better monitor the impact of climate change, including vulnerability impacts, and progress on adaptation by 2011		Actions will be completed when the two EEA reports are published but additional efforts will be needed to better assess the information provided by such indicators A set of studies and contributions from research projects will be used to convert the generic concept of vulnerability promoted by the Impact Assessment A (in the line of IPCC AR4) into an operational instrument to be used for raising awareness, guiding adaptation policy design (e.g. funding requirements), assessing the effectiveness of adaptation measures.EEA published a report on urban vulnerability and adaptation to climate change in May 2012 and is preparing 2 other reports: 1) 2012 indicator based report on climate change impacts and vulnerability in Europe (due in November 2012) 2) 2012 report on adaptation to climate change in Europe (due in early 2013)
Assess the cost and benefit of adaptation options by 2011		Even if actions have been undertaken to better assess the costs and benefits of adaptation options, in particular at a microeconomic level, some important gaps remain, in particular on the macroeconomic approach to model adaptation and assess their implications. A database on adaptation measures will be the backbone of this action. It will be integrated into Climate-ADAPT and will gather information available from existing FP7 projects and other on-going projects (see above). A methodological study has been launched that will conduct an extensive review of available information on costs of adaptation on adaptation measures within the EU and a review of existing methodologies for identifying these costs. It will also assess and compare such methodologies, identify the methodological and data challenges associated with calculating the expenditure on adaptation. It will propose a set of criteria for classifying different projects, programs or budget lines and calculating the expenditure on and propose a system to estimate the "adaptation share" for projects not exclusively intended for adaptation as well as producing a list of frequently occurring cases and borderline cases. The JRC PESETA II project, i.e. a multi-sectoral, bottom-up high-resolution impact and adaptation assessment using most recent high-resolution regional climate projections for Europe (IPCC/SRES in ENSEMBLES project) and operational physical impact models was initiated. . Results will be publicly available by the end of the year
Develop guidelines and surveillance mechanisms on the health impacts of climate change by 2011.		The EU has explored with the WHO and EU agencies means of ensuring adequate surveillance and control of the impact of climate change on health, such as epidemiological surveillance, the control of communicable diseases and the effects of extreme events. The Parma Ministerial Declaration brings new priorities in the environment and health process with one pillar dedicated on protecting health and environment from climate change. The Health Programme of the EU has been the key financing mechanism for projects, setting up networks and initiatives to support the work of the Health Security Committee. Funding of projects to address adaptation to climate

		change has been foreseen under the work plans for 2009-2011, including: PHASE *will provide the public health sector with prevention guidelines to promote resilience and reduce health risk associated to extreme weather events, their environmental consequences and development of tools to select vulnerable subgroups most at risk to specific extreme weather events;* CLIMATE TRAP: *Impact assessment, surveillance and preparedness guidelines, training, will play a pivotal role in assisting the process of strengthening the implementation of existing warning systems and plans and in strengthening the Health Sector in preparedness in facing the health impact of climate change; HIALINE aims at evaluating the effects of climate diversity and change on airborne allergen exposure, and to implement an outdoor allergen early warning network*; EUROSUN *aims at monitoring ultra violet exposure in the EU and its effects on incidence of skin cancers and cataracts;* EUROMOMO *aims at developing and operating a coordinated approach to real-time mortality monitoring across Europe such as pandemic influenza, emerging infections as well as environmental conditions with an impact on public health, i.e. heat waves and cold spells; CEHAPIS: Impact assessment, policy options and indicators on health and climate change aims at providing an evaluation of policy option impacts for successful health adaptation to climate change and monitor trends and policies over time;* EDEN*(Emerging diseases in a changing European environment) contributed to this effort*. Atopica: *Atopic diseases in changing climate, land use and air quality.* ECDC (European Centre for Disease Prevention and Control) has completed an infectious disease threat assessment with international experts (Suk, 2011). In the threat assessment numerous key disease drivers were identified to explore how they might interact to create new risks or exacerbate current ones. EFSA is developing scientific reports on vector-borne diseases and has already issued a general overview of the geographical distribution of tick species and an update on the role of tick vectors in the epidemiology of African Swine Fever and Crimean-Congo Hemorrhagic Fever in Eurasia.
Step up existing animal disease surveillance and control systems.		The development of a new Animal Disease Information System (ADIS), which will be operational in early 2013, will provide better and more comparable epidemiological data to risk managers, enabling them to better identify, evaluate and respond to changing or emerging disease situations.
Assess the impacts of climate change and adaptation policies on employment and on the well-being of vulnerable social groups.		Although initiatives are addressing climate change and health issues, no detailed assessment is available yet on the employment and well-being implications of climate change. Some achievements have been met in the context of the recently adopted employment strategy, and in particular by the work on green jobs. The social dimension of adaptation policies needs to be pursued within existing EU processes in the social and employment fields, and all social partners need to be involved. ECDC (European Centre for Disease Prevention and Control) is mapping EU vulnerability on climate change and has developed a Handbook for National Vulnerability, Impact, and Adaptation Assessments. See also PHASE project.

Ensure that measures for adaptation and water management are embedded in rural development national strategies and programmes for 2007-2013		Completed, as far as the current rural development programmes will last until 2013. The EU regulation on rural development 2007-2013 contains explicit references to the need to anticipate the likely effects of climate change on agriculture. After the "Health check" of the CAP in 2008, additional funds to measures that target new challenges faced by agriculture, such as climate change and the need for better water management, were made available. The revised RD programmes have been approved by the Commission within 6 months and the additional resources used as from 2009. A share of 15% of the new funds made available has been allocated to mitigation and adaptation measures. In addition, some measures aiming at improving water management (22% of funds allocated) and biodiversity (34%) will have some positive impact on adaptation.
Consider how adaptation can be integrated into the 3 strands of rural development and give adequate support for sustainable production including how the CAP contributes to the efficient use of water in agriculture		Completed, as far as the current rural development programmes will last until 2013. A number of actions with adaptation potential have been programmed by Member States and regions. Almost 70% of the RDP include actions to renovate irrigation equipment to improve the efficiency of water use. Half of the RDP supports waste water treatment installations on farms and water saving production techniques. Around 40% of the programmes also include the development/improvement of farm water storage capacity. After the 2008 "Health Check" reform better water management objectives have been included in the scope of cross compliance with a new "good agricultural and environmental condition" (GAEC) related to protection and management of water.
Examine the capacity of the Farm advisory System to reinforce training, knowledge and adoption of new technologies that facilitate adaptation		The Farm Advisory System (FAS) is an important tool to improve farm management. It requires national authorities to offer advice to farmers, at least for the rules included into cross compliance. Member States may use the FAS for advising farmers on the respect of standards going beyond cross compliance, e.g., water commitments under agri-environmental measures. RDP provides the possibility to co-finance the setting-up of the FAS and its use by farmers. The Commission proposal for the CAP post-2013 foresees to extend its scope to climate-related aspects, such as information on prospective impacts of climate change in the relevant regions, impact on GHG emissions of the relevant farming practices and on the contribution of the agricultural sector to mitigation.
Update forest strategy and launch debate on options for an EU approach on forest protection and forest information systems		Completed, with the expected adoption of the new EU Forest Strategy The 1998 EU Forestry Strategy established a framework for forest-related actions in support of sustainable forest management (SFM) which is currently being revised. A Green Paper on forest protection and forest information (preparing forests for climate change) was adopted in 2010 with a view to strengthening EU action on forest protection and forest information systems; currently a follow-up of the Green Paper on forest protection and information is ongoing. Two ongoing studies will have links to adaptation: "Disturbance of EU forests by biotic agents" and "Influences of EU forests on weather patterns". The EU's rural development policy for the period 2007–2013 provides a basis for the full integration of forestry. In the context of the review of Rural Development Policy post 2013 the further development of the forestry measures will be examined. A new EU Forest Strategy is expected to be adopted in Spring 2013.

Explore the possibilities to improve policies and develop measures which address biodiversity loss and climate change in an integrated manner to fully exploit co-benefits and avoid ecosystem feedbacks that accelerate global warming		Climate change was one of the four key policy areas identified in the Communication on "Halting the loss of Biodiversity by 2010 – and beyond" and the Biodiversity Action Plan includes the objective "to support biodiversity adaptation to climate change". The EU Biodiversity Strategy up to 2020 reiterates that biodiversity loss and climate change are intrinsically linked and states that "Ecosystem-based approaches to climate change mitigation and adaptation can offer cost-effective alternatives to technological solutions, while delivering multiple benefits beyond biodiversity conservation". Green Infrastructure is seen as an essential means of integrating biodiversity and climate change adaptation, a Green Paper on Green Infrastructure shall be presented by the end of 2012.
Develop guidelines and a set of tools (guidance and exchange of best practices) by the end of 2009 to ensure that the River Basin Management Plans (RBMP) are climate-proofed		The Water Framework Directive provides European countries with a common basis to address water challenges posed by climate change. In particular, the Directive's river basin approach to water management – centred on the establishment and review of river basin management plans every six years, including a Programme of Measures to bring waters to good status, establishes a mechanism to prepare for and adapt to climate change. The first river basin management plans were required by 22 December 2009. The ClimWatAdapt study, completed in 2011, looked into how key sectors, i.e. agriculture, industry, tourism, can adapt in order to counterbalance the effects of floods, water scarcity, droughts and changes in water quantity and aims to provide a sound basis for the assessment of vulnerability and of adaptation measures in the context of water policy, but also other environmental and sectoral policies.
Ensure that climate change is taken into account in the implementation of the Floods Directive.		Most Member States are doing so but the level of ambition may differ across Member States Directive 2007/60/EC on the assessment and management of flood risks requires Member States to assess if water courses and coast lines are at risk from flooding, then to map flood risks and to take adequate and coordinated measures to reduce the risk. Work is progressing on a catalogue of good adaptation measures and on the improvement of the information on past floods. Most Member States reported their preliminary flood risk assessments by March 2010. Member States must by 2013 develop flood hazard maps and flood risk maps for areas where potential significant flood risk exists.
Assess the need for further measures to enhance water efficiency in agriculture, households and buildings		The 2007 Communication on addressing the challenge of water scarcity and drought in the EU set out a number of policy options for addressing water scarcity, including the important roles played by water pricing and land-use planning in incentivising efficient water use. The Policy Review for Water Scarcity and Droughts will be integrated into the "Blueprint to safeguard European waters" to be presented by the Commission by November 2012. A set of completed studies helped bridging important knowledge gaps as regards water scarcity & droughts in the EU and assessed what measures are needed to improve water efficiency in various sectors: agriculture, buildings, water distribution networks, product labelling.
Explore the potential for policies and measures to boost ecosystem storage capacity for water in Europe		The Water Framework Directive (WFD) will contribute strongly to improving and maintaining ecosystems and works in order to deliver guidance on the relationship between inland river waterways and Natura 2000, selecting best-practice examples for integrated management, combining nature protection, climate change adaptation and transport navigation measures are ongoing. A service contract for the analysis of costs, benefits and climate proofing of natural water

		retention measures, as part of the "green infrastructure" approach for flood and water scarcity & droughts prevention was completed in April 2012. Modelling of the land-use, hydrological, and economic impacts of the natural water retention measures is undertaken by JRC in the context of the impact assessment of the Blueprint Communication, which will address the need and potential options for unlocking the potential of these measures.
Draft guidelines by 2010 on dealing with the impact of climate change on the management of Natura 2000 sites.		Completed when the guidelines are published As the establishment phase is nearing completion the focus is increasingly on the management and restoration of sites in the network, and on its overall ecological coherence. A study on Biodiversity and Climate Change in relation to Natura 2000 was conducted. The guidelines on Natura 2000 and climate change will assess current knowledge of risk from climate change to species and habitats of EU conservation concern protected by the network, as well setting out on approaches to reduce, mitigate and adapt to such impacts, both within the sites and at broader network level. They will also look at the benefits arising from management and restoration of Natura 2000 sites to climate change mitigation and adaptation. Further assisting guidelines will help dealing with the impact of climate change on the management of Natura 2000. Scheduled issuing autumn 2012.
Ensure that adaptation in coastal and marine areas is taken into account in the framework of the Integrated Maritime Policy, in the implementation of the Marine Strategy Framework Directive and in the reform of the Common Fisheries Policy.		Additional efforts would be needed at Member State level to meet the objectives When addressing maritime activities from a cross-sectorial perspective, the EU Integrated Maritime Policy provides a comprehensive framework for better understanding the impacts of climate change with coastal and marine areas and to integrate measures on climate change adaptation at EU level. The EU Integrated Maritime Policy is implemented at the level of marine regions and specific Sea Basin strategies have already been developed for the Baltic, the Mediterranean and the Atlantic Sea Basin. The Marine Strategy Framework Directive will facilitate adaptation to climate change by ensuring that climate change considerations are incorporated into Member States' marine strategies while providing a mechanism for regular updating of the marine strategies to take account of new information. Knowledge gaps in relation to climate change adaptation for marine and costal issues are handled with in the context of the EU Adaptation Strategy under the Commission's Green Paper on Marine Knowledge 2020. The Common Fisheries Policy is currently subjected to a root-and-branch overhaul with a view, in particular, to rebuild stocks to levels capable to produce maximum sustainable yield. Increasing the size of fish stocks and their productivity will make them less vulnerable to external factors like climate change. A more coherent and integrated approach to coastal and maritime planning and management through integrated coastal zone management (ICZM) and maritime spatial planning (MSP) will benefit adaptation in coastal and marine areas. The ICZM Recommendation (2002/413/EC) provides for Member States to take a strategic approach to the management of their coastal zones. The proposal for an EU framework on ICZM and MSP is expected towards the end of 2012.

Develop European guidelines on adaptation in coastal and marine areas		The Commission is committed to developing guidelines on best practice in coastal and marine areas which will contribute to ensuring a coordinated and integrated approach to climate change adaptation in these areas. This could be addressed as part of the EU Communication on a strategy on adaptation to climate change to be adopted in 2013. The guidance will take account of and build on existing studies, research and relevant policy initiatives, in particular the Community strategy on disaster prevention, the Floods directive, the EUrosion study and the study on the Costs of coastal defence and adaptation. OURCOAST is an initiative to support and implement sustainable coastal planning and management. It includes a database of coastal planning and management practices, with a key focus on adaptation to risks and climate change.
Take account of climate change impacts in the Strategic Energy Review process		Although clear synergies exist between energy efficiency and climate change adaptation objectives, further considerations is needed on adaptation for the long-term objectives of EU energy policy. The EU's agenda for 2020 has set out the essential first steps in the transition to a high-efficiency, low-carbon energy system. The EU needs to develop a vision for 2050 and a policy agenda for 2030. The fundamental technological shifts involved in decarbonising the EU electricity supply, ending oil dependence in transport, low energy and positive power buildings, a smart interconnected electricity network will only happen with a coordinated agenda for research and technological development, regulation, investment and infrastructure development. In addition, the transition to a high efficiency, low-carbon energy system needs to be promoted not only in Europe but worldwide. The Energy Roadmap towards 2050 was adopted in December 2011.
Develop methodologies for climate-proofing infrastructure projects and consider how these could be incorporated into the TEN-T and TEN-E guidelines and guidance on investments under Cohesion policy in the current period		References to climate change have been included in the proposals for TEN-E and TEN-T guidelines, although how to implement this in practice could be clarified to help transmission system operators meet their objectives of secure system operations. The 2008 Green Paper on infrastructure was designed to encourage a reflection on how energy networks should develop in the coming years, amongst others, to reflect the new climate change and energy policy. The Commission is currently working on a comprehensive energy infrastructure package. Elements such as increasing resilience of energy transmission infrastructure to cope with extreme weather condition, positioning of over-head power lines, impacts of climate change on LNG infrastructure will be examined in the TEN-E revision process. The TEN-T programme consists of hundreds of projects whose ultimate purpose is to ensure the cohesion, interconnection and interoperability of the trans-European transport network, as well as access to it. .
Explore the possibility of making climate impact assessment a condition for public and private investment		In the discussions on the future Cohesion Policy the inclusion of climate proofing as a horizontal condition for all investments is ongoing. Including climate proofing provisions in EU co-financed programmes could be exemplary for national and local public investments and for private sector take-up.
Assess the feasibility of incorporating climate impacts into construction design standards, such as Eurocodes		**While design standards are covering conventional aspects of stability (including seismic activities) an evaluation of if and how climate change should be addressed in European design standards is still ongoing** The Eurocodes are currently taken up by Member States and several

		have already fully replaced their previous national codes with the Eurocodes. In principle Member States are supposed to have the Eurocodes in place since the beginning of 2011. A new mandate to CEN is requiring an analysis of if and where climate change issues should be included in these design standards. The reply (work programme) is foreseen for early 2013.
Develop guidelines by 2011 to ensure that climate impacts are taken into account in the EIA and SEA Directives		Completed when the guidelines become available. The Commission has decided to develop practical guidance and recommendations for integrating climate change and biodiversity into EIA/SEA procedures to assist EIA/SEA practitioners in taking full advantage of EIA and SEA in achieving EU climate change and biodiversity goals. The study contract for the development of the guidance was finalised in December 2011. It is expected that the Commission Guidance should be subject to inter-service consultations in Sep-Oct 2012 and made publicly available by the end of 2012.
Estimate adaptation costs for relevant policy areas so that they can be taken into account in future financial decisions		Some actions have been undertaken but there are still important knowledge gaps CLIMATECOST developed estimates of adaptation costs and benefits for Europe in the following sectors: Coasts and tourism, Agriculture and water, Energy consumption and production, Infrastructure and extremes (floods & storms), Health, Ecosystems and forests. A methodological study finalised at the beginning of 2011 addresses the typology of adaptation actions, the methodology to project future adaptation costs and the methodology to estimate spending on adaptation.
Further examine the potential use of innovative funding measures for adaptation		A study commissioned by DG CLIMA in 2010 has reviewed and assessed the potential use of economic instruments for climate change adaptation purposes. The Commission is exploring possibilities for the future Life+ instrument to address adaptation issues. The instrument would among other issues finance adaptation actions and would be managed in an innovative manner. Drafting needs to be improved
Explore the potential for insurance and other financial products to complement adaptation measures and to function as risk sharing instruments		Completed but not yet mainstreamed in EU policies. A study on applying economic instruments for adaptation to climate change was finalised in 2011 which explored the application of the following instruments: Risk Management Instruments, Market Based Instruments, Public Private Partnerships. The application of the instruments is analysed from two perspectives: Promoting adaptation to climate change and sharing (transferring) the risks of climate change.
Encourage Member States to utilise the EU's ETS revenues for adaptation purposes		Some Member States are already considering the use of auctioning allowances for adaptation projects (AT, FR, etc.) The possibility of using revenue generated from auctioning allowances under the EU ETS for adaptation purposes should be utilised. The revised Directive governing the scheme from 2013 provides that at least 50% of the revenue generated from auctioning allowances should be used, inter alia for adaptation in Member States and developing countries. This additional revenue will be crucial for sharing adaptation costs between the public and private sector.

Take a decision to establish by 1 September 2009 an Impact and Adaptation Steering Group (IASG) to step up cooperation on adaptation		In order to assist the Commission in developing its approach to dealing with adaptation, the Adaptation Steering Group was established in September 2010. This Group brings together Member States and a diverse range of stakeholders and is giving guidance about the work on mainstreaming of Adaptation into various EU policies and other issues. The Group is also supposed to assist the COM in the establishment of the 2013 Adaptation Strategy.
Encourage the further development of National and Regional Adaptation Strategies with a view to considering mandatory adaptation strategies from 2012		Not all Member States or regions have developed yet an adaptation strategy Guidelines for regional adaptation strategies were developed and made available on DG Clima's website. Currently 12 Member States have adopted an adaptation strategy; other Member States are in the process of doing so. .
Step-up efforts to mainstream adaptation into all EU external policies	Not assessed in the context of this exercise	Bilateral and regional financial assistance programmes will aim to integrate adaptation considerations into all relevant sectors. The proposed review of the EU Environment Integration Strategy presents a good opportunity to emphasise the need for integrating adaptation needs, as will the Mid-Term Review of EC cooperation strategies.
Strengthen dialogue with partner countries on adaptation issues		The EU is strengthening its analysis and early warning systems and integrating climate change into existing tools such as conflict prevention mechanisms and security sector reform. Adaptation is also being brought into the dialogue with European Neighbourhood Policy (ENP) partner countries and the regular "Energy, Transport, Environment" sub-committees offer a forum for structured dialogue.
Take the Framework for Action on Adaptation forward in the UNFCCC		The EU is taking an active role in the negotiations to ensure adaptation issues are adequately dealt with in a post 2012 agreement.

1.4.2. Additional initiatives

Table 3: Policy actions beyond mainstreaming activities as mentioned in the White Paper of Adaptation

Policy option/Action	Timeline	Related Policy documents	Related adaptation measures
Commission Recommendation on Research joint programming initiative 'Connecting Climate Knowledge for Europe'	tentative: Adoption end of Oct. 2011, targeted for Council meeting 5 Dec 2011	Commission Recommendation and Staff Working Paper	1) Improve climate predictability, 2) Developing climate services, 3) Understanding societal transformation and 4) Improving decision-making
Set up of a Copernicus Climate Service. The service will be based on satellite and in-situ monitoring data, Modelling of the entire Earth system, including Model reanalysis and data assimilation. Specific services for Impact assessment (Indicators) and Attribution will be included	Definition of the service is still on going as part of the preparation of the Copernicus Operations from 2014 onwards. Developements activities are planned through the last call of the FP7 Space theme.	Documents related to Copernicus activities	No adaptation measures, but the Service will support Adaptation policy (i.e. the European Climate Adaptation Platform – CLIMATE ADAPT)
Reform of the Common Agricultural policy for the period 2014-2020 (on-going)	2012	Commission Communication on the CAP towards 2020 (November 2010) and Legal proposals for the CAP after 2013 (October 2011), currently being discussed with the Member States and the European Parliament (http://ec.europa.eu/agriculture/cap-post-2013/legal-proposals/index_en.htm)	Enhancing farmers' resilience to the threats posed by climate change features among the three main objectives of the next CAP for the period 2014-2020. A climate resilient agriculture is one of the six key priorities for the future rural development policy and Member States will be requested to plan actions related to all priorities. Adaptation is also an aspect to be taken into account when assessing the specific needs of the other five priorities. The future RD will offer a wide range of possibilities to support actions that are targeted or relevant for preparing for climate change impacts, particularly for water management.
Green Paper on Marine Knowledge	2012	2013 EU Strategy on Climate Change Adaptation 2007 Blue Book on Integrated Maritime Policy 2010 Report from the EU Parliament on the EU Integrated Maritime Policy	No specific adaptation measures, but the Service is developing a study on Marine Knowledge that will explore the benefits, for both bussiness and public autorithies, of reducing the uncertainty in the behaviour of the sea. Improving marine knowledge will contribute to take better adaptation measures to Climate Change

1.5. An overview and review of adaptation strategies

1.5.1. Perspective on Member States' actions

As of January 2013, 15 EU Member States have adopted an adaptation policy (strategy and / or plan) so far. Overall, the Adaptation Strategies that currently exist for European Member States are comprehensive and well-established. Some set out concrete action plans, namely Finland, Germany, Denmark, France, Malta and Spain. The Belgian and Portuguese adaptation strategies are comprehensive but do not include action plans. The Netherlands adaptation strategy, while comprehensive, states that it is a preliminary document setting out the first steps towards an agenda for a climate-resilient Netherlands. All adaptation strategies appear to be intended as evolving documents which will be reviewed and updated to take account of advancing climate change science, research and technology. Austria adopted its adaptation strategy in October this year.

Slovenia has an adaptation strategy planned for adoption in the near future. Bulgaria, Cyprus, Czech Republic, Estonia, Italy, Latvia, Poland, Romania and Slovak Republic have announced their willingness to develop an adaptation strategy or are in the process of preparing one. Member States for which the adoption of an adaptation strategy currently remains uncertain include Greece and Luxembourg.

A brief analysis of the existing adaptation strategies is given in the following

1.5.1.1. Brief analysis of existing adaptation strategies[93]

Legal framework; mandatory and voluntary actions

Each of the Adaptation Strategies has been directed by government; therefore it is considered that the Member State is committed to delivering all actions outlined in the adaptation strategy. However to provide further detail on the types of actions, mandatory actions are defined as those which have a specific legal requirement or policy commitment (e.g. relating to the Water Framework Directive). Voluntary actions are those without a specific policy commitment (e.g. general awareness raising activities). However, this is not always made explicit.

Action plans

6 of the adaptation strategies in place have action plans of varying levels of detail. The Finnish adaptation strategy assigns timeframes and owners to the adaptation actions, which are categorised by sector. The German adaptation strategy is accompanied by an action plan which commits to concrete steps in its further development and implementation. It follows an integrated approach which takes account of the interactions between sectoral and regional activities and strives to anchor consideration of the possible impacts of climate change in all relevant policies. In some cases the adaptation strategy provides a framework for developing an adaptation Plan, e.g. Belgium and Portugal. The Dutch adaptation strategy recognises that

[93] This assessment is based on information made available by Member States as of November 2012. As such, it does not include the developments associated with the adoption of the latest adaptation strategies in Lithuania and Ireland. Ireland's National Climate Change Adaptation Framework was published on 28th December 2012. The Framework provides the policy context for a strategic national adaptation response to climate change in Ireland. Our Framework, which is based on the EU approach, introduces an integrated policy framework, involving all stakeholders on all institutional levels to ensure adaptation measures are taken across different sectors and levels of government to manage and reduce Ireland's vulnerability to the negative impacts of climate change. The relevant Government Departments, Agencies and local authorities have been asked to commence the preparation of sectoral and local adaptation plans and to publish drafts of these plans by mid-2014.

a framework for assessing adaptation actions is the 'missing link', but the Delta Programme has been commissioned to fill this gap.

Trans-boundary and international issues

Only one of the adaptation strategies in place considers trans-boundary issues, i.e. those issues affecting neighbouring countries: Belgium. The Belgian adaptation strategy mentions the cross-border SCALDWIN project (2009-2012) which aims to identify the best measures available for an improvement of the ecological status of surface water and groundwater, and a promotion of biodiversity in the Scheldt basin. The TIDE project (2010-2013) focuses on a better knowledge of the ecosystem functioning and a coherent management of the estuaries including the Scheldt (BE/NL). The AMICE project (2009-2012) is a transnational project about the adaptation of the Meuse and its catchments to the impact of flooding and low waters due to climate change. The Future Cities - project (2009-2012) aims at making city regions in Northwest Europe fit to cope with the predicted climate change impacts. While the Maltese adaptation strategy does not make significant reference to trans-boundary issues, it highlights that the Environmental Impact Assessment regulations can address the trans-boundary effects of a development project and sets out the procedures to be followed when a project is likely to have a trans-boundary impact.

In contrast eight of the adaptation strategies consider international issues: Belgium, Denmark, Finland, France, Germany, Malta, Netherlands and the United Kingdom. For example, the international focus is very important for the ARK programme in the Netherlands, both in terms of the development of knowledge and policy. Knowledge will be developed in a manner consistent with international programmes and initiatives such as Climate Impact Research Coordination for a Larger Europe (CIRCLE), Biodiversity Requires Adaptation in Northwest Europe under a Changing Climate (BRANCHE) and European Spatial Planning: Adaptation to Climate Events (ESPACE). The projects of the EU's Sixth Framework Programme will also be involved. The Finnish adaptation strategy contains a chapter on the need to adapt to changes taking place in other parts of the world, including the adaptive capacity in different countries; the interrelationship between the global impacts and adaptation to climate change in Finland; financial measures and mechanisms and connections between adaptation and reduction of emissions. The adaptation strategy recognises that climate change will bring challenges in the planning of Finland's development cooperation. International supply issues, for example concerning food and water, by contrast are only mentioned in two adaptation strategy (Finland and Belgium).

Governance structure for implementation

Eight adaptation strategies have been directed by government. This explains why they are being implemented (or will be implemented) by government / inter-ministerial committees or working groups, e.g. Finland, Germany, Netherlands, Portugal and Spain. The objective of these working groups is to create a forum for cross-department working, as well as to reach out to businesses and citizens at the national, regional and local levels. In the Netherlands, the State wishes for all parties, including government bodies, the business community, scientists, and civil-society organisations, to share in the responsibility for implementing the adaptation strategy. In Belgium, it is foreseen that the future adaptation strategy will be based on a bottom-up approach, building on the plans already developed by the regions of Walloon, Flanders and Brussels. A number of regional committees are already bringing together the sectors. This will result in the federal government working closely with regional government to ensure effective implementation and follow-up (monitoring and evaluation). This approach confirms an acceptance of adaptation as something that must be implemented by stakeholders at all levels and in all areas of society, and not something to be pursued in isolation of other

policy objectives, programmes and services. Adaptation is an emerging policy area and it is important for government (national or regional) to facilitate dialogue with the relevant stakeholders and to be seen to be leading by example until adaptation becomes firmly embedded. In Denmark, the central government plays less of a role and adaptation strategy development and implementation is driven by the municipalities.

Integration and mainstreaming

Each of the adaptation strategies has been developed with sectoral focus, reflecting the need for Cross-Government Adaptation Working Groups to drive implementation. Integration and mainstreaming adaptation with existing national programmes and policies is central to each of the adaptation strategies. For example, the objective of the Spanish adaptation strategy is to mainstream adaptation to climate change in the planning processes of all the relevant sectors or systems. To achieve this, it is important that the development of the Plan becomes a major collective project with the participation of all institutions and key players. In Finland, some government departments have already developed adaptation plans of their own, e.g. Ministry of Agriculture and Forestry, to assist with integrating and mainstreaming adaptation in other policy areas. The French adaptation strategy outlines a number of cross-sectoral initiatives, e.g. Club ViTeCC connects local policy makers with scientists involved in adaptation, thus addressing the need for information on the local climate impacts and for funding innovative projects; indeed 'cross-cutting actions' is one of the 20 thematic areas outlined in the adaptation strategy. The German adaptation strategy follows an integrated approach which takes account of the interactions between sectoral and regional activities and strives to anchor consideration of the possible impacts of climate change in all relevant policies. The German adaptation strategy is intended to supplement and support other cross-sectoral strategies such as the National Strategy for Biological Diversity. In other Member States, integration and mainstreaming of adaptation is a key pillar of the adaptation strategy, including in Denmark, and the Netherlands.

Communication and awareness raising

As with integrating and mainstreaming adaptation, communication and awareness raising is another key principle of each of the adaptation strategy. Member States acknowledge that without effective communication and awareness raising, the adaptation strategy will not be successful. For example, the Spanish adaptation strategy states "*the National Adaptation Plan will not be effective unless its existence, progress and results are disseminated and communicated to stakeholders*". In Portugal, awareness raising and knowledge dissemination are one of four objectives. The Dutch adaptation strategy centres on three work packages, all of which depend on awareness raising and communication.

Communication is also inherent in many of the actions outlined in the adaptation strategy. In France, four thematic groups explicitly addressing communication have been created. These are: information, education and training, research and governance. The success of other actions depends on effective communication, e.g. the National Flash Flood Plan. Finally the Cross-Government Working Groups which have been created will also facilitate communication and awareness raising.

1.5.1.2. Barriers and challenges identified to the development of adaptation strategies

Fundamental understanding of what adaptation is

Understanding of what adaptation is by policy-makers still remains a barrier, there is often a mix up between what is mitigation and what is adaptation. Also, society in general does not have enough understanding of what adaptation is about. The Italian experience of working with municipalities has shown that there is need to make them aware they may already be

working on adaptation, and that they are just not calling it adaptation. It was reported that there is a lack of understanding of what adaptation is by the scientific community in some countries and that it is not only about action, but having a strong scientific knowledge base behind it to inform planning.

Insufficient human and financial resources

Some central governments have little management or technical capacity so their adaptation role is about mainstreaming, improving access to the knowledgebase, assisting organisation with technical queries on adaptation, promoting the participatory process, responsibility for international and EU commitments.

Insufficient human resources and financial resources at all levels is a major barrier, more so under the current economic climate where results of the debates and agreed proposals are difficult to take forward due to a lack of human resources both for research and the incentive to move forward. Financing is an issue more widely for adaptation, specific studies need to be commissioned and budgets do not always allow for this. If national government budgets are cut so will the budget for climate change. To try and overcome this, Malta suggested an independent authority that is separate so decisions can be taken even during elections and changing governments.

In some Southern European Countries, the restructuring of the public services has delayed action and reduced or changed staff in sectors. This has delayed work in almost every sector and at coordination level. However, in the case of Portugal, this has created the opportunity to create an adaptation team in the Portuguese Environment Agency.

Partial lack of dedicated research, which is also hard to identify

Southern European Countries want to compile, collect and organize existing information with relevance for adaptation to climate change first as they realise a lot of research exists already, but is disperse and is not easily accessible. This takes time and slows the production or move to developing the national strategy.

Terminology used to interact with stakeholders

Terminology confusion and the mixing of mitigation issues and other political issues with adaptation make communication internally and with stakeholders difficult. The distinction between adaptation strategy and adaptation plan and which is most appropriate in the country makes it harder to inform the Commission or compare member states on the status of national progress on adaptation.

Mitigation is more straight-forward to communicate

Mitigation is much simpler to communicate as the measures are easier to understand (e.g. through quantitative analysis, progress towards targets). Mitigation is more quantitative so it is easier to measure progress, adaptation is more difficult to measure and update year on year. Countries are finding it difficult to addressing urgency of adaptation planning when the focus is on mitigation; some countries suggested the focus and strategies should be on both mitigation and adaptation together.

How to mainstream adaptation

Mainstreaming adaptation into existing EU policies without creating extra administrative burden on Member States is a major challenge which combined with the need to address more medium to long term adaptation planning that is outside Member States elections results in a major barrier to overcome to progress towards a national strategy for adaptation.

The uncertainty gap

Bridging the uncertainty gap is also a challenge, especially on communicating this well so that institutions and stakeholders do not use uncertainty to do nothing and focus on short-term planning and reacting.

The Joint CIRCLE-2 and DG CLIMA project "Support to the development of the EU strategy for adaptation to climate change" SHARE Workshop Supporting the development of the EU strategy for adaptation to climate change – Views and Challenges in Eastern Europe in Vienna on 2 July 2012 found that many Eastern European countries are facing similar barriers in terms of financial and practical constraints. Funding is seen as a very important issue to get work on adaptation policies started. Countries from Eastern Europe also highlighted the lack of knowledge base as a major barrier to developing an adaptation strategy (i.e. collection of other projects data with a new 'label' called adaptation). There is expectation from the EU level that there will be an external 'push' for action (with the EU setting the example for action).

1.5.2. Transnational, regional and local adaptation efforts

Many transnational cooperation projects on adaptation have been initiated over the last years. They are typically partially financed by EU-funds such as the Life+ and INTERREG programmes. INTERREG activities have been initiated in all regions in Europe. However most focus on North-West Europe and the Alps while less adaptation projects address the Mediterranean and Eastern Europe. An overview of on-going and finalized projects can be found on Climate-ADAPT[94].

INTERREG projects differ in scope and focus, nevertheless they share the advantage to deal with regional specifics and develop appropriate adaptation responses. They all very much focus on involving stakeholders on regional and local level aiming at gathering knowledge and specific needs from the regional and local communities and develop jointly feasible adaptation responses. Many of these transnational projects are set up with case study regions within the greater transnational cooperation area, where project results can be tested and discussed with regional and local stakeholders towards their practical applicability.

Results of INTERREG projects often also inform sub-national and national strategic initiatives and programmes or are even being integrated in legislation. UN Conventions as e.g. the Alpine and Carpathian Conventions are highly engaged with INTERREG projects and make use of their outcomes in a political context (e.g. Climate Action Plan under the Alpine Convention).

On local efforts, some information has been provided by Member States towards the countries webpages on Climate-ADAPT[95] on a voluntarily base end of 2011. Most of the local actions reported seem to be triggered by research programmes, either on national or EU level. Many EU Member States also established databases on their national climate change website that collect and present regional and local adaptation good practices. On the policy level, Denmark is particularly focusing its adaptation efforts on municipalities with all of them having to prepare climate change adaptation plans within the next 2 years.

City level adaptation has been addressed in detail in the EEA 2012 report 'Urban adaptation to climate change in Europe' (EEA 2012)[96], which provides a wide range of examples of local adaptation action in various European countries.

[94] http://Climate-ADAPT.eea.europa.eu/web/guest/transnational-regions
[95] http://Climate-ADAPT.eea.europa.eu/web/guest/countries
[96] http://www.eea.europa.eu/publications/urban-adaptation-to-climate-change

1.6. JRC PESETA II: methodology and preliminary results[97]

This annex presents the methodology and preliminary results of the economic integration of the biophysical impacts of the JRC PESETA II project, and other impact evidence derived from the FP7 ClimateCost project (on coastal impacts and agriculture in the 2080s), into the computable general equilibrium (CGE) GEM-E3 model[98].

The four main questions to be addressed are the following. Firstly, how great are the impacts of climate change under future climate scenarios, in particular, under a reference and a 2°C scenario? Secondly, what are the distributional implications of climate impacts? Fairness and equity issues can be analysed assessing the dispersion of economic impacts across EU regions. Thirdly, by how much can adaptation reduce climate impacts? Fourthly, are spatial (cross-country) transboundary impacts significant?

With the proposed methodology high time-space resolution climate data feed highly disaggregated sector-specific impact models to estimate the biophysical impacts. Such structural approach, as opposed to the reduced form formulation, aims indeed to consistently integrate what is known on climate impacts in the various natural sciences disciplines into the economic analysis. With this kind of methodology it is possible to derive macroeconomic estimates of the economic effects.

Methodology and scope of assessment

The methodology here applied has three steps, following Ciscar et al. (2011). In the first stage the climate runs used as input to all biophysical models are selected. In a second stage, the biophysical impact models are run to compute the biophysical impacts. In a third step, those impacts are valued in economic terms using a computable general equilibrium model.

The use of a multi-country general equilibrium model implies that the economic impacts include both the direct impact of climate change (e.g. the losses in the agriculture sector due to lower yields) and the indirect consequences in the rest of the sectors (e.g. in the agrofood industry) and the rest of the world (considered via trade flows). The main economic output variables relate to household welfare, and GDP.

The study evaluates a counterfactual situation: the impact of future climate on the economy of today. This approach is known as comparative static. The advantage of this approach is that the modelling effort can be focused on the impacts of climate change rather than the wider question of how Europe's economy might develop to 2100. The disadvantage is that by definition the interactions between climate change and economic and population growth are not considered, since climate change is the only shock imposed on the EU economy. From this perspective, impacts are underestimated because economic growth would notably increase the assets exposed to climate risk.

The following climate impact categories have been considered in the preliminary economic assessment: agriculture, coastal areas, energy, river floods, forest fires, and transport infrastructure[99].

The results are presented dividing the EU into the following regions, according to their latitude and the relative economic size, as it was made in PESETA:

- Northern Europe: Sweden, Finland, Estonia, Lithuania, Latvia, and Denmark.

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97 The JRC PESETA II project is on-going. Final results are expected to be published during 2013 (project information can be found at http://peseta.jrc.ec.europa.eu/).

98 http://ipts.jrc.ec.europa.eu/activities/energy-and-transport/gem-e3/index.cfm

99 Impacts related to tourism and human health (labour productivity) are expected to be added in the next analysis.

- UK & Ireland: UK and Ireland.
- Central Europe north: Belgium, Netherlands, Germany, and Poland.
- Central Europe south: France, Austria, Czech Republic, Slovakia, Hungary, Slovenia, and Romania.
- Southern Europe: Portugal, Spain, Italy, Greece, and Bulgaria.

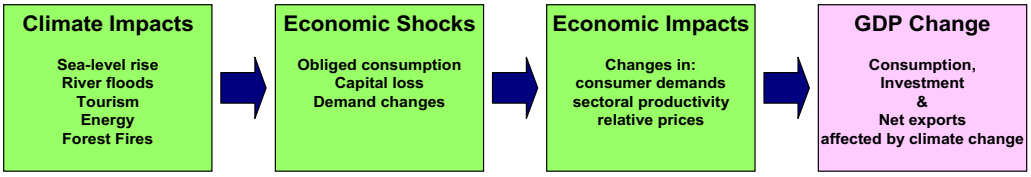
All reported impacts assume that there is not public adaptation, unless otherwise stated. Therefore, the methodology can be useful to understand where to prioritise adaptation options.

Economic impacts on welfare are provided in monetary terms, and are presented undiscounted, in 2005 Euros. The welfare changes are also compared to GDP.

Box: GDP and Welfare impacts

When presenting results from the JRC PESETA II project two distinct metrics of economic impacts are used; change in GDP (which measures the value of goods and services produced) and change in welfare (which measures the economic wellbeing of households).

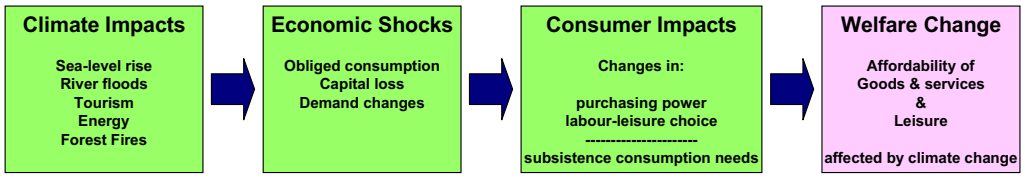
GDP is calculated as the sum of household spending, government spending, investment by firms and net exports (exports increase GDP while imports reduce it). Climate change causes GDP to differ from its baseline value due to impacts on consumer demands, industrial productivity and changes in relative prices, as the figure below shows.



Welfare is obtained by consumers when they choose to spend their time either working (in order to earn income for the purchase of goods & services) or not working (thereby "consuming" leisure). Consumers have a total endowment of time which they distribute between these two possibilities depending on their preferences, incomes, the value of their labour (the real wage) and the prices of goods & services.

However, each consumer must consume a subsistence amount of each good (including leisure) which does not contribute towards welfare. Therefore welfare is derived from consumption of goods, services and leisure above the subsistence level.

As the figure below shows, climate change affects welfare in two ways: firstly, changes in productivity and prices affect consumers' purchasing power and may cause substitution between labour and leisure ; secondly, when climate change affects obliged consumption (such as requiring spending on flood repairs) this has a direct impact on the fraction of the consumer's budget that is available for the consumption that contributes to welfare.



Change in welfare is calculated using the concept of equivalent variation. This measures the amount of money that would have to be given (or taken) from consumers in the baseline to replicate the effects of

Climate scenarios and runs

For the JRC PESETA II study climate simulation runs were obtained from the FP6 ENSEMBLES project (van der Linden and Mitchell, 2009). Runs were driven either by the SRES A1B emission scenario (Nakicenovic and Swart, 2000), or the so called E1 emission scenario (Tol, 2006). The E1 scenario was developed within ENSEMBLES as an attempt to match the European Union target of keeping global anthropogenic warming below 2 °C above pre-industrial levels.

It is important to note that climate model outputs may present significant errors (biases) when compared to observations: for instance, modelled summer temperatures in Southern Europe are usually overestimated, while large biases exist for precipitation. The existence of such biases needs to be taken into account when using the outputs of climate models for impact assessment. Consequently, the climate runs originally obtained from the ENSEMBLES project (12 A1B and 3 E1) were corrected for biases in temperature and precipitation by Dosio and Paruolo (2011), and Dosio et al. (2012).

Process-based impact models are often too expensive to consider running every single climate run through every physical impact model. Therefore, the JRC PESETA II study considered four core climate runs:

- **Reference Run**. It is interpreted as representing well the central or average of the A1B runs. This run is called 'reference' in this project, being interpreted as business as usual scenario. Two additional A1B runs show significant deviations from the average climate change signal, being usually warmer and drier (Reference Variant 1) or colder and wetter (Reference Variant 2) than the average;
- **Reference Variant 1** is the climate run that is warmer and drier than the average;
- **Reference Variant 2** is the climate run that is colder and wetter than the average;
- The **2°C Scenario.** This run is an example of the E1 scenario. This run is therefore referred to as '2°C scenario' in the project.

The combination of climate models chosen for each core run is shown in Table 4[100]. All the models driven by the same A1B emission scenario represent an equally probable projection of the future evolution of the climate. However, the selected runs show a significant variety in climate change signal for both temperature and precipitation. One can therefore expect that by using these three simulations as an input for the study of impact assessment of climate change, the main statistical characteristics of the A1B scenario as modelled by the whole ensemble of RCMs are relatively well represented.

[100] It is necessary to combine results from different climate models since the climate models used for agriculture and sea-level rise follow a different classification system from the other impacts.

Table 4: Climate models chosen for PESETA II core runs

	Climate Models Employed		
Core run	Agriculture	Sea-level rise	All other impacts
Reference run	A1B ECHAM5 (UKMO)	30 cm sea-level rise (median A1B projection)	A1B KNMI-RACMO2-ECHAM5
Reference Variant 1	A1B ECHAM5 (DMI)	30 cm sea-level rise (median A1B projection)	A1B METO-HC-HadRM3Q0-HadCM3Q0
Reference Variant 2	A1B EGMAM2006 (FUB)	30 cm sea-level rise (median A1B projection)	A1B DMI-HIRHAM5-ECHAM5
2°C run	E1 ECHAM5.4 (MPI)	18 cm sea-level rise (median E1 projection)	MPI-REMO-E4

The sea level rise projections come from the ClimateCost project (Brown et al. 2011). For the A1B scenario, the medium projection for SLR in the 2080s is 30 cm, and 18 cm for the E1 medium projection. The respective values for SLR in 2100 are 37 cm and 26 cm. The coastal impacts have been computed taking into account the projected damages for the 2080s.

CGE methodology

GEM-E3 model[101]

The GEM-E3 model is used to compute the overall economic impacts of climate change. The model uses a computable general equilibrium (CGE) approach that allows exploring the indirect economic consequences of climate change due to the cross-sectoral effects within the economy, on top of the direct economic impacts.

The GEM-E3 CGE model analyses the interactions between the economy, the energy system and the environment. The current EU version is based on EUROSTAT data (base year 2005), with most member states individually modelled. The countries are linked through endogenous bilateral trade flows. The GEM-E3 model integrates micro-economic behaviour into a macro-economic framework and allows the assessment of medium to long-term implications for policies.

Climate shocks to GEM-E3

The various impact categories are integrated by changing specific elements of the production structure and supply-side (capital and labour) of the different sectors and of the consumption structure of households. Table 5 summarizes the implementation of the different impact categories[102] in GEM-E3.

[101] http://www.gem-e3.net/

[102] A similar methodology was followed in the PESETA project (see Ciscar et al., 2012).

Table 5: Implementation of sectoral climate impacts in GEM-E3

Impact	Biophysical model output	Model implementation
Agriculture	Yield change	Productivity change for crops
Coastal areas	Migration cost	Additional obliged consumption
	Sea floods cost	Capital loss
River floods	Residential buildings damages	Additional obliged consumption
	Production activities losses	Capital loss
Energy	Heating and cooling demand changes	Energy demand changes in residential and service sectors
Transport infrastructure	Changes in cost of: - road asphalt binder application - bridge scouring	Additional obliged consumption
	Net change in costs related to: - extreme flooding - winter conditions	Capital loss[103]
Forest Fires	Burned area damage	Capital loss
	Reconstruction costs	Obliged consumption

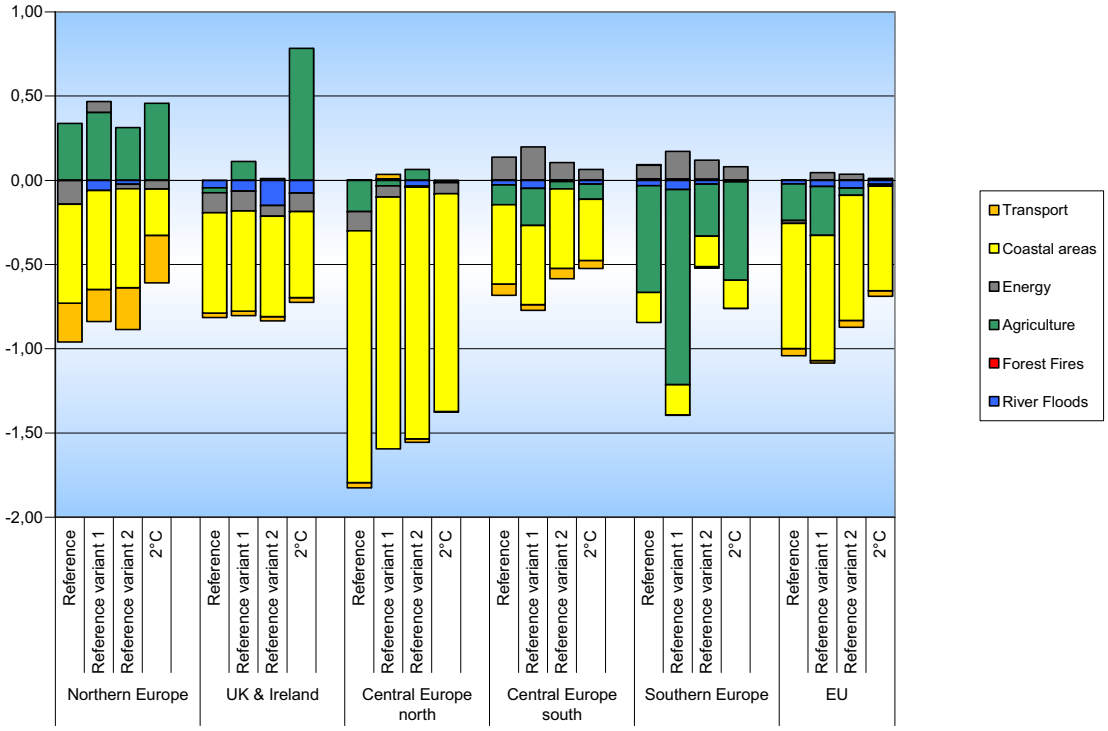
Impacts on GDP

Figure 8 shows the GDP effects for the EU, decomposed both by impact categories and EU regions. Under the reference run, losses could reach 1% of EU GDP, mainly because of impacts on coastal areas and agriculture. The overall GDP loss is reduced under the 2°C scenario. Impacts of changes in energy demand (led by reduced need for heating) are positive at EU level. Regarding the regional pattern of impacts, Central Europe north is the area most affected by GDP losses (up to 1.7% of GDP), as a consequence mainly of sea level rise. Southern Europe GDP losses are also around 1% of GDP, led mainly by agriculture impacts. In all considered regions, GDP losses become smaller when one moves from the reference run to the 2°C scenario.

It is interesting to note that the two main impact categories in terms of the effects on GDP are coastal areas and agriculture.

[103] Capital loss can be negative when combined changes in winter conditions and extreme flooding create conditions that are more benign than the baseline

Figure 8. GDP impacts (% GDP)



Source: preliminary results of JRC PESETA II project

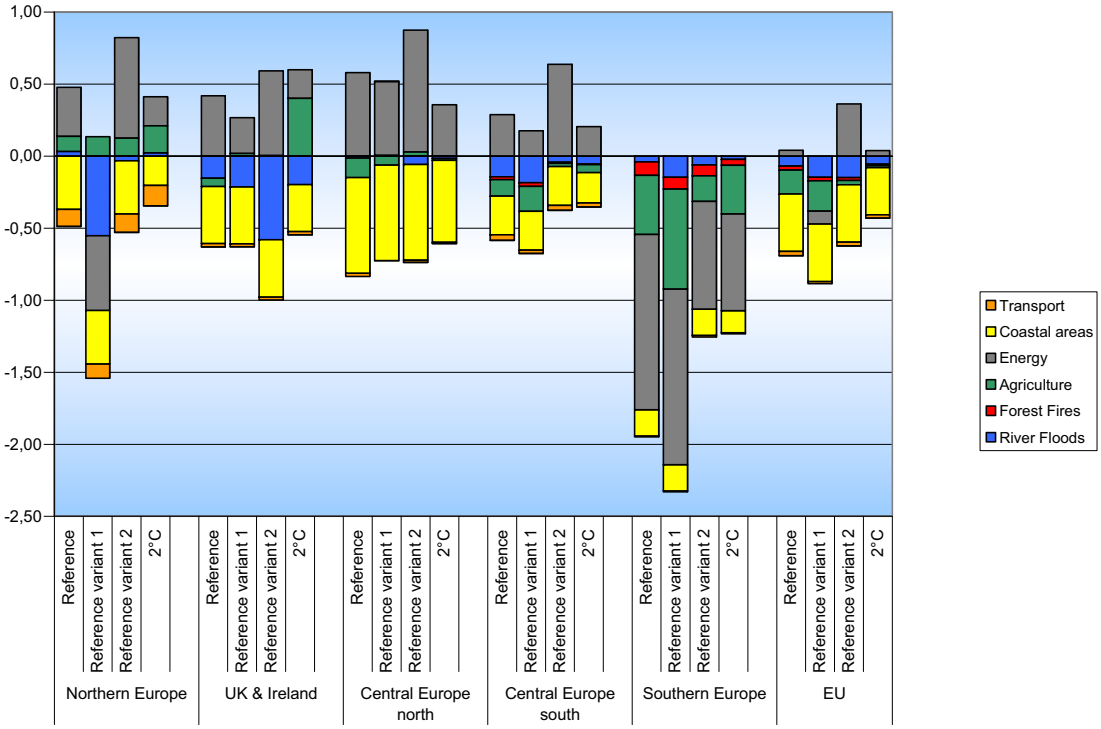
Impacts on welfare

The most appropriate way to interpret the results of GEM-E3 is in terms of welfare changes, as the economic model is rooted in neoclassical economics, where households pursue the maximisation of their welfare levels. Figure 9 shows welfare changes for the core runs, expressed as a percentage of GDP. For the EU as a whole (bars on the right-hand of the figure), the net welfare loss of the reference runs is estimated to be around 0.7% of GDP[104].

The most significant negative impacts are linked to coastal areas, agriculture and river floods. Damage from river floods is more harmful to welfare than GDP because flood damage requires spending on repairs by households. This is compulsory consumption that brings no welfare benefit (but contributes to GDP). Moving to a 2°C scenario would reduce the impact on agriculture and river floods for the EU as a whole and would reduce coastal impacts to a lesser extent.

104 That impact is lower than the impact of the previous PESETA project, in particular because for the high emission scenario the sea level rise considered is 30 cm in PESETA II, while it went to up 88 cm in PESETA.

Figure 9. Welfare impacts (% GDP)



Source: preliminary results of JRC PESETA II project

The overall EU climate impacts are disaggregated by EU region in the rest of the figure. Energy impacts are positive in most climate runs in all regions, expect Southern Europe. Starting with the Northern Europe region (bars on the left-hand side), the region could have welfare gains associated with lower energy expenditure and positive agriculture yield changes. Impacts in coastal areas are the main negative climate impact, and for Variant 1 river floods could lead to substantial losses. The negative climate impacts in UK & Ireland are due to river floods and sea level rise in coastal areas. The negative impacts in the Central Europe north area are mainly provoked by sea level rise. The Central Europe south region could register negative impacts due to sea level rise, agriculture and river floods. The Southern Europe region impacts, all negative, appear to be driven mainly by energy, as well as by agriculture and coastal damage.

Adaptation implications in coastal impacts

The only model that is able to explicitly analyse the effects of public adaptation measures is the DIVA coastal impacts model. The adaptation measures considered in DIVA relate to building dikes and beach nourishments. The GEM-E3 model has been run for the Reference case with and without public adaptation to sea level rise. In that case (Table 6) the overall welfare loss in the EU would be reduced from 42 billion Euros (under no adaptation) to 2 billion (with adaptation).

Table 6. Effects of adaptation in coastal impacts (reference run)

	No Adaptation	Adaptation
Northern Europe	-2.485	-43
UK & Ireland	-7.616	-181
Central Europe north	-21.483	-844
Central Europe south	-6.011	-378
Southern Europe	-4.659	-132
EU	**-42.253**	**-1.577**

Source: preliminary results of JRC PESETA II project

Possible transboundary effects of climate change, a preliminary analysis

An interesting issue to analyse is to what extent climate impacts occurring in one EU region could affect the rest of the EU, via trade effects. The intuition is the following. If one region would not adapt to climate change, it would undergo welfare losses, and they would affect the rest of the EU, via trade effects, given the high degree of economic integration between the EU member states. Two preliminary simulations with the reference run setting have been made to explore these trade effects.

In the first analysis (first column of Table 7), one can imagine a counterfactual situation where only Central Europe north is affected by sea level rise, while the rest of the EU regions do not suffer any direct impact. Under such a case, the economic modelling results suggest that Central Europe north would have a welfare loss of 20.5 billion Euros. There would be an additional 30% welfare loss (5.6 billion Euros) felt in the rest of the EU due to the economic linkages between EU regions.

Table 7. Transboundary effects (reference run)

	Coast / Central Europe North	Agriculture / Southern Europe
Northern Europe	-491	-122
UK & Ireland	-1.677	-580
Central Europe north	-20.518	-950
Central Europe south	-1.966	-900
Southern Europe	-1.530	-10.218
EU	**-26.181**	**-12.770**

Source: preliminary results of JRC PESETA II project

A similar simulation regarding agriculture impacts has been estimated. The hypothetical case would be that only the Southern Europe region would be affected by agriculture impacts. It is then assumed that the rest of the EU does not experience any initial yield change. In that case the impact in Southern Europe could be 10 billion Euros. There would be an additional loss of 25% (2.5 billion Euros) in the rest of the EU regions, leading to an overall welfare loss estimated at 13 billion Euros (second column of Table 7).

Variability in climate impact estimates

There are many uncertainties inherent to climate impact assessment since science has only a limited ability to measure, estimate and quantify the true relationship between changes in the

climate, the physical environment and the economy. The four core runs are able to cover some of this 'uncertainty space' by considering different climate models (GCMs and RCMs) and emissions scenarios. The three A1B runs show how results vary when different climate models are used, maintaining the same physical and economic models and emissions scenario. Furthermore, comparison between the Reference and 2°C scenarios provides insight into the estimated impacts of climate change in a low emissions scenario compared to business-as-usual (using the same physical and economic models in each case).

The river flood assessment provides additional insight by considering results from twelve climate models, for the same emissions scenario (A1B) and economic model (GEM-E3). The differences in the results are therefore uniquely attributable to the use of different climate models. Table 8 shows the welfare impacts for the reference run and the worst and best cases, out of these twelve runs. It is interesting to note the wide variability of impacts. Impacts for the whole EU could be around four times bigger or half the reference value. The range of variation is larger for the EU regions. For instance, the Central Europe north region would have a welfare loss more than eight times bigger in the worst case run, compared to the reference, while Southern Europe suffers nearly two times more in the best case (though this is the least damaging outcome for the EU as a whole).

Table 8. Welfare impacts of river floods in worst, reference and best cases (million Euro)

	Worst case	Reference	Best case
Northern Europe	-493	212	-26
UK & Ireland	-13.462	-2.965	110
Central Europe north	-3.702	-469	-383
Central Europe south	-9.818	-3.210	-57
Southern Europe	-4.489	-1.037	-2.603
EU	**-31.965**	**-7.469**	**-2.958**

Source: preliminary results of JRC PESETA II project

Table 9 presents the related GDP changes. The EU GDP loss could be 0.1% in the worst case run, being 0.2% in some regions in UK & Ireland.

Table 9. GDP Impact of river floods in worst, reference and best cases (% GDP)

	Worst case	Reference	Best case
Northern Europe	-0,1%	0,0%	0,0%
UK & Ireland	-0,2%	0,0%	0,0%
Central Europe north	0,0%	0,0%	0,0%
Central Europe south	-0,1%	0,0%	0,0%
Southern Europe	-0,1%	0,0%	-0,1%
EU	**-0,1%**	**0,0%**	**0,0%**

Source: preliminary results of JRC PESETA II project

Scope of the assessment and limitations

The preliminary results should be taken with care, due to the inherent uncertainties of the integrated assessment. This preliminary analysis has provided an illustration of the variability created by using different climate models and emissions scenarios. However, the trajectory of GHG emissions and behaviour of the climate system are only a subset of the factors that could

influence the consequences of climate change. Furthermore, while the Reference run uses temperature and precipitation estimates that are close to the average of the twelve climate models considered, one cannot say which of the climate outcomes is fundamentally more likely to occur.

Additional limitations of the assessment are related to the fact that several large climate impact categories have not been considered. That is notably the case of all the impacts affecting ecosystems, biodiversity and human life, for which there are not market prices. Abrupt climate change, including climate tipping points, has also not been considered in the analysis. From this perspective, the assessment of this study is expected to largely underestimate the potential consequences of climate change.

Moreover, the impacts refer to a hypothetical, counterfactual situation where future climate of the 2080s occurs in today's economy. In this respect, the assessment is computing one-off impacts, and not dynamic impacts such as changes in the rate of economic growth.

A methodological difficulty relates to the proper modelling of adaptation and their economic costs. The state-of-the-art in adaptation cost-benefit analysis is a developing field and further research is required in this area to better understand how and by how much adaptation options can reduce the climate vulnerabilities in particular hot spots.

Moreover, the proposed bottom-up methodology has a series of limitations related to the integration of the biophysical impacts into the CGE model that one should bear in mind. A first issue relates to the characterisation of biophysical shocks as economic impacts that can be computed in a CGE model. Each category of biophysical model impacts has been implemented in a specific way which was considered appropriate given the information and tools available.

Finally, the analysis has assumed that the rest of the world remains unchanged in spite of climate change. This translates into changes in areas such as trade flows and prices that will affect European impacts. For instance, the impacts of climate change on agriculture production can be quite large in some world regions, with a substantial influence on agriculture prices world-wide. In this respect, for each of the sectoral studies it would be interesting to explore how impacts in the EU differ depending on how climate change affects the rest of the world.

1.7. Summary of results of public consultation

For complex and socially relevant issues - such as climate change and adaptation - a broad discourse with stakeholders is seen as important for the policy-making process. This relates to enhancing the quality of the content and the implementation success. Thus, stakeholder involvement with the aim to raise awareness, provide relevant information and gather expectations and needs are seen as important elements in the development process of the EU Adaptation Strategy.

From January 2012 to the end of August 2012, stakeholder involvement activities to support the development of the EU Adaptation Strategy have been carried out on two levels: (i) stakeholder involvement with line different Commission Services, Member States, private sector and stakeholders for specific themes and (ii) public consultation via the online consultation on 'Your Voice in Europe'.

For the first level, the identification of relevant stakeholders was carried out in close agreement with the Commission. Questions such as "*Who will be affected by climate change*"; "*Who can contribute to the quality of the EU strategy*"; *"Who will need to take adaptation actions*?*"* were used to guide the selection of stakeholders. The stakeholder involvement

events provided an arena for exchanging knowledge on the issue of climate change adaptation and on practical experiences.

For involving the broad public, a public consultation was carried out by DG CLIMA with the objective to collect opinions from stakeholders and experts in the field of adaptation to climate change. The "Consultation on the preparation of the EU Adaptation Strategy" was open from 21.05.2012 – 20.08.2012 on the website "Your Voice in Europe".

In order to secure the transparency of the stakeholder involvement processes and enhance the usability of key results to be included in the EU Adaptation Strategy (and accompanying documents), every single activity was documented by using a common structure. Meetings and formats used for stakeholder involvement as well as results gained from the public consultation are described in detail in chapters 3 and 4.

Stakeholder groups involved and methods used

For stakeholder involvement within the **Commission**, lunchtime seminars (1.5h workshops, lecture setting with 30-60 people) were held with DG MARE, DG SANCO and DG MOVE. Two more seminars are to be held in October 2012 (DG REGIO and DGs dealing with social issues). Furthermore, a dedicated meeting has been organised with DG ENV. The specific aims of these seminars were to increase the general awareness on climate change, to provide information on the approach towards an EU Adaptation Strategy and to obtain information on the issue and the current state of adaptation from the DGs.

The stakeholder process with **Member State representatives** identified the need and opportunity to engage with different regions in Europe. In order to achieve this objective, two meetings were carried out in specific regions – central/eastern Europe (with approx. 30 persons attending) and southern Europe (with approx. 20 persons attending). Furthermore, a scheduled conference (Second Nordic International Conference on Climate Change Adaptation in Helsinki) was used to gain input from the Nordic countries. The meetings (1-2 days; interactive workshop setting; change between plenary and working groups) were structured in a similar way to gain comparable results and to provide good coverage for feedback on the needs and expectations from central/eastern, southern and northern Europe. The focus was on the needs and expectations of European guidance to support the elaboration of national adaptation policies (i.e. strategies and action plans).

In addition, other scheduled meetings (EIONET, organised and hosted by EEA; 2 EPA Interest Group on Climate Change Adaptation, meetings chaired by PBL Netherlands) were used to involve stakeholders from the Member States in the development process of the EU Adaptation Strategy. In general, these workshop sessions (2-3 hours; interactive workshops setting; change between plenary and working groups) aimed to provide information on the development of the EU Adaptation Strategy and offered an arena for sharing knowledge and experience on adaptation policy and practice.

Stakeholders from the **private sector** were approached through two types of engagement: (i) a questionnaire and (ii) dedicated meetings for specific issues. In addition, the private sector was engaged by establishing a two-way dialogue and a productive working relationship. Dialogues with the following stakeholders were carried out: CEN/CENELEC (1.5h meeting); CEN/CENELEC together with stakeholders from European transport sector (half day-workshop); experts on climate scenarios and (the costs of) natural disasters (1-day workshop); forest experts (1-day workshop) and insurance experts (three 1-day workshops). All events aimed at collecting inputs from practitioners and mobilising the experiences of the private sector about climate change adaptation.

Stakeholders dealing with marine spatial planning and integrated coastal zone management have been involved having a specific session in their first common meeting.

For the broad involvement of the **public**, the information on the public consultation for the strategy was circulated via various networks such as the Adaptation Steering Group, CIRCLE-2-network, etc. The public consultation received a total of 175 responses were received.

Selected results from stakeholder involvement

The stakeholder meetings with representatives from Member States and the private sector were used to discuss the various approaches taken towards adaptation, existing knowledge gaps (e.g. in regional vulnerability assessments) and other barriers (e.g. insufficient financial resources) that might hinder the process. While most stakeholders contributed substantially to the discussions, others highlighted adaptation as a new dimension and thus the events were also appreciated for both awareness raising and capacity building (this applies in particular to feedback from central/eastern European countries).

In general, the stakeholders involved in the development process of the strategy were supportive towards a European approach on adaptation to climate change. The stakeholders highlighted that the strategy will be especially useful for Member States and actors (e.g. from the private sector) that are less advanced on the issue of climate change adaptation.

Within the public consultation the overall focus was on the role of the EU in encouraging and supporting adaptation efforts at more regional/local governmental level and within the private sector. With respect to facilitating research, participants viewed a strong involvement by national and regional governments as highly important, but that the EU should be most involved in research focussing on improving monitoring and evaluations systems.

More specifically, representatives from Member States made clear that a focus on **mainstreaming of adaptation into existing EU policies** and on the specific challenge of trans-national adaptation efforts would be an added value to the EU Adaptation Strategy. This too was confirmed by the public consultation results: just under ½ of participants selected reviewing EU legislation to facilitate mainstreaming as having added value. In addition, stakeholders mentioned that the strategy should enhance the sharing of experiences and good practice on climate change adaptation, which can be provided by strengthening the European platform on climate change adaptation, CLIMATE-ADAPT.

Representatives from Member States also widely agreed that the **development of guidelines for national adaptation policy making** would be of added value. They suggested that the guidance should be generic to cover differences among Member States (e.g. different governance structures) but also specific in providing tools and recommendations. The guidance document should also provide support to the process of setting up national adaptation policies but also on key issues to be considered when implementing and monitoring/evaluating. The proposed structure of the guidance document and the presentation of good practice examples across Europe were broadly welcomed. In the public consultation over half of participants indicated that they welcome such guidance; the consultation also emphasized the need to include in the guidance documents methods for risk assessment and how to develop the strategies themselves.

The EUROSAI WGEA – Cooperative audit, indicates, among others, that "*governments are not sufficiently prepared for the expected impacts of climate change, and do not have adequate actions in place to deal with these unavoidable negative effects" (EUROSAI WGEA, 2012,*

http://www.eurosaiwgea.org/Environmental%20audits/Air/Documents/Adapatation%20to%20climate%20change%20final%20version%2005112012%20web%20format.pdf)

Private sector involvement showed clearly that the issue of climate change adaptation is a new topic on their agenda and the process is mainly in an initial phase. Respondents to the public consultation highlighted the barrier "short-term vs. long-term horizons" as most significant. "Policy and regulatory weaknesses and change" was also often labelled as a very significant barrier for the private sector in adaptation. When writing in their own barriers, "Contradictory requirements from different EU policies" and their corresponding "Harmful subsidies" came up a few times as well as an additional barrier. With respect to the barrier "Uncertainty of the impacts and modelling tools", only 1/5 of the respondents identified this barrier as highly significant. In comparison, the respondents from the private sector to the questionnaire carried out within the support project ranked the barrier "Lack of awareness" as the top barrier, followed by "Lack of information". Interestingly the cost of adaptation was ranked as the joint lowest barrier. However, in the free form section, a number of participants in the public consultation nevertheless highlighted "budgetary constraints" and "cost sharing issues" as barriers to making the economy more resilient. To overcome these barriers, the EU could help the private sector strengthen its adaptive capacity through a number of actions. "Improving the climate resilience of infrastructure investments" including "Green infrastructure" were actions most considered relevant by respondents of the public consultation, 35% and 47% respectively. "Addressing financial issues" and "emphasizing market-based instruments" were also considered medium to highly relevant by well over ½ the consultation participants. When asked to personally name additional actions the EU should take, respondents focussed on enhanced collaboration through networks and guidance covering a range of topics such as economic valuation of environmental goods, interdependencies between sectors and on the regulatory framework.

On the issue of **standards** (with focus on transport), the stakeholders involved supported an EU approach on adaptation in order to integrate adaptation into existing key standards concerning long life cycles.

Stakeholders from the **forestry** sector saw themselves in a unique situation as they play on the one hand an important role in mitigating climate change, but on the other hand the sector also needs to adapt to the impacts from climate change, and they build also the basis for adaptation in other sectors (e.g. protection function of the forest sector against increased avalanches and landslides). Stakeholders argued that the overall discussions on adaptation at EU level hardly reach the ground (single forest owner) due to the diversity and fragmentation of the sector (few large companies versus several small forest owners). Thus, they considered awareness raising/communication and the provision of tools/methods for assessing impacts and supporting adaptation of crucial importance.

Overall, **barriers to adaptation** policy making was an issue for discussion at all stakeholder meetings and also addressed by the public consultation´s results. Representatives from Member States mentioned that the lack of human and financial resources as well as political reluctance is key barriers for adaptation. Respondents to the public consultation also felt that the EU should be more involved in funding adaptation projects. Increasing direct funding for research was viewed as a highly potential action by around ½ of the respondents. Furthermore, stakeholders at all meetings raised the issue of uncertainty and reported that the lack of dedicated research hinders the adaptation process. This is also supported by the feedback to the public consultation, where training and awareness was well received as well as strengthening policy-making overall and the science-policy interface specifically. In addition, communicating relevant information to decision makers was named as a challenging task. Participants to the public consultation also viewed communication and awareness-raising

as topics that should especially be addressed by the EU. Decision-making under uncertainty, however, should be addressed at all governmental levels. In terms of support for trans-boundary issues, respondents felt the EU should focus on facilitating cooperation among countries and providing funding for adverse effects of climate change and for increasing resiliency and reducing vulnerability of affected countries.

Detailed results online public consultation

The pie chart presents **the distribution of responses by category of respondent**. The greatest number of responses came from companies and/or business associations, followed by an equal share of environmental NGOs and national/regional governmental institutions; private individuals were also well represented. Research facilities, universities and think tanks were only marginally represented; the same for international organisations and European institutions. Both business specific and nature oriented associations were well represented; therefore, the responses to the questions in the public consultation include a broad range of special interests. Interestingly, out of the 25 respondents from environmental NGOs, almost ½ (11 out of 25) are bird specific interest groups, represented by, for example, national Birdlife chapters and national ornithology groups.

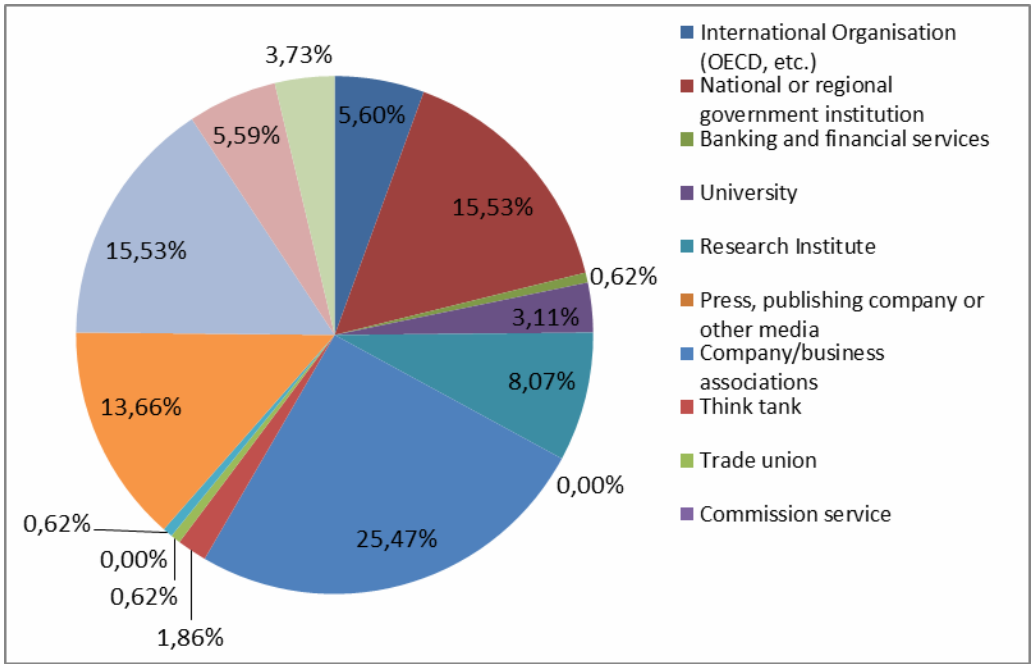


Figure 10 Distribution of responses per affiliation

Part 1 of the public consultation asked questions relating to the current problems the environment and society is facing in light of climate change as well as issues relating to the potential for adaptation measures to increase the economy's resilience.

Respondents were asked to select a maximum of three adverse effects of climate change that concern them the most. In total the different choices were selected a total of 454 times. The greatest concern selected was biodiversity loss and degradation of ecosystem services (chosen 85 times), followed by water availability/droughts (79 times) and flooding of surface waters (66 times). Seen of lesser importance were erosion (13 times), forest fires (13 times), storm surges (12 times) and soil degradation (10).

For this question it is important to consider the influence the main stakeholders have on the popularity of the top 3 selected adverse effects. For example, environmental NGOs selected "biodiversity loss and degradation of ecosystem services" 23 times compared to only 14 times

by national/regional governments and only 9 times by companies. On the other hand, companies/business associations selected river flooding 39 times, compared to only 15 times by national/regional governments and only 5 times by environmental NGOs. Interestingly, private individuals chose "biodiversity losses" much more often (17 times) than river flooding (only 4 times). For "water availability/droughts" – the second most often chosen effect – companies/business associations, environmental NGOs and national/regional governments selected the effect rather equally: 21, 15 and 12, respectively.

Respondents were asked to select a maximum of 2 populations/groups that in their opinion are the most vulnerable to the adverse impacts of climate change. 259 entries were recorded, and by far the elderly population (71 times) and low-income households (65 times) were chosen.

In light of the most pressing climate change impacts, *the public consultation asked respondents to rank a set of barriers regarding their significance in preventing the economy from becoming more climate resilient.*

The graph below highlights the level of significance given to each barrier. The barrier 'short term vs. long-time horizons' received the highest ranking with an average 4.4, and the average ranking for the barrier 'Policy and regulatory weaknesses and change' was 4. 'Lack of awareness of climate-change related risks" average rank was a 3.8, whereas 'Cost and reversibility of adaptation actions' received the lowest average at 3.4. The remaining barriers – 'Lack if available funding', 'Lack of understanding of potential adaptation measures' and 'Uncertainty of the impacts and modelling tools' – equally received an average 3.7 ranking..

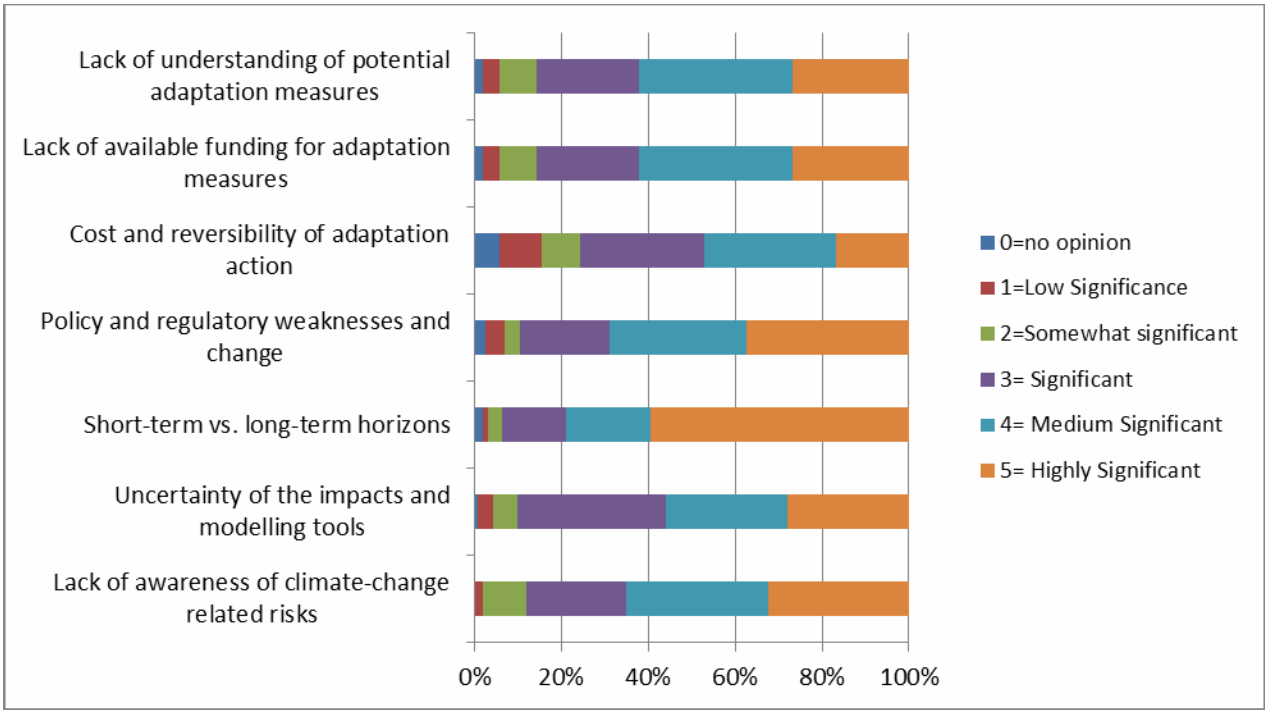


Figure 11 Significance of barriers in preventing the economy from achieving climate resilience

The public consultation asked respondents to rank sectors regarding their relevance for improving Europe's resilience to climate change impacts. Respondents could either indicate no opinion or rank the barriers from 1 to 5, with 5 being very significant and 1 being not significant at all.

According to the respondents, the sector with the highest relevance for improving resiliency is water, receiving an average 4.5 ranking. This is closely followed by agriculture and rural development (4.4 average) and nature conservation (4.2). The energy sector also received a

high overall ranking with a 4.2 average. Forestry (3.9), maritime (3.8), transport (3.8) and cities (3.8) received similar average rankings. These sectors are followed by migration and construction/buildings, both with a 3.6 average rank. Industry/SMEs received a solid 3.5 average rank in terms of its relevance in making the EU more resilient, while the health sector received a 3.4 average rank. Civil protection received an overall average 3.2 score. The employment sector received the lowest overall score of 2.8.

As with the question on adverse effects of climate change, the selection of sectors most relevant for improving Europe's resilience was largely split according to the type of stakeholder. For companies/business associations, the top three sectors considered most relevant (i.e. receiving a '5') for action are energy (21 times or 51%), water (19 times or 43%) and transport (13 times or 32%). For environmental NGOs, on the other hand, the top three sectors considered most relevant for action are water (25 times or 100%), nature conservation (22 times or 88%) and forestry (20 times or 80%). National/regional governments selected as their top three sectors energy (13 times or 52%), water (12 times or 48%) and nature conservation (10 times or 40%). Finally, private individuals selected water (16 times or 73%), energy (15 times or 68%), and forestry and nature conservation (13 times each or 51%). These responses highlight that the most homogenous group in choosing sectors were the environmental NGOs.

The results of the public consultation have indicated that climate change is considered a pressing issue and EU action is very important in a number of sectors in order to improve the economy's resilience to the identified climate change impacts. Respondents were asked to consider in what timescale adaptation efforts will lead to certain outcomes; multiple answers were possible. Whereas respondents think that job creation and growth will largely happen in the short (32% of responses) and medium term (36.5%), social objectives will more likely be achieved through climate change adaptation in the medium (38%) and long term (31%). Similarly, attaining a resilient economy and environment will more like happen in the medium (40.6% and 36% respectively) and longer term (36.5% and 36.4% respectively) due to climate change adaptation efforts.

Important issues regarding the effectiveness of adaptation policies and measures

For the companies/business associations, the main issues to be addressed are facilitating cooperation and raising awareness at all level (local, regional, national and international), and ensuring funding. For the environmental NGOs and the national or regional government institutions, the priorities are the adaptation of the water sector and the natural environment, the implementation of financial mechanisms and of policy framework. International organisations, other NGOs and private individuals mainly consider the need to facilitate cooperation and raising awareness at all level. Other, NGOs, private individuals and research institutes also consider water sector and natural environment as priority issues.

Part 2 of the consultation asked participants to consider where gaps in research remain and how best to develop funding mechanisms further. Respondents were asked to point out which areas of climate (adaptation) research require attention and/or resources at different levels of governance. In each research area, participants could select between 1 and 5 levels of governance that should get more involved in climate research.

With respect to monitoring and evaluation and communication and awareness-raising, respondents favoured action at European level. For sensitivity and adaptation options respondents most often felt that national and regional/local level administrations should be involved. Respondents felt that research on adaptive capacity, however, should rather receive attention and research at the regional/local level. Decision-making under uncertainty and research on impacts were evenly spread between EU, national and regional level, while

interregional level was not considered as relevant in this research domain (only 34% supported work at this level). Sectoral level involvement only received more than ½ of the responses for research relating to sensitivity (51.5%), adaptation options (59%) and communication (57%).

Respondents were asked to rank the capability of actions to improve the use of EU funding for climate change adaptation projects. Out of the 6 actions presented in the questionnaire, the options to 'increase direct funding for adaptation-related research' and 'better involvement of the policy-making community' received the highest average ranking of 4.2. Respondents selected the rank '5' most often for direct funding. 'Better dissemination of research results' and 'training and awareness-raising' both received an average rating of 3.8. Respondents gave 'more support of coordination between national and international research programmes' a 3.7 as average score. The least selected action to improve the use of funding was 'increased support for pan-European Climate Services', which received an average score of 3.6. Overall, the 6 actions were well-scored and none of them were particularly discarded by the respondents.

The final question in this section asked respondents to judge additional actions that could be considered at EU level to facilitate further knowledge and dissemination and sharing. Respondents could make multiple selections. Most of the options were well regarded. 'Activities to promote the use of the European Climate Adaptation Platform' was not as well received as the other options, although it was nevertheless selected by over half (54.66%) of the respondents. 'Support of pan-European discussion forums to exchange best practice' was most often selected by respondents (76.4%).

Part 3 of the consultation focussed on how respondents view the role of the EU in facilitating working among the Member States, also in the context of transboundary issues.

The consultation asked respondents how the EU can facilitate the work of local authorities in adapting to climate change. Respondents could select between 1 and 4 answers, of which only 13 (8%) felt that no direct EU intervention is needed. All three options received high responses, but enhancing awareness and providing guidance on adaptation at regional/local level were considered more relevant than enhancing awareness at sectoral level.

In the context of transboundary issues relating to climate change, respondents were asked to select between 1 and 4 options that the EU could take. Most of the options were well regarded, but only 26% of respondents feel that the 'creation of EU agencies to address transboundary risks' was an action the EU should consider. 'Facilitating cooperation among countries' received the greatest number of responses (82.61%). 'Awareness and guidance' was selected by 63.35% of respondents.

Part 4 of the consultation focused on the link between EU policies and the private sector and on what can be done at EU level to facilitate work on the national level.

The consultation asked respondents to select which type of instruments would bring the most added-value to further support and incentivise Member States to develop national adaptation strategies (NAS). The option to have 'Legislation in place that requires Member States to develop NAS' received the least number of responses (around 25%). None of the business sector respondents selected the legislation option, whereas 68% of environmental NGO respondents did; only 6% of national institutions and 13.6% of private citizen respondents selected enacting legislation. It is important to note that 35% of the respondents selected a combination of these instruments; thus, the low percentage of respondents that selected legislation as a potential instrument should be viewed with care.

Respondents were asked to rate actions at the EU level to strengthen the adaptive capacity of the private sector from a scale of 1 to 5 (5 being very relevant and 1 not relevant). 'Promoting and developing green infrastructure' received with a 4.2 the overall highest average regarding actions to strengthen the adaptive capacity of the private sector. 'Improving the climate resilience of infrastructure investments' receive the next highest overall average with a rating of 3.9. 'Public-private partnerships' received an overall average score of 3.6, and 'emphasising the role of market-based instruments' received an overall average score of 3.4. The action to 'review the role and assess the needs for insurance' received the lowest overall average rating with a 3.1.

1.8. Glossary

Adaptation: Adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities. Various types of adaptation can be distinguished, including anticipatory, autonomous and planned adaptation (IPCC, 2007):

Anticipatory adaptation: Adaptation that takes place before impacts of climate change is observed. Also referred to as proactive adaptation.

Autonomous adaptation: Adaptation that does not constitute a conscious response to climatic stimuli but is triggered by ecological changes in natural systems and by market or welfare changes in human systems. Also referred to as spontaneous adaptation.

Planned adaptation: Adaptation that is the result of a deliberate policy decision, based on an awareness that conditions have changed or are about to change and that action is required to return to, maintain, or achieve a desired state.

Adaptation benefits: The avoided damage costs or the accrued benefits following the adoption and implementation of adaptation measures.

Adaptation costs: Costs of planning, preparing for, facilitating, and implementing adaptation measures, including transition costs.

Adaptive capacity (in relation to climate change impacts): The ability of a 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.

Adaptation measures: Adaptation measures are technologies, processes, and activities directed at enhancing our capacity to adapt (building adaptive capacity) and at minimising, adjusting to and taking advantage of the consequences of climatic change (delivering adaptation).

Reactive adaptation is adaptation that takes place in response to the consequences of a particular event

Maladaptation: Action taken ostensibly to avoid or reduce vulnerability to climate change that impacts adversely on, or increases, the vulnerability of other systems, sectors or social groups.

Adaptation strategy – generally understood to be a broad policy document that outlines the directions of actions intended to the capacity to adapt to climate change.

Adaptation actions plan – more specific document guiding action. It can cover adaptation actions generally or focus on some sector(s).

Capacity building: In the context of climate change, capacity building is developing the technical skills and institutional capabilities in developing countries and economies in transition to enable their participation in all aspects of adaptation to, mitigation of, and research on climate change, and in the implementation of the Kyoto Mechanisms, etc. (IPCC, 2007). Capacity building involves creating the information and conditions (regulatory, institutional, and managerial) that are needed before adaptation actions can be undertaken[105]

Climate change: Climate change refers to any change in climate over time, whether due to natural variability or as a result of human activity. This usage differs from that in the United Nations Framework Convention on Climate Change (UNFCCC), which defines 'climate change' as: 'a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods'. See also climate variability. (IPCC, 2007)

Climate variability: Climate variability refers to variations in the mean state and other statistics (such as standard deviations, statistics of extremes, etc.) of the climate on all temporal and spatial scales beyond that of individual weather events. Variability may be due to natural internal processes within the climate system (internal variability), or to variations in natural or anthropogenic external forcing (external variability). See also climate change. (IPCC, 2007)

Climate system: The climate system is defined by the dynamics and interactions of five major components: atmosphere, hydrosphere, cryosphere, land surface, and biosphere. Climate system dynamics are driven by both internal and external forcing, such as volcanic eruptions, solar variations, or human-induced modifications to the planetary radiative balance, for instance via anthropogenic emissions of greenhouse gases and/or land-use changes.

Disaster: A serious disruption of the functioning of a community or a society involving widespread human, material, economic or environmental losses and impacts, which exceeds the ability of the affected community or society to cope using its own resources. Comment: Disasters are often described as a result of the combination of: the exposure to a hazard; the conditions of vulnerability that are present; and insufficient capacity or measures to reduce or cope with the potential negative consequences. Disaster impacts may include loss of life, injury, disease and other negative effects on human physical, mental and social well-being, together with damage to property, destruction of assets, loss of services, social and economic disruption and environmental degradation. There are different ways in which disasters can be framed. See for example an inventory made for the disaster reduction community.

Disaster risk: The potential disaster losses, in lives, health status, livelihoods, assets and services, which could occur to a particular community or a society over some specified future time period. Comment: The definition of disaster risk reflects the concept of disasters as the outcome of continuously present conditions of risk. Disaster risk comprises different types of potential losses which are often difficult to quantify. Nevertheless, with knowledge of the prevailing hazards and the patterns of population and socio-economic development, disaster risks can be assessed and mapped, in broad terms at least.

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[105] West, C.C. and Gawith, M.J. (Eds.) (2005) Measuring progress: Preparing for climate change through the UK Climate Impacts Programme. Available from www.ukcip.org.uk

Disaster risk management: Disaster risk management stands for a systematic process of using administrative directives, organizations, and operational skills and capacities to implement strategies, policies and improved coping capacities in order to lessen the adverse impacts of hazards and the possibility of disaster. Comment: This term is an extension of the more general term "risk management" to address the specific issue of disaster risks. Disaster risk management aims to avoid, lessen or transfer the adverse effects of hazards through activities and measures for prevention, mitigation and preparedness. There are different ways in which risk management can be framed. See for example inventories made for the disaster reduction community or for the Dutch Climate Changes Spatial Planning Programme.

Disaster risk reduction: The concept and practice of reducing disaster risks through systematic efforts to analyse and manage the causal factors of disasters, including through reduced exposure to hazards, lessened vulnerability of people and property, wise management of land and the environment, and improved preparedness for adverse events.

Ecosystem: The interactive system formed from all living organisms and their abiotic (physical and chemical) environment within a given area. Ecosystems cover a hierarchy of spatial scales and can comprise the entire globe, biomes at the continental scale or small, well-circumscribed systems such as a small pond. (IPCC, 2007)

Ecosystem-based approaches to climate change adaptation (short ecosystem-based adaptation, EbA: includes the sustainable management, conservation and restoration of ecosystems to provide services that help people adapt to the adverse effects of climate change. EbA often also contributes to climate change mitigation, by conserving carbon stocks, reducing emissions caused by ecosystem degradation and loss, or enhancing carbon stocks. EbA increases resilience and reduces vulnerability. EbA can be a cost-effective adaptation strategy across the major adaptation sectors. (Report CBD AHTEG, 2009 adapted)

Extreme weather event: An event that is rare within its statistical reference distribution at a particular place. Definitions of 'rare' vary, but an extreme weather event would normally be as rare as or rarer than the 10th or 90th percentile. By definition, the characteristics of what is called 'extreme weather' may vary from place to place. Extreme weather events may typically include floods and droughts. (IPCC, 2007)

Exposure: is the nature and degree to which a system is exposed to significant climatic variations (IPCC, 2007)

Global warming: Global warming refers to the gradual increase, observed or projected, in global surface temperature, as one of the consequences of radiative forcing caused by anthropogenic emissions.

Hazards: A physically defined climate event with the potential to cause harm, such as heavy rainfall, drought, flood, storm and long-term change in mean climatic variables such as temperature (UNDP, 2004)

Impacts (climate change): the effects of climate change on natural and human systems. Depending on the consideration of adaptation, one can distinguish between potential impacts and residual impacts (IPCC, 2007):

Potential impacts: all impacts that may occur given a projected change in climate, without considering adaptation. This allows assessing all effects of climate change if no adaptation occurs for a specific sector or area.

Residual impacts: the impacts of climate change that would occur after anticipatory, planned and autonomous adaptation. This would allow assessing the actual need for intervention for a specific sector or area.

Autonomous adaptation residual impacts: impacts that may occur given a projected change in climate, considering only autonomous adaptation. This would allow assessing the actual need for public intervention for a specific sector or area

Likelihood – See probability

Mitigation: An anthropogenic intervention to reduce the anthropogenic forcing of the climate system; it includes strategies to reduce greenhouse gas sources and emissions and enhancing greenhouse gas sinks. (IPCC, 2007)

Probability: the likelihood or possibility of an event or outcome occurring. Probability can range from being qualitative, using word descriptions such as likely or highly confident, to quantified ranges and single estimates, depending on the level of understanding of the causes of events, historical time series and future conditions (UNDP, 2004).

Projection: The potential evolution of a quality or set of quantities, often computed with the aid of a model. Projections are distinguished from predictions in order to emphasise that projections involve assumptions — concerning, for example, future socio-economic and technological developments, that may or may not be realised — and are therefore subject to substantial uncertainty.

Regional: Area covered by an administrative geographic unit below national level that is responsible for the development of the adaptation strategy (e.g. province, Länder, large cities). (IPCC, 2007)

Resilience: The ability of a social or ecological system to absorb disturbances while retaining the same basic structure and ways of functioning, the capacity for self-organisation, and the capacity to adapt to stress and change. (IPCC, 2007)

Risk: The combination of the probability of an event and its consequences[106]. Some climate change glossaries consider vulnerability a part of risk, for example the UNDP guidance defines climate related risk as the result of the interaction of physically defined hazards with the properties of the exposed systems, i.e., their sensitivity or (social) vulnerability. Risk can also be considered as the combination of an event, its likelihood, and its consequences, i.e., risk equals the probability of climate hazard multiplied by a given system's vulnerability (UNDP, 2004).

Scenario: A plausible and often simplified description of how the future may develop, based on a coherent and internally consistent set of assumptions about driving forces and key relationships. Scenarios may be derived from projections, but are often based on additional information from other sources, sometimes combined with a 'narrative storyline'. (IPCC, 2007)

SRES: The storylines and associated population, GDP and emissions scenarios associated with the Special Report on Emissions Scenarios (SRES) (Nakićenović et al., 2000), and the resulting climate change and sea-level rise scenarios. Four families of socio-economic scenario (A1, A2, B1 and B2) represent different world futures in two distinct dimensions: a focus on economic versus environmental concerns and global versus regional development patterns... (IPCC, 2007)

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[106] United Nations, International Strategy for Disaster Reduction (UN/ISDR) Terminology on Disaster Risk Reduction (2009), available from http://www.unisdr.org/eng/library/lib-terminology-eng.htm

Sensitivity: 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 (IPCC, 2001).

Threshold: The level of magnitude of a system process at which sudden or rapid change occurs. A point or level at which new properties emerge in an ecological, economic or other system, invalidating predictions based on mathematical relationships that apply at lower levels (IPCC, 2007).

Uncertainty: An expression of the degree to which a value (e.g., the future state of the climate system) is unknown. Uncertainty can result from lack of information or from disagreement about what is known or even knowable. It may have many types of sources, from quantifiable errors in the data to ambiguously defined concepts or terminology, or uncertain projections of human behaviour. Uncertainty can therefore be represented by quantitative measures (e.g., a range of values calculated by various models) or by qualitative statements (e.g., reflecting the judgement of a team of experts). See also confidence and likelihood (IPCC, 2007).

Vulnerability: Vulnerability is the degree to which a system is susceptible to, and 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 change and variation to which a system is exposed, its sensitivity, and its adaptive capacity (IPCC, 2007).

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