COMMISSION OF THE EUROPEAN COMMUNITIES

Brussels, 1.4.2009
SEC(2009) 387

COMMISSION STAFF WORKING DOCUMENT

accompanying the

WHITE PAPER

Adapting to climate change: Towards a European framework for action

IMPACT ASSESSMENT

{COM(2009) 147 final}
{SEC(2009) 386}
{SEC(2009) 388}

TABLE OF CONTENTS

1. INTRODUCTION, PROCEDURAL ISSUES AND CONSULTATION OF INTERESTED PARTIES

This report accompanies the Commission's White Paper on Adaptation to Climate Change. Its objective is to raise the profile of adaptation and to build a coherent approach at institutional level across the EU. The proposed EU Framework would complement and re-enforce Member States actions, particularly through existing funding channels, the provision of accurate climate information and appropriate guidance, ensuring that adaptation is integrated in important EU policy sectors and guaranteeing solidarity between countries/regions. The White Paper adopts a phased approach: Phase 1 (2009-2012) will lay the ground work for the preparation of a more comprehensive adaptation strategy for the EU to be implemented during phase 2 commencing in 2012.

This report is first and foremost a taking-stock exercise, reviewing the literature and gathering the views of services and stakeholders, on the basis of the 2007 Green Paper. It is also meant to serve as a reference framework to develop an EU adaptation policy in future. It is a cross-cutting exercise and it is complemented by sectoral papers on water, coasts and marine issues[1], agriculture[2] and health[3].

Chapter 1 explains briefly the process for the elaboration of both documents since the publication of the Green Paper on Adaptation in 2007[4] and the broad internal and external consultation.

Chapter 2 defines key concepts such as impacts, vulnerability and adaptive capacity. It identifies the uncertainties and the knowledge gaps to be filled to establish priorities and monitor further action. It provides an overview of the vulnerability of EU sectors, regions or groups, to Climate Change impacts. Taking into account how national, regional and sectoral adaptation strategies already address some of these challenges, it evaluates the scope for EU action, focusing on mainstreaming adaptation into EU policies and on the necessary co-ordination of the different policy levels.

Chapter 3 describes the objectives of the IA and explains how the general objective of promoting adaptation is translated into this context to specific objectives i.e. of identifying priority adaptation measures and of defining an action plan for the next 4 years. It also establishes operational objectives corresponding to the key problems identified in the previous section.

This impact assessment is of a qualitative nature. A first set of options is presented in Chapter 4, these refer to the overall adaptation approaches, for which a proportionate assessment of the economic, environmental and social impacts is conducted to allow a prioritisation of adaptation actions.

A second set of options is presented in Chapter 5, which refers to the specific actions to be undertaken in the short term. These options are assessed with respect to the operational criteria defined in chapter 3, and with respect to subsidiarity, knowledge basis and resources aspects.

---

1 SEC(2009) 386
2 SEC(2009) 417
3 SEC(2009) 416
4 COM(2007) 354 final, http://ec.europa.eu/environment/climat/adaptation/index_en.htm

Chapter 6 describes the monitoring and evaluation actions to be undertaken in priority, to allow a further review of the action framework with respect to the operational objectives defined in chapter 3.

The analysis is based on the 2008 EEA/JRC/WHO report on Climate Change Impacts[5], and on a list of other reports and papers quoted in footnotes or detailed in an appendix, together with a glossary and a report providing detailed results on the public and stakeholder consultations on the Green Paper.

Annex 1 provides further details on the framework for integrated assessment of adaptation policies, including recent estimates on adaptation costs from the literature. A more detailed analysis of climate change vulnerability, adaptation potential and the need for EU action is provided for environmental cross cutting issues (Annex 2) and at Sectoral or geographical level (Annex 3). Annex 4 provides an overview of National adaptation strategies. Annex 5 provides details on the concrete measures that have been screened for the short-term EU action plan.

An executive summary is presented in a separate document[6].

1.1. Context and legal basis

The Commission adopted a Green Paper on adapting to climate change in Europe, recognizing that all parts of Europe will increasingly feel the adverse effects of climate change. This is confirmed i.e. by the 4th IPCC report[7] (IPCC, 2007) or the 2008t EEA/JRC/WHO report on the impacts of CC in Europe (EEA, 2008) and by the 2009 international scientific congress on climate change[8].

The Green Paper was followed by a broad stakeholder consultation (see section 0). It was also the subject of opinions and resolutions by the Committee of the Regions[9], the European Economic and Social Committee[10] and the European Parliament[11]. There was general agreement on the need to exploit the synergies between mitigation and adaptation efforts and to do more research and knowledge gathering on vulnerabilities and risks of climate change. The need to exchange best practices, the importance of subsidiarity, the crucial role of local and regional authorities and necessity to integrate adaptation in all relevant EU policies were also highlighted. Other issues raised include: the need for greater awareness raising, the active participation of all administrations and civil society in tackling this issue. They also stress the importance of protecting ecosystems and biodiversity and analysing current and future funding mechanisms to be more in line with the adaptation needs. They agree with the Commission on the need and the benefits of early action and share the Commission's view that although a 'one size fits all' approach would not be an adequate response, an action at EU

---

5 Impacts of Europe's changing climate - 2008 indicator-based assessment, EEA Report No 4/2008, http://reports.eea.europa.eu/eea_report_2008_4/en/

6 Add ref

7 Alcamo et al., Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, available on http://www.ipcc.ch/ipccreports/assessments-reports.htm

8 "Climate Change: Global Risks, Challenges and Decisions" (10-12 March 2009 in Copenhagen, Denmark, http://climatecongress.ku.dk/)

9 CdR 118/2007- 72th Plenary Session 28-29 November 2007

10 CESE/2007/1702 of 12 December 2007

11 B6/2008/131 of 10 April 2008

level coupled with action at all administrative levels, would yield significant added value compared to initiatives exclusively taken by the Member States.

1.2. Stakeholder consultation

Following the publication of the Green Paper on adaptation to climate change, the Commission consulted widely with stakeholders and the public in developing this subsequent White Paper. From the feedback gathered through various channels (see Appendix), it was clear that stakeholders found it easier to identify problem areas than to propose concrete action. They also emphasised the importance of giving adaptation a high priority considering it in parallel with mitigation efforts, and that more recognition should be given to the differences in vulnerability between sectors and geographical locations. For the respondents, the priority areas for the EU should be:

- Environmental impacts notably: water management (including methods for tackling water shortages, water quality, flooding), biodiversity and ecosystems.

- Social impacts particularly health and diseases, infrastructure resilience, food security, social equity, migration and

- Economic impacts notably: agriculture and energy infrastructure.

According to the feedback received, the Green Paper gave too little attention to the following areas: communication and awareness raising, the importance of additional research and monitoring systems, an overarching strategic vision demonstrating EU leadership, the importance of migration and social cohesion aspects, the need for coordinating mitigation and adaptation strategies and the mechanisms for financing adaptation efforts. Many stakeholders emphasised the cross-cutting role of biodiversity and ecosystems.

Most stakeholders consider that the EU had a role to play in providing climate change information, appropriate guidance, financial support and technical expertise and suggested that the EU should develop a clear and strong strategic framework for adaptation across all sectors, addressing cross-border issues and coordinating action across Europe, strengthening or extending existing EU frameworks and directives to include adaptation while updating and harmonising existing structures.

1.3. Scientific expertise

The Impact Assessment has benefited from input from various reports and research projects on climate change impacts and adaptation (see reference list in Appendix) produced by the IPCC, EU research programmes, EEA, international organisations, national and regional authorities, the private sector and NGOs.

1.4. Internal consultation

In the preparations for the White Paper, extensive consultation took place within the Commission. Several informal inter service meetings were organised (in September and December 2007, and in April, May and July 2008). These meetings were targeted to exchange information on ongoing activities by all Commission services related to climate change

adaptation[12], including a report on the progress of the preparations for the White Paper. Furthermore, bilateral meetings with relevant key services took place in April, May, November and December 2008. In these meetings, ongoing activities related to adaptation were discussed in more detail and adaptation options for consideration in the Impact Assessment were addressed. Various drafts of the Impact Assessment were sent to the inter-service group members for informal comments

The Impact Assessment Board (IAB) has provided comments on three earlier drafts of the IA report. The present impact assessment report integrates the IAB recommendations expressed in its final opinion, which are detailed in Appendix 4.

[12] DGs AGRI, AIDCO, BUDG, COMM, DEV, EAC, ECFIN, EMPL, ENTR, ESTAT, JLS, JRC, MARE, MARKT, REGIO, RELEX, RTD, SANCO, SG, TRADE, TREN and the EEA.

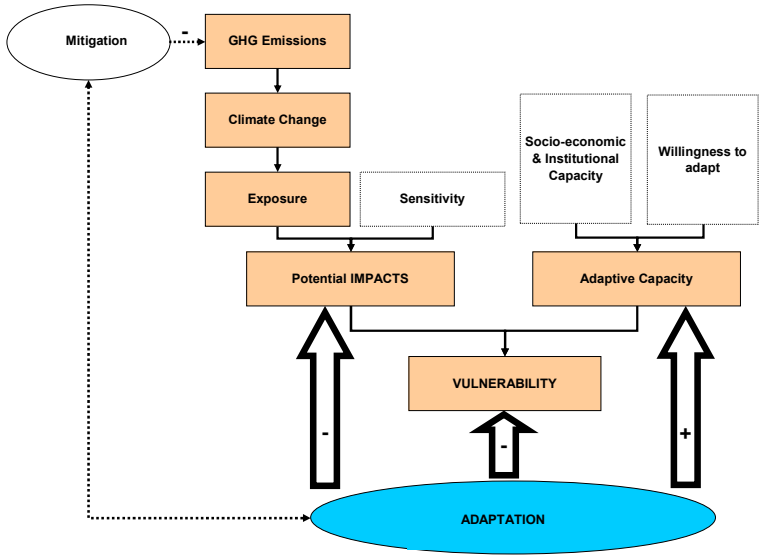
2. NEEDS AND LIMITATIONS FOR EARLY ADAPTATION ACTION AT EU LEVEL

2.1. Climate Change Adaptation: a new agenda for public policy

2.1.1. The concepts of vulnerability and resilience

Vulnerability (as defined in IPCC, 2007) 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 (EEA, 2008) 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 (see Figure 1).

Figure 1 - Conceptual diagram for climate change impacts, vulnerability and adaptation. Source: Isoard, Grothmann and Zebisch (2008) quoted in EEA (2008)



This means that pro-active adaptation policies should not be restricted to the analysis of the impact of Climate Change across different sectors, regions or social groups, but should encompass the assessment of their uneven adaptive capacity. In some cases climate change might provide opportunities for innovations in processes, technology and governance, but in others public action will be needed to address the vulnerability to CC impacts.

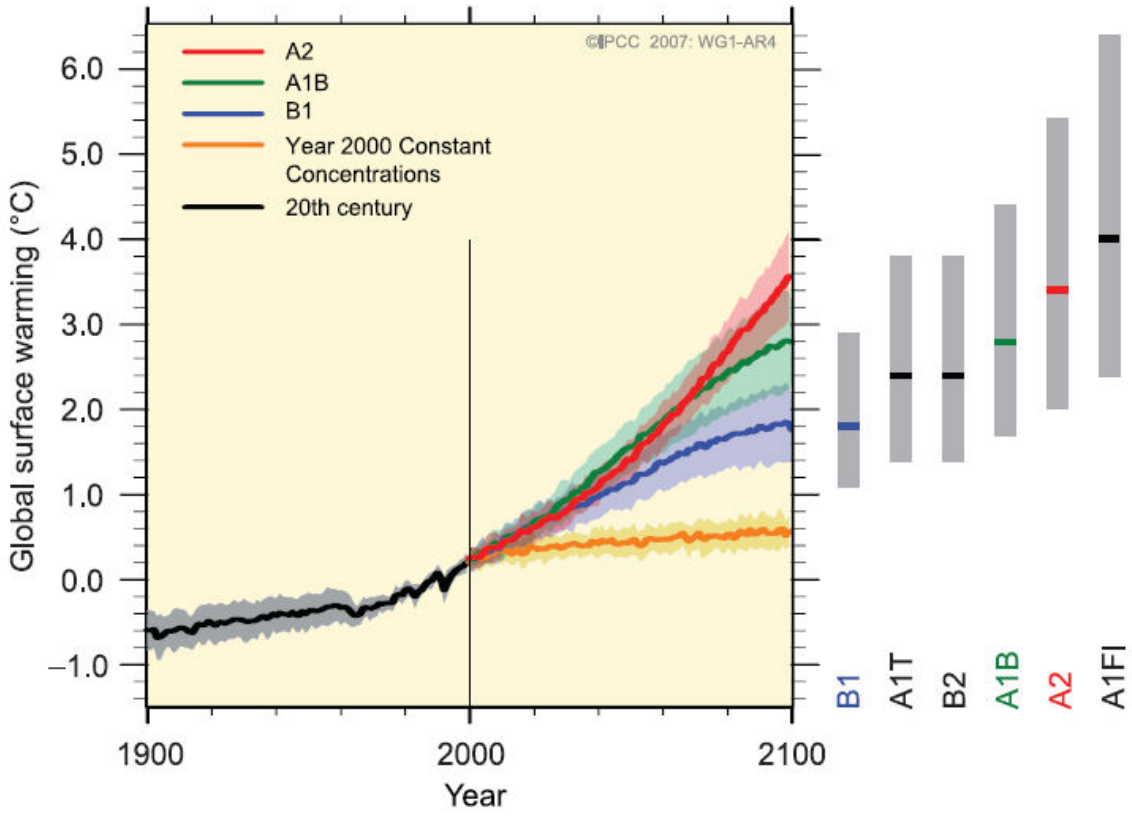
The concept of resilience can be defined as the ability of a social or ecological system to absorb disturbances while retaining the same basic structure and ways of functioning, the capacity for self-organisation, and the capacity to adapt to stress and change (IPCC, 2007).

2.1.2. Uncertainty

The 4th IPCC report recalls that there are major uncertainties in future climate projections, as well as in future socio-economic trends. The latter are important in determining the vulnerability of social and economic systems to climate change, as well as their adaptive capacity. There are also major uncertainties over the future baseline for adaptation, i.e. in considering which emission and mitigation trajectory we are on. While the current EU

ambition level is to limit global climate change to 2 degrees Celsius above pre-industrial levels[13], this target is reliant on global action, and is associated with considerable uncertainty, i.e. the 50% global reduction in GHG outlined in the 2007 Communication has only a 50% chance of achieving the 2°C target. The 2009 international scientific congress on climate change confirmed that the (globally) worst-case IPCC 2007 scenario trajectories (or even worse) are being realised and there is a significant risk that many of the trends will accelerate, leading to an increasing risk of abrupt or irreversible climatic shifts.

Figure 2 - Best values and likely ranges of global mean warming for the time horizon of 1900-2099[14] relative to the control period of 1980-99. (Source: IPCC 2007).



It is therefore necessary to consider a wide range of scenarios in formulating possible adaptation policy. The available information is however still fragmented, and the 2008 EEA/JRC/WHO report relies on different global scenarios and regional downscaling for about 40 climate impact indicators. The report identifies 3 basic types of uncertainty:

---

13 Communication of 10 January 2007, entitled: "Limiting Global Climate Change to 2 degrees Celsius - The way ahead for 2020 and beyond" [COM(2007) 2 final - Not published in the Official Journal].

14 The 21st century warming is shown as continuation of the 20th century simulations. Solid lines are multi-model global averages of surface warming (relative to 1980–1999) for three SRES (IPCC's Special Report on Emissions Scenarios) marker scenarios (A2, A1B and B1). Shading denotes the ±1 standard deviation range of individual model annual averages. The orange line, for the experiment where concentrations were held constant at year 2000 values, shows that we are already committed to 0.6 °C warming due to the past greenhouse gas emissions. The grey bars at right indicate the likely range assessed for the six SRES marker scenarios and the solid line within each bar indicates the best estimate. The assessment of the best estimate and likely ranges in the grey bars includes the AOGCMs (Atmosphere-Ocean coupled General Circulation Model) in the left part of the figure, as well as results from a hierarchy of independent models and observations.

– **Incomplete knowledge**: Responses in systems with high levels of complexity such as biological, social or economic systems are very difficult to assess. Climate impacts can either be increased by other, non-climatic factors, or compensated by adaptation of the system, or internally compensated until a critical level of resilience is exceeded.

– **Insufficient observed trends**: Observed data and trends for many of the impact indicators often lack the appropriate spatial and temporal scale to provide the adequate level of information to properly develop and assess adaptation strategies.

– **Socio-economic developments**. The most important sources of uncertainty are human behaviour, evolution of political systems, demographic, technological and socio-economic developments. To address this issue requires using a set of global emission scenarios, such as the ones presented in the last IPCC reports, and making use of consistent regional socio-economic and climate change and impact projections as soon as they become available.

Additionally, the tools for integrated assessment of adaptation policies are still much less advanced[15] than those addressing mitigation. This delay is due to some extent to the misunderstanding and misinformation surrounding adaptation, perceived as a substitute for mitigation. However, adaptation integrated assessment poses also methodological problems, such as up-scaling from the local to the regional or national level, or measuring the vulnerability and the degree of adaptation.

6th EU Research Framework Programme (6FP) projects such as ENSEMBLES[16] and ADAM[17] are progressing in defining a set of consistent scenarios designed for the further integrated assessment of adaptation and mitigation policies. Initial research under 7th EU Research (FP) Framework Programme[18] (7FP) will further address the quantification of damage and adaptation cost for global and regional emission scenarios. A description of the most relevant projects is provided in Appendix.

2.1.3. Potential Impacts of Climate Change in Europe

In order to highlight the most relevant potential impacts of Climate Change, the feedbacks, the conflicts and synergies, an analytical framework has been defined based on the work of EEA (EEA, 2008) and OECD[19] (OECD, 2008), as well as consistent with the work undertaken for the "Economics of Ecosystem and Biodiversity" study[20] (TEEB, 2008) . This chain (which does not mean that impacts will occur subsequently) is represented in Figure 3, and is composed of 3 blocks: physical and meteorological impacts, impacts on biodiversity & ecosystems and their services, socio-economic impacts:

Physical and meteorological impacts:

---

15 Dickinson, T. (2007):The Compendium of Adaptation Models for Climate Change: First Edition; Environment Canada, Adaptation and Impacts Research Division

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

17 www.adamproject.eu

18 SEC(2008) 3104

19 OECD, Economic Aspects of Adaptation to Climate Change - Costs Benefits and Policy Instruments; 2008, available at www.oecd.org/env/cc/adaptation

20 European Commission, 2008, The economics of ecosystems & biodiversity – an interim report, available at: http://ec.europa.eu/environment/nature/biodiversity/economics/pdf/teeb_report.pdf

– Depending on global scenarios, annual average temperature in Europe would increase between 1° and 5.5°C over the 21st century, with strong distributional pattern of warming across Europe (greatest warming predicted for Southern Europe and Arctic) and differences between summer and winter.

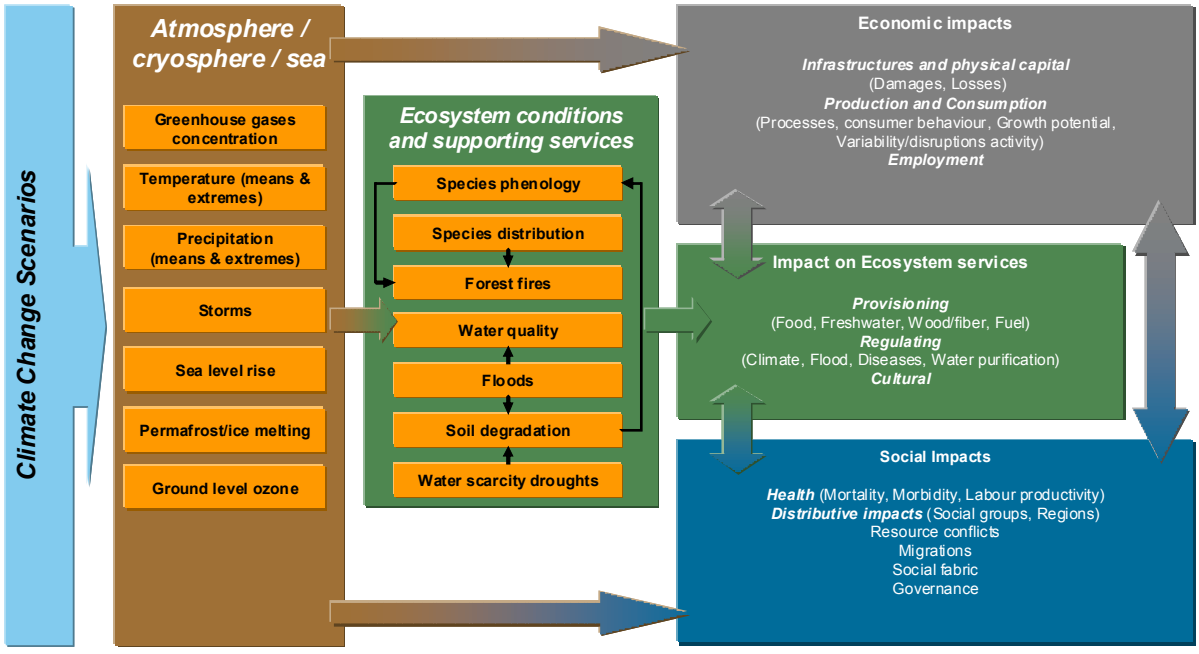
– Winter precipitation would increase in Northern Europe, summer precipitation would decrease in Southern Europe. There are still large uncertainties on the magnitude and geographical details of the change.

– Additional global sea level rise would be between 0.18 and 0.59m by 2100 (IPCC, 2007), although recent projections indicate a sea level rise that may exceed the IPCC upper limit.

– Extreme events are becoming more frequent and intensive even in the short term. Heavy precipitation events will become more frequent. Dry periods are projected to increase especially in Southern Europe. For Europe as a whole, heat waves are projected to increase in frequency, intensity and duration. Projections of future storminess are still very uncertain and model dependent.

– The decreases of European glaciers and snow cover are projected to continue, while the decrease of ice sheets in Greenland and the Arctic sea ice extent have accelerated the past years, although no reliable projections for the future can yet be made.

Figure 3 - Selected key potential impacts of Climate Change. Source: DG Environment based on (EEA, 2008), (OECD, 2008) and (TEEB, 2008). Potential impacts are all impacts that may occur given a projected change in climate, without considering adaptation.



These phenomena will, in turn, have a significant impact on European ecosystems conditions, and will lead to changes in ecosystems functions and services, upon which society depends. The effects of climate change exacerbate the impacts of already existing factors including pollution, land-use changes and resources over-exploitation, which may reduce the resilience of many ecosystems.

– Ecosystems play a direct role in climate regulation via physical, biological and chemical processes that control the fluxes of energy, water, and atmospheric constituents including greenhouse gases (for example the storage of carbon in peatlands and wetlands), and such services are likely to be affected. Terrestrial and marine ecosystems currently absorb roughly half of the anthropogenic CO2 emissions[21]. Continuing biodiversity loss and degradation of ecosystems may lead towards irreversible tipping points; Ecosystem "provisioning services" such as the production of food and materials, will also be affected, as will "regulating services such as flood protection, protection against soil erosion and nutrient re-cycling.

– Climate change will cause climatic zones to move, at a much faster rate than in the past. The potential distribution of European species is projected to shift by tens to hundreds of kilometres by the end of the century (depending on the scenario). There are also additional – and largely unknown effects – related to the incidence of pests and diseases establishing themselves in EU territory as the climatic conditions change. Of large concern is also the potential for abrupt change when thresholds are exceeded.

– Future changes in precipitation, combined with rising temperatures, will have impacts on water quality and quantity, affecting many sectors. The percentage area under high water stress in Europe is likely to increase from 19% today to 35% by the 2070s due to climate change (IPCC, 2007), Water quantity issues will be efficiently addressed only if the functioning of the water cycle is fully considered. Permanent vegetation has a positive impact on the regulation of evaporation and significantly helps maintain the thermal stability on land. A lack of water in soil and atmosphere leads to extreme thermal conditions. Soils saturated with water and permanent vegetation have a significant cooling effect and air-conditioning capability. Soils transformed and drained for human activities have more difficulty to absorb rainwater. Soil partially saturated with water can absorb water more efficiently than dried out soil

– Water quality will also be influenced by climate change. High water temperature, low water flows and lower dilution of pollutants may affect aquatic ecosystems, drinking water and water based recreation activities. Sea level rise may increase saline intrusion in coastal aquifers.

– Climate change also affects soil in a number of ways. This includes a potential decline in organic matter (and increased GHG emissions), knock-on effects on water run-off (and increased flooding risk), lower soil moisture (decreased water availability), increased erosion risk (increase in flood vulnerability), organic matter decline, and salinisation. These effects will disrupt soil function: biomass production and decomposition; storing, filtering and transforming nutrients, substances and water; acting as a biodiversity sink and loss of soil biodiversity.

A proper analysis of socio-economic impacts requires innovative assessment methods:

– The changes in ecosystem condition and services will affect the productivity and business continuity of ecosystem-dependant sectors such as agriculture, forestry, fisheries, tourism. Some sectoral forecasts are available from research projects such as FP6 PESETA or

[21] Canadell et al., 2007 Contributions to accelerating atmospheric CO2 growth from economic activity, carbon intensity and efficiency of natural sinks, PNAS, 104 (47) : 18866 – 18870

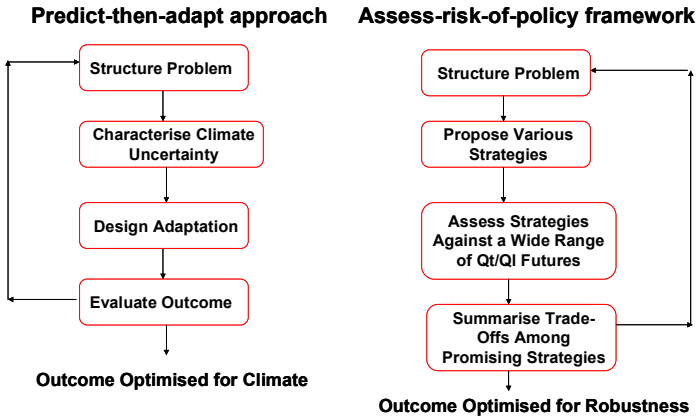
ADAM (See Annex 3), but they tend to be based on a limited set of parameters (e.g. for Agriculture, changes in hydrologic cycles, limits for the use of fertilizers and impacts of extreme events (storms, floods) have still to be included in the modelling). The direction of net changes in fisheries is unpredictable, and changes in energy and tourism depend very much on potential modifications in consumer behaviour. Direct impact of climatic changes and extreme events on infrastructures and buildings on the one hand, and health on the other hand, can be subject to monetary valuation subject to the definition of appropriate damage functions, but here again the potential of ecosystem services (flood regulation, local cooling, water purification, pest control) has to be taken into account.

– The increasing conflicting demand between different water and land users (agriculture, industry, and human consumption) will trigger negative social effects if there are no appropriate sustainable resource management measures in place.

2.1.4. Risk management, uncertainty and flexibility

Significant investment will be needed to tackle climate change impacts, and the need for long-term anticipation raise the question of efficiency of public spending: governments expect decisions to be based on the 'best possible' science. But the science of climate prediction is unlikely to fulfil the expectations of decision-makers and, through over-precision, could potentially lead to mal-adaptation if misinterpreted or used incorrectly. These epistemological limits to climate prediction should however not be interpreted as a limit to adaptation[22], and climate adaptation strategies can be developed in the face of deep uncertainties. Society will even benefit much more from a greater understanding of the vulnerability of climate-influenced decisions to large irreducible uncertainties than it will from extremely expensive attempts to increase the accuracy and precision of climate predictions. An alternative approach to the conventional one based on climate prediction would therefore focus on exploring how well strategies perform across wide ranges of assumptions and uncertainties (Robust Adaptation Decision-Making).

Figure 4 - Alternative approaches for uncertainty management (source Hulme, 2008)



Given the deep uncertainties associated with long term climate change impacts and other drivers of adaptation to climate change, robust decision making methods are worth exploring, especially where there is a large portfolio of adaptation options available. This context also

[22] Hulme M. (2008), "Is Climate Prediction a Limit to Adaptation?", Lecture at European Commission, 22 May 2008 - School of Environmental Sciences, University of East Anglia.

favours the implementation of a flexible or adaptive management, involving putting in place incremental adaptation options, rather than undertaking large-scale adaptation all at once. These measures are mainly preparations towards, or incremental introduction of, more costly or risky measures. They include the assessment of further adaptation measures that makes sense today, but as part of a sequence of responses that also allows for incremental or directional change in future, as vulnerability, knowledge, experience and technology evolve. This may also include delaying implementing specific (potentially harmful) adaptation measures while exploring options and building the necessary standards and regulatory environment.

2.1.5. Autonomous adaptation and the need for public intervention

Structural changes are a continuing process in all economies, societies and ecosystems, and climate change impacts will contribute to faster and more vigorous changes with corresponding challenges for ecosystems, population, economic agents and policy-makers. Adaptation is defined as any adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities (IPCC 2007).

Biodiversity & ecosystems may adapt autonomously, if other conditions are favourable as autonomous adaptation will be limited by land use, dispersal ability and the availability of suitable habitat. A hierarchy of species responses can be identified: behavioural responses (birds that stay longer in some areas, change their migration patterns or don't migrate at all), population dynamic responses, adaptive genetic responses, spatial responses and macro evolutionary responses.

Population and economic agents will also adapt to climate change autonomously without interference from a central authority, moderating the final impacts of climate change and also exploiting climate change "opportunities", although triggering another layer of economic, social and environmental impacts and shifting the climatic impacts to other social, economic or environmental compartments.

Natural system autonomous adaptation is obviously exclusively reactive, as well as most of human system (change/relocation in activity, reconstructions). However, there is room for anticipatory adaptation (e.g. crop diversification, insurance purchase, house design, etc.) which will depend very much on the level of information and perception of climate risks[23]. This triggers the need for action by public authorities to provide a level playing field for the information on climate vulnerability and on costs and benefits of adaptation options.

The need to develop adaptation strategies by central authorities first emerges under imperfect market conditions, such as when externalities appear, when the adaptation measure is a public good, when the transaction costs related to adaptation are large, or when information is imperfect.

– Climate change impact and some autonomous or planned adaptation actions will trigger additional **externalities** (pollution, water scarcity, floods, coastal erosion, etc.) for which

[23] AMICA (2005) Relation between Adaptation and Mitigation in Climate Change: AMICA - Adaptation and Mitigation - an Integrated Climate Policy Approach Thematic Working Group Flooding / Rivers / Water-balance in Urban Areas Kick off Meeting Dresden 7./8. Nov. 2005 Dr. Manfred Stock Potsdam Institute for Climate Impact Research

public intervention will be required for the further implementation of regulations or internalisation mechanisms. Conversely, adaptation options will often trigger the provision of **public goods**, for which a payment mechanism could be envisaged.

– Two factors seem to be of vital importance for the magnitude of the **transaction costs**. The first is the extent and character of the uncertainty about the impact of climate change, as uncertainty extends the room for diverging views and conflicts of interest among agents. The second factor relates to the fact that adaptation takes time, and substantial losses may accrue in the meantime.

– Regarding **information imperfections**, education and information campaigns may be needed to facilitate the switch to new production processes (e.g. drought-resistant species), whereas the use of current techniques (e.g. increased use of fertilizers) is likely to happen smoothly, without public intervention.

  – The degree of public intervention in adaptation strategy will also depend on **predefined responsibilities**, such as the public management of economic sectors, the degree of regulation and public financing, etc.

Autonomous adaptation will be mainly driven by a sectoral and short-term perspective. Planned adaptation measures will therefore be needed to provide a multi-sectoral approach aimed at improving the adaptive capacity of the natural and economic system and/or facilitating specific adaptations, often in a medium and long term perspective.

2.2. The need for indicators of vulnerability

2.2.1. Distributive aspects of vulnerability

The 4th IPPC Report and the Green Paper identified the most vulnerable geographic areas in Europe as: Southern Europe and the Mediterranean Basin, mountain areas, in particular the Alps, coastal zones, densely populated floodplains and the Arctic region, though this does not mean that other areas will not be vulnerable to the impacts of climate change. During 2007-2008 more work has emerged on potential impacts and economic effects of climate change in Europe (EEA 2008, EEA 2007[24]; FP6 PESETA) which is of particular relevance for this impact assessment. The studies show the projected changes in climate (including extremes), compounded by other environmental changes and socio-economic development. Many of the climate change impacts are projected to be adverse and to lead to economic costs ('losses'), though there will also be economic benefits (gains). The studies also show a strong distributional pattern of effects predicted across Europe, with a significant trend towards more negative potential effects in South-eastern Europe and the Mediterranean (e.g. in relation to energy demand, agricultural productivity, water availability, health effects, summer tourism, ecosystems, etc). In northern and Western Europe a more complex balance between negative and positive effects is projected for moderate levels of climate change. The Outermost Regions (ORs) and overseas countries and territories (OCTs) already experience severe climate change impacts, and are precursors for what might happen on the main land.

[24] Climate Change: the Cost of Inaction and the Cost of Adaptation. Technical Report 17/2007, available at http://reports.eea.europa.eu/technical_report_2007_13/en/Tech_report_13_2007.pdf

At sectoral level[25], the degree of adaptive capacity is uneven:

– The agricultural sector has a long record of adapting to climate variability. Adaptation measures will be mainly implemented at the farm level through short-term production decisions including adjustments in planting dates, crop mixes, or in the intensity of input use such as fertilizer or water abstraction. However, these decisions will be largely influenced by the economic environment including market conditions and public policies.

– External factors such as globalisation and demands for rationalisation and profitability are constraining the adaptive capacity in the forestry sector. There are significant differences across Europe in socio-economic conditions within the sector (e.g. ownership structure, workers education level) that will affect adaptive capacity.

– The fisheries and aquaculture industries need to develop their adaptive capacity even further in order to cope with new conditions. The demand for aquaculture may increase as a result of decreasing available fishing resources.

– In energy, southern European region will need to undertake more and more costly investments in electricity production. Throughout Europe there will be a need for increased investments in the distribution system to deal with disruptions due to extreme events and changing demand and supply localisation.

– In infrastructures & buildings, adaptation will require a strong degree of innovation in materials and design, bioclimatic buildings, climate proofing, reduction of energy consumption, integrated approach to spatial planning and location of infrastructure.

– For tourism & industry, adaptation will require changes in period of operation, relocation of activities, development of less climate-dependant supply chain. Insurance will have a great role to play in particular for SMEs. Adaptation will largely be autonomous, private and local, although public action may be needed to facilitate the reconversion of regions and economic activities impacted by climate change, to promote solutions favourable to both climate adaptation and to competitiveness, or to provide appropriate support for SMEs for managing climate risks properly.

– Regarding Health, much adaptation can be achieved in the context of pursuing wider development objectives—for example, improved health and education services.

– Regarding nature conservation measures to maintain diversity in and increase connectivity between nature conservation sites are necessary.

The impacts of climate change are likely to fall heaviest on the more vulnerable parts of society who spend a higher proportion of their disposable incomes on basic needs such as housing, energy and food. This will also have an impact on the social integration of migrants – both because environmental pressures (and in particular, the search for water) may drive migration into Europe from drought-hit areas; and on the other hand because once inside Europe, migrants form part of the vulnerable groups most at risk.

Adaptive capacity is often positively correlated with economic development, thus access to efficient adaptation is greater for high-income groups and richer areas, and less for the poor,

[25] See Annex 3 for more details

and such effects are often compounded by levels of awareness and access to information (as well as insurance).

For some particularly vulnerable groups, these issues overlap, and more adverse impacts may be expected in some regions with lower economic development (which is often related to lower adaptive capacity). Indeed, several studies have found strong distributional effects for vulnerability in Europe, e.g. in relation to health[26] or coastal flooding risk[27], where strong correlations between vulnerability and socio-economic status/social deprivation are founded. These inequalities are important in defining the baseline scenario, and in looking where planned adaptation policy might be needed, e.g. in relation to solidarity.

2.2.2. Measuring adaptive capacity

Adaptive capacity of ecosystems depends in their diversity and the availability of sufficient space. The greater the diversity the greater the chance, that traits are present which can cope with changing climatic conditions. Healthy ecosystems have a greater adaptive capacity than degraded ecosystems.

Adaptive capacity of human systems includes economic wealth, technology and infrastructure, information, knowledge and skills, institutions, equity and social capital. The vulnerability of a population is also believed to depend on population density, level of economic development, food availability, income level and distribution, local environmental conditions, pre-existing health status, and the quality of public health care[28].

Social and individual factors act as barriers to adaptation at both individual and collective decision-making levels[29]. There are various cognitive barriers to adaptation including, for example, the observation that vulnerable individuals perceive themselves to be powerless to act in the face of risk. At the policy level, adaptation policies, like many other areas of public policy, are constrained by inertia, cultures of risk denial, and other phenomena well known in policy sciences. These barriers are often not accounted for in programmes advocating technologically feasible, and apparently sustainable, adaptation. While lack of resources for the most vulnerable is often cited as a barrier to effective adaptation, other financial mechanisms and market failures reduce potential efficacy of adaptation. Uncertainty in impacts may lead to increasing upward pressure on insurance premiums and possible withdrawal of insurance cover in areas at risk from catastrophic impacts. Finally threats to undervalued cultures, lifestyles, icons and places may also represent limits to adaptation and need to be explored further.

---

[26] Menne, B., and Ebi, K.L. (eds) (2006) Climate change and adaptation strategies for human health. WHO (Europe).

[27] Environment Agency (2006). Addressing Environmental Inequalities: Flood Risk. SCHO0905BJOK-E-P Science Report: SC020061/SR1. Authors: Gordon Walker, Kate Burningham, Jane Fielding, Graham Smith, Diana Thrush, Helen Fay. Available at www.environment-agency.gov.uk

[28] World Health Organization (WHO, 2003), "Climate Change and Human Health – Risks and Responses", available at: http://www.who.int/globalchange/climate/en/ccSCREEN.pdf

[29] Hulme et al. (2007) Limits and barriers to adaptation: four propositions. Tyndall Centre for Climate Change Research - Briefing Note 20, July 2007, available at: http://tyndall.webapp1.uea.ac.uk/publications/briefing_notes/bn20.pdf

2.2.3. Towards a vulnerability index

Coarse estimates of vulnerability have been generated by combining some measures of exposure (e.g. sea level rise, change in average temperature and precipitation) and some measures of adaptive capacity under a scenario-based approach[30].

Besides the general need for more knowledge (research) on the adaptation subject, specific attention needs to be given to region-specific and applied research because concrete measures, financing and transfers take place at these levels. At present, there are only a few regions that know more or less what they have to expect in the future – but uncertainty is even higher due to lacking data and appropriate modelling.

Some work has also already been recently undertaken by DG Regional Policy[31] to present the Climate Change impacts in the form of a synthetic index, combining information on vulnerability to drought, population affected by river floods and exposed to coastal erosion, exposure to climate change of the agriculture, fisheries and tourism sector.

Work is already ongoing at DG Environment to assess the feasibility and provide options for the design of a (set of) vulnerability indicator(s), that could be used to help preparing EU-wide adaptation policy. It will require bringing together indicators at economic, social and environmental levels for different CC scenarios, available at sectoral and regional levels.

2.2.4. External dimension

The impacts of climate change beyond the EU are well documented although there are uncertainties related to the predictions. In IPCC 2007 information is now available across regions of the world concerning the nature of future impacts. Water resources, freshwater ecosystems and access to drinking water are expected to be negatively affected. In Africa alone between 75 million and 250 million people are projected to be exposed to increased water stress due to climate change. Ecosystems and biodiversity will also undergo major changes to their structure and function and regions, which will often lead to a deterioration of the provision of ecosystem services on which human livelihoods depend. The expected reductions in crop yields are expected to reduce agricultural production potential of developing countries, critically impacting food security. Rising sea levels will increase the relative vulnerability of coastal deltas, leading to in excess of 1 million people being potentially displaced from each of the three 3 larger global deltas (Nile, Ganges/Brahmaputra and Mekong). Climate change related impacts will also alter the geographic range and seasonality of certain vector-borne infections. Global security could also be threatened by climate change as a result of impacts on access to water and food. It will have huge economic costs, aggravating poverty, worsening health conditions, and potentially increase competition for the control of resources.

The EU, enlargement countries and ENP partners have a common strategic interest in further enhancing dialogue and cooperation on adaptation issues, as the area include some of the most vulnerable regions to climate change, where impacts are expected to range from increased water stress due to droughts and water scarcity, to degradation of soils, loss of arable land, flooding, salinisation and forest fires. This could lead to developments in the region which

---

30 ATEAM (Advanced Terrestrial Ecosystem Analysis and Modelling), project funded by the 5th Framework Programme, results available at http://www.pik-potsdam.de/ateam/ateam.html

31 http://ec.europa.eu/regional_policy/sources/docoffic/working/regions2020/index_en.htm

would negatively affect the EU's enlargement and ENP policies objectives of promoting an area of prosperity, stability and security.

Scientific evidence has shown however that it will be the poorest regions and countries in the world (particularly the least developed countries, Africa, and small island states[32]) that will be hit the earliest and hardest. Climate change is a serious challenge to poverty reduction in developing countries and threatens development policy achievements. The weakest countries will have most difficulties with adapting to climate change, which may lead to less growth, more forced migration and possibly radicalization and state failure causing internal and external security risks. Failure by the international community to appropriately address these tensions may undermine multilateralism. Climate change could lead to vast displacement of populations, including into regions close to Europe or EU ultra-peripheral regions. Parts of the Mediterranean region being both a neighbouring region and susceptible to the effects of climate change is particularly important in this respect.

2.3. Tackling insufficient knowledge and institutional weaknesses.

2.3.1. Review of national adaptation strategies

Most EU Member States are actively taking measures to mitigate climate change. Integration of climate change adaptation in policy making is more recent, but most Member States have already started to take action on adaptation. Moreover, Article 4 of the United Nations Framework Convention on Climate Change[33] to which the EU and all its Member States are parties, requires the formulation and implementation of national and, where appropriate, regional programmes containing measures for climate change mitigation and adaptation as well as the obligation to cooperate in preparing to adapt to the impacts of climate change.

In addition to the national communications to the UNFCCC, a number of Member States have recently produced national adaptation plans[34]. Most of the reports are still a preparatory step towards a concrete adaptation strategy. Some Member States are well advanced in their thinking on adaptation, with policies already in place while others are still at the phase of identifying the problems or debating the direction that their actions should take.

More specifically, the following can be concluded from the national communications:

- The majority of EU Member States have already implemented some kind of adaptation policy measures at national level, but there is also a large difference in progress among the countries. The overall state or level of adaptation is generally low (if compared to mitigation activities), and most countries have yet to formulate a wide range of clear and implementable policy measures

- As regards the aim of adaptation actions, four main categories could be identified: building adaptation capacity, reducing of risk and sensitivity, increasing capacity to extreme or damaging events and exploiting the benefits of climate change (capitalizing on climatic conditions). It has been observed that, for all countries, the objective of reducing risk is the one given the highest priority, but here again there are differences in approaches.

---

32 Some of them being part of EU (Ultra-peripheral regions)

33 See Commitments in paragraph 1 indents b and e,

34 See annex 4.

- The impacts of climate change vary regionally and every country has its own national priorities, the national adaptation strategies focus upon sectors of particular relevance and different countries consider different sectors. At the same time there are some sectors which hold importance in all reviewed strategies. Water management (in particular flood prevention) land use/agriculture and ecosystems are clearly considered to be a priority in the majority of strategies. Two diverging features are that biodiversity/ecosystems seems to be significantly more tackled in Northern Europe; whereas for Central Europe food production and security is the most targeted area. In all strategies, cross cutting themes are addressed, such as the need for awareness rising, the need for coordinated action at different levels and between Member States and coordinated research.

A recent review of National Adaptation Strategies[35] provides useful insights on the factors that have either contributed to or hampered the achievement of adaptation strategies. According to the study, political institutional problems may be a greater challenge then finding the appropriate technical solutions. The report also identifies important issues that should be taken into account for future developments. The cross-level or cross-sectoral conflicts, as well as the need to take into account the global dimension of adaptation problem, are areas for which EU contribution is essential.

Table 1 – SWOT analysis of National Adaptation Strategies (NAS) (Source:PEER, 2009)

	Contributing significantly to achieving the NAS objectives	**Hindering the achievement of the NAS objectives**
Related to historical conditions and institutional development of the NAS	**(STRENGTHS)** – Targeted research programmes – Planning for the implementation, monitoring and funding of adaptation – Planned coordination between sectors and administrative levels	**(WEAKNESSES)** – Lack of coordination between levels and sectors – Lack of adequate stakeholder involvement – Unclear responsibilities between administrative levels – Lack of context-specific adaptation knowledge
Related to current and future conditions and developments external to the NAS	**(OPPORTUNITIES)** – Development and export of knowledge – Spill-over of policy integration and multilevel governance for non-climate policies	**(THREATS)** – Cross-level conflicts – Cross-sectoral conflicts – Insufficient resources – Lack of public support – Impacts of global impacts (trade, migration, security)

The baseline scenario has to include these current national responses. Nevertheless, the Commission does not know all the actions already in place in the Member States at all levels, as there is no obligation to report to the Commission such initiatives. Moreover, the Commission has not found any ex-ante assessment of the envisaged benefits and impacts of the measures currently being implemented in the Member States, therefore the analysis in the baseline scenario can only be qualitative and quite general.

2.3.2. Adaptation at regional and local levels

Adaptation to climate change is complex because the severity of the impacts will vary from region to region, depending on physical vulnerability, the degree of socio-economic development, natural and human adaptive capacity, health services, and response mechanisms. To address this variability, multilevel governance is emerging involving all

[35] "Europe adapts to climate change: status of developing National Adaptation Strategies", Partnership for European Environmental Research, to be published in 2009 (PEER, 2009).

actors from the individual citizens and public authorities to the EU level. Actions to adapt to climate change will need to be taken at a very local level to match the specific conditions therein. Moreover, actions will be needed in areas where the competences lay with regional authorities. Therefore regions have a very significant role to play for adaptation to climate change.

Some regions or cities have already produced regional adaptation strategies; others are in the process of doing so. Still many regions would benefit from assistance for capacity building and best practice sharing. During the discussion of the Green Paper on adaptation, it was recognised that the lack of information, knowledge and expertise at local and regional level and the lack of guidance to the local and regional authorities is, in part, a consequence of the uncertainties as regards the scale, timing and consequences of climate change, and hinders policy-making.

This means that some co-ordination of regional and local adaptation initiatives at the EU-level may be necessary in order to avoid major gaps, to provide strategic direction and to ensure a comprehensive and coherent approach to adaptation across the EU, especially in situations with trans-national linkages. The lack of information, knowledge and expertise at local and regional level and the lack of guidance to the local and regional authorities may hinder access and use of available tools. In this area the EU could also play an important role, by developing methodologies for assessing the impact and designing cost-effective adaptation policies. Finally, in light of the climate change challenge, it is likely that local and regional authorities will have to bear the cost of developing and implementing adaptation strategies. A new context for solidarity and burden sharing will therefore emerge, and there will be the need for revising the framework for EU financial support to the regions to facilitate adaptation.

2.3.3. The need for early action at EU level: establishing priorities for the White Paper

In existing national adaptation plans it is recognised that coordination between Member States is needed, and benefits in approaching adaptation in an integrated, coordinated manner at EU level are recognised. Reasons for action at EU level are the following:

- Climate change will result in **trans-boundary impacts** and will require adaptation measures based on cooperation between different Member States, as well as appropriate coordination with relevant non-Member States. Climate change impacts with a trans-boundary nature can be for example forest fires, effects on migratory species, floods and infectious deceases. In addition, some adaptation measures may need to be taken in another Member State than the one who suffers the impacts and would reap the benefits; therefore there is a need for **coordination** at EU level. This could be the case for taking flood protection measures upstream, where they may be more (cost-) effective.

- Climate change will have different spatial effects and strong variability meaning that impacts across the EU could vary considerably. There is a need to ensure that **solidarity** is enshrined in the adaptation strategies, as it has to be ensured that he ones who are hit hardest by climate change will be able to adapt. **Cohesion policy** can further contribute to address the consequences of new disparities between those regions which suffer most from climate change and those that can more easily cope with its impacts. The rural development policy also contributes to a balanced territorial development of European rural areas, which socio-economic disparities could amplify due to uneven climatic effects on agricultural systems, forestry and rural economies.

- Adaptation action should not lead to a shift in the impacts or exacerbating the problem in another area, country, sector or social group. Such **mal-adaptation** is often best addressed at trans-boundary or European level. In particular, building water reservoirs, caputing groundwater or using techniques for ensuring precipitation will increase water availability in a certain area at the expenses of others, and may also not be the most effective long-term solution on a larger scale.

- Climate change will have strong impacts on sectors that are largely integrated at EU level through the **single market and common policies**. It makes sense to integrate adaptation goals into these policies (e.g. transport, energy networks, forestry, agriculture, water, biodiversity and fisheries). The lack of Community action could significantly damage Member States interests and could hinder the **internal market** (e.g. animal trade and infectious diseases). Coordinated action at EU level could overcome these disadvantages for taking action.

- Adaptation can be taken into account in **EU spending programmes** (e.g. cohesion, rural development, agriculture, fisheries, social fund, research, external actions and the European Development Fund) to complement the resources spent by the Members States.

- Due to the **scale of any activity at EU level**, actions can leverage greater results and magnify the efforts in capacity building, research, information and data gathering, knowledge transfer, exchange of best practice, development and cooperation. This will contribute greatly to a robust knowledge base for policy making at all administrative levels. Intensive exchange of best adaptation practices between Member States with comparable conditions, or further streamlining research efforts are clear-cut examples of this.

- As regards external action, the increased negotiating power of the EU, rather than individual Member States, may confer a **leading role to the EU** in adaptation in some sectors. Moreover, if climate change impacts have consequences for the EU economy, or the EU supply of critical goods (e.g. food, energy) as a whole there is a need for oversight and responsibility at EU level to complement the actions at national level.

2.3.4. The baseline scenario for assessing EU framework for adaptation

The baseline is dependent on several factors, being the implementation of the EU acquis, planned and existing policy instruments that address adaptation at national or regional level (like national adaptation strategies), and autonomous adaptation performed by ecosystems, social groups and economic sectors which will depend on their perception of climate risks and their adaptive capacity. At this stage the baseline is constrained to the short-medium term and is not linked to emission scenarios (which will also depend on the extent to which mitigation efforts are materialising and have a positive effect in limiting temperature increase). The baseline explores therefore the risks and opportunities under current EU legislative framework to highlight the need for additional early action:

– **Biodiversity**: The current Natura 2000 network establishment and management provisions in the Directives may not be sufficiently dynamic to respond to the rapid changes to ecosystems induced by climate change. The creation of ecological networks in fragmented landscapes needs to happen swiftly. Shifting bioclimatic zones do not respect borders, and Member States need to act in a co-ordinated manner, as otherwise actions by one Member State may be jeopardised by those of a neighbouring country. The inclusion of biodiversity

goals in other sectoral policies as advocated in the Biodiversity Action Plan[36] is indispensable to ensure the achievement of nature conservation goals under changing climatic conditions.

– **Water** is by nature trans-national and requires a coordinated approach within each river basin. Since 2000 water management the flagship for addressing water management at the (international) river basin level is the European Water Framework Directive, and the Floods Directive (2007) follows the same river basin approach to address flood risks. This offers a flexible framework for managing Europe's water, based on integrated water management. It also provides the principles to set up water demand management measures and effective economic instruments to use water resources efficiently, which is extremely important for areas where water might be scarcer due to a changing climate. The 6 years planning cycle provided by the Water Framework Directive offers the possibility to integrate climate change impacts. Full implementation of the Water Framework Directive is a priority in order to address mismanagement of water resources and is therefore a key tool for adaptation to climate change. Regarding water scarcity and droughts, the annual European assessment will make possible to monitor the evolution of the issue across Europe on a regular basis.

– **Soil** degradation can have trans-boundary consequences (losses of soil organic matter impair achievement of the EU's Kyoto Protocol targets, dams are blocked and infrastructure is damaged downstream by sediments from massive erosion further upstream, etc.). Therefore it is of outmost importance to act at source to prevent damage and subsequent remedial actions, otherwise costs to restore environmental quality may be borne by another Member State. The Commission adopted a Soil Thematic Strategy (COM(2006) 231) and the proposal for a Soil Framework Directive (COM(2006) 232), which would heavily contribute to this objective.

– The Common **Agriculture** Policy and its resources (both direct payments and rural development), as revised by the "Health Check", provide a framework that can facilitate climate adaptation and adjustment of agricultural practices at EU level. The challenge and opportunity for the EU and its Member States in the period up to the end of 2013 is to make the best possible use of the CAP tools available to support a sustainable adaptation and promote the role of ecosystem services.

– The EU **Forest** Action Plan is a framework for common action which proposes to encourage adaptation within the forestry sector, to enhance the protection of forests against forest fires and the increasing threat from extreme weather events, as well as other factors affecting their health; Support for the sector and the possibility for adaptation actions is provided by Rural Development.

– For **Fisheries and Aquaculture**, the integration of climate change concerns and the development of the adaptation strategies will take place through the reform of the Common Fisheries Policy (in 2012) and the adoption of the Aquaculture Strategy (in 2009).

– The Integrated **Maritime** Policy (which second phase of implementation will be prepared in 2010), the Integrated Coastal Zone Management (ICZM) and the Maritime Spatial

[36] Commission Staff Working Document SEC (2006) 621 Annex to the Commission Communication on "Halting the Loss of Biodiversity by 2010 – and beyond, sustaining ecosystems services for human wellbeing COM (2006) 216

Planning can play an important role in adaptation in maritime areas and coastal waters[37]. The Marine Strategy Framework Directive contributes to adaptation through reducing pressures placed on marine ecosystems so that the combined pressures do not push them to a point beyond which they are unable to recover.

– For **infrastructure, energy, industry or services** plans or projects, the Environmental Impact Assessment (EIA) Directive and the Strategic Environmental Assessment (SEA) Directive traditionally consider the impact of projects and policies on the environment. They will need to be updated to explicitly require the consideration of how changes in climate will affect the viability proposed projects and policies (e.g. facing a disruption of the hydrological cycle). Other guidelines, legislations or norms should also be reviewed to take climate change vulnerability into account, such as TEN guidelines, Directive 2002/91/EC on the energy performance of buildings, Eurocodes, etc.

– For **Health**, a recovery approach only dealing with heat waves and cold bites cases when they arrive, only deal with infectious diseases when the outbreaks occur (no preventive approach) is not sufficient in the long run. Human and Animal Health legislations, and surveillance mechanisms need to be updated to better enable the Community to adapt to the possibly changing patterns.

At a later stage, once integrated scenarios for adaptation and mitigation policies as suggested above become available, it will be possible to define the baseline under a further time horizon and review it regularly, once more information on mitigation agreements and achievements, climate change projections and impacts and implementation of adaptation actions at various levels becomes available.

2.3.5. Impact on EU finances

Private funding of adaptation measures will concentrate on economically interesting investments, whereas investors located in the most affected weaker regions and sectors will have difficulties to obtain appropriate funding for re-investment or risk coverage, and if so, only at relative high costs, deepening thus existing disparities or creating new ones.

For the other regions, public funds will remain the main source of assistance, in particular to compensate for damage and losses due to extreme weather events. In a number of regions, less populated and economically less performing, often located in areas that are particularly sensitive to climate change risks areas (coastal, mountainous), the costs to cover adaptation needs will be so huge that they exceed the capacity of public funding. In these regions, losses can take such massive dimensions also for the private sector that they raise eventually beyond the financial capacity of individual companies and businesses. Climate risks and the implementation of climate adjustment policies will accelerate the development of appropriate financial market instruments to finance longer term adaptation measures as well as to alleviate the burden of individual cost coverage and to promote efficient risk sharing (risk transfer instruments, catastrophe bonds, debt financing schemes, public/private equity funds). However, these funding instruments make clear distinctions between regions, sectors and industries which are affected adversely and those that benefit from new business opportunities. The competition for funds is expected to increase.

[37] COM (2008) 791

Moreover there is a pressing need to ensure that current and future investments done with EU funds are compatible with the alterations that climate change will bring about and prevent investments that will hinder our common efforts to mitigate and to adapt to climate change.

Therefore there is a need to assess, in the context of the preparation of the next multi-annual financial framework, how EU funding mechanisms can build-up further knowledge and support the Member States in their efforts to become more resilient to climate change impacts, thus ensuring the sustainability of Europe, while at the same time bearing in mind the need for additionality.

Equally the EU funds are likely to be called upon to support adaptation measures in a country who would not be the beneficiary of the positive effects of such measures and therefore may not be inclined to bear the costs (for instance anti flood measures to be taken in a Member State upstream to protect another Member State downstream).

However, the lack of an accepted methodology for identifying and classifying adaptation and adaptation-related projects for accounting and other purposes is not only required to have an overview of the EU's current expenditure on adaptation and adaptation-related projects but is also necessary to establish future funding needs. This triggers the need for agreeing a methodology for calculating the costs of adaptation, consistent with the work undertaken under the UNFCCC[38] or by the OECD[39].

[38] UNFCCC (2007) Background paper on "Analysis of existing and planned investment and financial flows relevant to the development of effective and appropriate international response to climate change" available at: http://unfccc.int/cooperation_and_support/financial_mechanism/items/4053.php

[39] OECD (2008) Draft OECD Guidelines on Integrating Climate Change adaptation into Development and Coo-operation. COM/ENV/EPOC/DCD/DAC(2008)2.

3. OBJECTIVES OF THE WHITE PAPER

3.1. General, specific and operational objectives

The general objective of adapting to climate change is to cope with unavoidable climate change and reduce the cost of climate change by both decreasing the vulnerability and enhancing the resilience of society, economy and environment to climate change impacts.

Taking into account the current knowledge on Climate change vulnerability and adaptation actions, and the specific institutional framework for the development of EU adaptation policy, as described in the previous chapter, the specific objective of this report are twofold:

– To highlight no-regret and win-win adaptation measures while identifying the risks of not sustainable adaptation practices

– To establish a work plan for action at EU level in the short and medium term.

Against that background, and providing an analytical correspondence with the key 3 problems identified, the operational objectives - that will have to be addressed by the instruments included in the action plan and further monitored - are threefold:

– Improve the knowledge base on CC vulnerability (impacts and adaptive capacity) and on the costs and benefits of adaptation options.

– Ensure early implementation of identified no regret and win-win measures and avoid mal-adaptation by mainstreaming adaptation in EU policies

– Put in place a process for a better co-ordination of adaptation policies and the assessment of next steps, including launching a debate for next multi-annual financial framework

3.2. Consistency with horizontal strategies

3.2.1. Sustainable Development and Lisbon Strategies

The long-term perspectives of both EU policy on Adaptation to Climate Change and EU Sustainable Development Strategy[40] (SDS) make the link between them obvious. This is also consistent across all priority areas of the SDS:

- Climate Change and Clean Energy: The strong potential synergies between CC adaptation and mitigation have been identified in the previous section, and convergences can be found in the building of a low carbon society which will target the most vulnerable segments of EU society and territory.

- Sustainable Transport: The review of the vulnerability of transport infrastructure and management systems will have to be included as a key element for the sustainability of transport activity.

[40] http://ec.europa.eu/sustainable/welcome/index_en.htm

- Sustainable Consumption and Production (SPC): a lower dependence on water, energy and resources is at the heart of ambitious adaptation policies. SPC policy instruments such as eco-design and labelling will need to include Climate Adaptation challenge and can help to the transition of production and consumption to a less vulnerable profile.

- Conservation and Management of Natural resources: The maintenance of biodiversity and ecosystems is essential for both ensuring their resilience to climate change impact and allowing the provision of ecosystem-based services ("green infrastructure") as adaptation options alternative to "grey infrastructure". Ecosystem-based services provide often multiple benefits including mitigation.

- Public Health: Adaptation policy should address new public health challenges. Preventive public health policies and the reduction of health inequalities are essential elements for decreasing the vulnerability of population.

- Social Inclusion, Demography and Migration. Building adaptive capacity should become an essential element of strategies for social protection and social inclusion. Moreover, Climate change may trigger substantial demographic challenges (migrations) which will have to be addressed.

Adaptation policy, through a better knowledge of impacts, may help to create support for Climate Change mitigation and energy efficiency policies, which is one of the 4 key priorities of the renewed **Lisbon Strategy**[41]. Decreasing the vulnerability of the economy, in particular SMEs which can be more affected e.g. by extreme weather events, is a key convergence area between Adaptation policy and Lisbon strategy. Actions on research & innovation and on investing in people will have to be targeted to a better knowledge of impacts at all levels, in decreasing vulnerability and increasing resilience of nature, economic and social systems.

An adaptation strategy must also be developed considering the Renewed Social Agenda[42], which is based on a holistic approach to social policy and which calls for better mainstreaming of employment and social policies into all EU policies.

3.2.2. External Policy

EU adaptation policy cannot be exclusively defined in the narrow focus of EU territory. International cooperation on adaptation should be strengthened through greater synergy between public and private actions and by promoting coherence amongst international processes and organisations.

The EU is committed to the UNFCCC process where work is being carried out, in the context of the Nairobi Five-year programme of work on impacts, vulnerability and adaptation to climate change (UNFCCC, 2006), the National Adaptation Plans of Actions (NAPAs) and the Bali Action Plan (UNFCCC, 2007). The Bali Action plan resulting from the most recent COP/MOP meetings (Conference and Meeting of the Parties, Dec. 2007) recognizes that adaptation will need to be explicitly included in a global post-2012 climate change agreement, currently being negotiated with the aim to reach an agreement in Copenhagen by the end of 2009 (UNFCCC COP15).

---

41 http://ec.europa.eu/growthandjobs/index_en.htm

42 COM (412) of 2 July 2008

In view of the availability of strong external instruments at EU level, adaptation should be mainstreamed in the EU's policies and co-operation programmes. Mainstreaming of climate change into cooperation and development strategies and programmes ("climate proofing") are imperative in this regard. The complexity and global nature of the adaptation challenge calls for additional focus to be put on the coherence of our policies to ensure they are mutually supportive and blend in the proper policy mix.

Adaptation should be mainstreamed into all EU's external policies. In trade policy adaptation should be incorporated, notably through the liberalisation of trade in environmental goods and services and in the elaboration of Free Trade Agreements (FTAs).

Progress towards the Millennium Development Goals (MDGs) will enhance countries' capacity to adapt to climate change. At the same time, however, the implications of climate change will significantly undermine progress towards the MDGs .It is therefore crucial for the EU's cooperation programmes and for third countries sustainable development, poverty alleviation and sectoral strategies to take into account climate change adaptation needs in order to ensure that progress towards the MDGs is sustained and sustainable.

Failed adaptation can lead to security implications. The EU is therefore also stepping up its analysis and early warning systems and integrating climate change into existing tools such as conflict prevention mechanisms and security sector reform. The effects of climate change on migratory flows should also be considered in the broader EU reflection on security, development and migration policies.

Enhancing the EU's dialogue and cooperation with neighbouring countries on adaptation issues is also in line with the aim of the Enlargement and European Neighbourhood policies to work closely with partners to promote prosperity, stability and security.

4. OPTIONS FOR ADAPTATION APPROACHES

In terms of adaptation approaches, choices have to be made about how to pursue adaptation policy further, and what should be the adaptation measures that should be either promoted or prevented.

4.1. Identification of planned adaptation options

Adaptation to climate change involves taking practical actions to either reduce vulnerability to climate risks (either through a reduction to the exposure to climate stress or an increase in adaptive capacity), or to exploit positive opportunities. There are numerous examples of typologies (OECD 2008).

It is out of the scope of this report to provide any detailed inventory and assessment of the adaptation options for each sector and region. Annex 1 provides detailed information on key adaptation options in each sector (both autonomous actions and those requiring public intervention). It is however possible to classify adaptation options in 3 broad categories based on the overall approach:

- **"Grey" infrastructure approaches**, corresponding to physical interventions or construction measures and using engineering services to make **buildings and infrastructure** essential for the social and economic well-being of society more capable of withstanding extreme events.
    - These approaches are focused on direct climate change impacts on infrastructure and buildings, such as changes in temperature and precipitations, floods, sea level rise, etc.
    - They target exercising a degree of control over the environmental threat itself (e.g. flood control works: dams, dikes, levees), or preventing the effects of climate change and variability (.g. increased irrigation water, air conditioning, etc.).
- **"Green" structure approaches**[43] are contributing to the increase of ecosystems resilience and, while addressing goals such as halting biodiversity loss, degradation of ecosystem or restoring water cycles, at the same time use the functions and services provided by the ecosystems to achieve a more costs effective and sometimes more feasible adaptation solution than relying solely on grey infrastructures alternatives. Increasing the resilience of green infrastructures therefore can be considered as synergy and no regret actions. Examples are:
    - Using the cooling capacity of trees and other biomass, in particular for densely populated urban spaces.
    - Preserving biodiversity and ecosystems including multiple groups performing similar functions for restoring and maintaining resilience. Integrated agricultural

[43] Healthy plants and animals & properly functioning natural processes such as water cycle, food chain, etc.: see Benedict (2006), Green infrastructure: linking landscapes and infrastructures / Mark A. Benedict, Edward T. McMahon. Island Press, 2006, 299 p. Available at: http--regserver.unfccc.int-seors-file_storage-1w5hqo976pnsiyq.pdf

systems with a diversity of crops and surrounding ecological zones can provide strong defences in the face of weather extremes, pest infestations and invasive species. Un-even, mixed species forests are more resistant to storms and pests and have a lower fire risk, compared to monocultures.

– Wetlands management, enabling plants and animals to survive and helping wetland-dependent communities to adapt to climate change, while at the same time providing through wetlands and salt marshes for natural barriers that allow managing increasing water flow, floods and storms over large areas.

– Improving infiltration and retention of water into the soil and progressing towards soil saturation helping the restoration of groundwater and surface water resources and therefore the development of permanent vegetation accompanied by cooler temperatures, contributing inter alia to mitigating climate change risks such as floods, droughts and heat waves.

- **"Soft" non-structural approaches**, corresponding to design and application of policies and procedures, and employing i.a. land-use controls, information dissemination, and economic incentives to reduce or prevent disaster vulnerability. They require more careful management of the underlying **human systems**. They include:

    - Economic instruments , which could play a particularly key role in adaptation (OECD 2008): insurance is a recurring instrument within the context of adaptive responses in a number of sectors, particularly agriculture; price signals and environmental markets, meanwhile, might be critical to adaptation within the context of many climate sensitive natural resources including water and ecosystems; public private partnerships, meanwhile, could potentially play a very critical role in the financing and enhancing the climate resilience of infrastructure, where the costs of adaptation are high.

    - Gathering and sharing information (undertaking research on new technologies, new methods of adaptation and positive feedbacks; collecting and monitoring data, communication education and training initiatives to increase awareness, buy-in and behavioural change);

    - Creating a supportive institutional framework (changing standards, legislation, and best practice guidance, and developing appropriate policies, plans and strategies);

    - Creating supportive social structures (changing internal organisational systems, developing resources to deliver the adaptation actions, and working in partnership).

4.2. Assessment of adaptation options

The 3 approaches all have to be part of any adaptation policy portfolio, therefore this report will not perform any choice between options. However, on the basis of the preliminary elements of assessment provided below, it is already possible to highlight priority early action on adaptation that should be undertaken because 1) they would generate net social and/or economic benefits irrespective of whether or not anthropogenic climate change occurs (otherwise known as "no regret" measures); or 2) because they have the desired result in

terms of minimising the climate risks or exploiting potential opportunities but also have other social, environmental or economic benefits ("win-win"). It is also possible to identify adaptation measures for which there are important risks of mal-adaptation.

4.2.1. Economic aspects of adaptation

Adaptation has an extremely important role in reducing economic costs of Climate Change. While adaptation has a cost, the information available shows that adaptation significantly reduces the costs of inaction and in many cases has benefits that dramatically outweigh costs. However, there is very little quantified information on the costs and benefits of adaptation, and further work is urgently needed to progress the evidence base, and provide the information needed to allow informed, cost-effective and proportionate adaptation in Europe. Annex 1 summarises the information on the potential costs of adaptation in Europe and globally, by looking at various studies, approaches, and estimates.

The burden of financing the reallocation of resources and new investment will not fall only on the private sector: involvement of the public sector will be needed, especially in the countries where the net economic impact of climate change is expected to be negative, and/or in specific areas such as infrastructure provision (water, flood control), public goods (to address public health risks and to facilitate adaptation in agriculture, forestry or tourism) and subsidies (to facilitate the relocation of population and activities)

Abrupt climate change impacts would entail more significant fiscal interventions to help the private sector to adapt and address the economic and social consequences that could arise. An in-depth scenario analysis will have to be performed to better understand how governments should tackle uncertainties and extreme events.

The assessment of costs and benefits of adaptation policies requires considering the full picture of both EU and national public intervention (CAP and cohesion policy funds, environmental, health and enterprise policies, etc.) and should consider how an inflexion or a reformulation of a broad range of policies may contribute to a more cost-effective, quicker and flexible adaptation.

A study on the fiscal implications of climate change adaptation has recently been launched by the Commission[44], and will assess the knowledge gaps and formulate key proposals in this area. Another study[45] on the economic costs of climate change adaptation policies in EU coastal areas will also provide detailed cost estimates over the coming months.

There is a need for early action when adapting to climate change, particularly in certain sectors. Early action will bring clear economic benefits by anticipating potential damages and minimizing threats to ecosystems, human health, economic development, property and infrastructure. Reactive adaptation, often after a disaster, is considered far more costly. In all sectors, early action is therefore needed to raise awareness for climate change impacts and build capacity for taking the necessary adaptation measures.

- Moreover, certain investments have a very long lifetime and will be fully operational when climate change impacts will fully materialise. For such investments, the current direction of climate change predictions should already play a role in decision-making now.

---

44 http://ec.europa.eu/economy_finance/procurements_grants/call4tenders12327_en.htm

45 http://ec.europa.eu/maritimeaffairs/climate_change_en.html

- Uncertainty in climate change projections sometimes makes it difficult to take early targeted action in all sectors. But in general, adaptation actions that can provide several benefits and are sustainable and cost effective in the current situation should be part of the "early action" approach.

4.2.2. Synergies and trade-offs with Climate Change Mitigation

There has been some focus in the literature (see Annex 1) on the need to define a policy mix between adaptation and mitigation. Indeed measures for adaptation must not hinder the efforts or hamper the achievement of the objectives on mitigation. However, there are numerous examples of measures that are significant and beneficial both for climate change mitigation and adaptation:

– Climate change adaptation and mitigation can come together in the planning of urban areas, notably in locations that are vulnerable to climate change. This would both limit energy use (and associated GHG emissions) and also reduce exposure to the possible negative consequences of climate change (heat waves, floods, etc.). Reduced air pollution as a side effect of climate policies can lead to lower health impacts and consequently higher resistance to climate stresses. The same applies to ecosystem vitality.

– Afforestation and reforestation enhance carbon sequestration and meanwhile may prevent erosion or flooding. However, the types of trees best suited to preventing flooding and protecting biodiversity may not be the most effective from a carbon sequestration point of view[46]. The IPCC report (2007), states that "in the long term a sustainable forest management strategy aimed at maintaining or increasing forest carbon stocks, while producing an annual sustained yield of timber, fibre or energy from the forest, will generate the largest sustained mitigation benefit".

– In the fisheries sector, there is potential for energy savings of up to 20% by improving vessel and gear design and operation. If this is combined with a reduction in fleet capacity, it will contribute to healthier stocks and therefore more climate resilient fish stocks.

– Conservation and sustainable use of biodiversity and ecosystems and the reduction of environmental pressures lead to healthy ecosystems, which are essential for any adaptation and mitigation strategy.

There can also be some trade-offs.

– Some technological adaptation options may trigger an increase in GHG emissions. Adaptation to changing hydrologic regimes and water availability will also require continuous additional energy input. Studies undertaken in the context of the follow-up of the Commission's 2007 Communication on Water scarcity and Droughts show that plugging the expected increase of the gap between supply and demand in some Mediterranean countries – if demand is not addressed – may increase their energy consumption by 15-50%. Other adaptation options, such as coastal protection infrastructure

[46] If, in order to take advantage of improved growing conditions in Northern Europe, the area of tillage land is increased this is likely to lead to a loss of soil carbon and hence emissions of CO_2. However, there may be opportunities to sequester carbon on degraded land or land in southern Europe, formerly used for crop production, on which due to lack of moisture crop production is no longer viable.

and additional cooling requirements also increase energy use, often with associated GHG emissions, and thus increase the need for mitigation.

– In the water sector, the development of hydropower facilities can reduce fossil-fuel-related energy use and reduce dependency on foreign energy imports. The associated water storage can also limit vulnerability to precipitation variability, and if properly designed, not significantly hampering the ecosystem functioning of the river. A high dependency on hydropower production in some regions can lead to an increase of the vulnerability to climate change due to decreased precipitations[47] (IPPC 2008).

– The use of forestry biomass contributes to mitigation by replacing fossil-intensive materials and energy. But there is need to harmonise this use with water availability, with the provision of non marketed ecosystem services (such as conservation of biodiversity and protection against avalanches or water pollution), and with maintaining the carbon pools.

In short, this recalls the need for an integrated assessment of mitigation and adaptation strategies. On the one hand, mitigation strategies (both energy and land-use) should fully integrate their vulnerability to climate change. On the other one, adaptation options (in particular "technological ones") deserve a careful assessment. This confirms the importance of integrated land and water management strategies to ensure the optimal allocation of scarce natural resources (land, water).

4.2.3. Environmental impacts

Climatic changes and autonomous and planned adaptation options may modify other environmental processes on agricultural land, which will need to be addressed in sustainability assessments. The diversity of vulnerability across EU-27 and sectors, and the scope for adaptation options can evidently not be addressed in the present document. There are however important aspects that need to be explored as soon as possible to design a sustainable adaptation policy, avoiding "mal-adaptation":

– Autonomous adaptation actions by farmers can counteract and even reverse some of the potential impacts of climate change which do not consider changes in agricultural management, technological progress and trends to better farming practices adaptation. However in some cases, autonomous adaptation options will also interfere with agri-environmental processes, and could lead to an increased use of pesticides to cope with more emerging and increasing pests, diseases and weeds, an increased use of mineral fertilisers[48] to compensate for a loss of soil fertility, an increase in irrigation, as well as in extreme cases land abandonment (when changes in climatic conditions or frequent extreme events difficult agricultural activity). Biotechnology developments, such as drought-resistant varieties requiring less water, or varieties requiring less fertiliser may offer a solution for some problems, but will have to be used under application of the EU regulatory framework.

---

47 IPCC (2008) Technical Paper on Climate Change and Water, April 2008, available at http://www.ipcc.ch/meetings/session28/doc13.pdf

48 The implications of climatic changes on use of fertilisers are very uncertain and will depend on the site-specific effects on agriculture. While fertilisation could increase following expectations of better yields (and the contrary), the shortening of crop cycle in parts of Europe may lead to a decrease of nitrogen fertilisers.

– Increased forest productivity in some regions, together with provisions for climate change mitigation (increased use of biomass as a renewable energy source) may increase the stress on non marketed vital services (such as conservation of biodiversity and protection against avalanches or water pollution). Lost forest ecosystem services (windbreaks, irrigation networks, large scale erosion protection, dams and dikes) will often be substituted by building grey infrastructures to replace, which may result in a mal-adaptation to be avoided.

– Autonomous adaptation consists in adapting to new and constantly changing conditions for fishing. This creates the risk of the development of unregulated fisheries and early measures need to be taken to manage emerging fisheries, which will results more cost-effective than try later to reverse over-fishing. The increased access in the Arctic due to reduced ice cover is a specific case of 'new' resources becoming available to fisheries which need specific mechanisms to distribute access.

– Adaptation of energy supply system to CC impact may trigger building new infrastructure for the protection of existing infrastructure, as well as building new power plants and distribution grid. These projects will have substantial environmental impacts, to be addressed under environmental impact assessment, and should be compared with alternative solutions such as energy efficiency improvement and infrastructure protection through green structural approach.

– Regional and local authorities may plan to support industry and services most affected e.g. by water or snow scarcity by financing investments in water supply or snow-making equipments, together with helping relocating activities in more favourable areas. Both categories of projects will have substantial environmental impacts, to be addressed under environmental impact assessment.

– Finally, the building of infrastructure to protect from sea level rise or floods, while ensuring that land use can be orderly planned, houses built and transport infrastructure maintained, tends to disturb the natural dynamic nature of coastal and river systems. Maintenance costs are high and the ecosystem services are negatively affected. Hence, we see in many countries a shift towards a more flexible approach, that works with the natural processes instead of against it. Examples are the now often used sand nourishments, buffer zones (setback lines) and managed realignment of the coast.

The assessment of adaptation strategies must take into account the potential of green infrastructures and compare it with the potential impact of more "traditional" adaptation measures. Moreover, green infrastructures serve multiple purposes (e.g. mountain forests are biodiversity rich, protect against erosion, filter the air, sequester carbon, increase water holding capacity, fulfil nature conservation goals and provide renewable raw materials). A good example is given by coastal or river protection: the building of infrastructure to protect from sea level rise or floods traditionally tends to reduce the flexibility of the coastline or of the river stream, so that land use can be orderly planned, houses built and transport infrastructure maintained.

4.2.4. The social impact of adaptation

Adaptation to climate change will be effective only when the adopted strategies seek to reduce the vulnerabilities of the various society groups, while strengthen capacity building and awareness for the most vulnerable groups. A strategy for adapting policies to climate

change can only succeed if it is perceived as socially fair, notably through its employment and distributive consequences, so that this does not lead to further social divisions. This raises the issue of whether planned adaptation should specifically try and target such groups, or apply distributional analysis to ensure equitable adaptation strategies.

The far reaching repercussions of climate change, often also considered as a "fundamental restructuring of our industrial society", and its expected enormous costs, can only be faced through a wider partnership which shares losses and profits. To facilitate meaningful involvement of social partners in adapting to climate change, the debate should be engaged over similar time perspectives. Social partners are generally interested in a much shorter time frame than those envisaged in the climate change debates. It would be helpful to provide a series of intermediate periods as stepping stones to deliver the desired objective in 50 to 100 years as a structure for future generations to build upon. A strategy for adapting to climate change has to be socially fair, notably through its employment and distributive consequences and to include a strong notion of the importance of human capital. "Human capital" comprises aspects ranging from awareness for the challenges linked with adaptation to climate change, starting from (pre-)school age, to very concrete training and qualification initiatives to make sure that Europe has the skills and competences to adapt to climate change.

4.2.5. Prioritizing adaptation measures

As mentioned above, the broad adaptation approaches are not mutually exclusive, they all have to be taken into account when defining a portfolio of measures for adaptation, having as an objective the sustainability of adaptation strategy. Adaptation options identified above will need to be further evaluated in terms of their contribution to risk mitigation or to increasing the resilience of system, as well as costs and ancillary benefits and technical feasibility.

There is however a range of options that deliver the required adaptation and which also minimise the risks associated with implementation even in the face of associated uncertainties. These options are normally referred to as no-regrets and win-win options, and should be identified and selected where possible.

At this stage this report is only able to present a preliminary assessment based on literature review and National Adaptation Strategies. Short term actions will allow a systematic assessment on costs and benefits, based on national/regional/sectoral assessments and modelling

(1) "No-regrets" options – adaptive measures whose socio-economic benefits exceed their costs whatever the extent of future climate change. Focusing on no-regrets options is particularly appropriate for the near term as they can deliver obvious and immediate benefits and can provide experience on which to build further assessments of climate risks and adaptation measures. Such measures will require investments but overall are at least cost neutral when the immediacy of the targeted risks and realised benefits are considered. Examples (with a potential EU dimension) include:

- Actions or activities directed at building adaptive capacity as part of an overall adaptive strategy;

- Actions where short-term benefits of adaptation justify early action, e.g. with respect to current climate variability (OECD 2008);

- Avoiding infrastructure development and building in high-risk areas (e.g. flood plains, water scarcity) when locating or re-locating[49];

- Improving preparedness and contingency planning to deal with risks (including climate);

(2) "Win-win" options – adaptation measures that have the desired result in terms of minimising the climate risks or exploiting potential opportunities but also have other social, environmental or economic benefits. Within the climate change context, win-win options are often associated with those measures or activities that address climate impacts but which also contribute to mitigation or other social and environmental objectives. These types of measures include those that are introduced primarily for reasons other than addressing climate risks, but also deliver the desired adaptation benefits. Examples include:

- The above mentioned measures providing synergies with mitigation policies (building design, urban planning, air pollutant emission abatement, reforestation, reduction in fisheries fleet capacity).

- Flood & coastal management that includes creating or re-establishing flood plains or salt marshes, which increase flood/sea level rise management capacity and support biodiversity and habitat conservation objectives;

- Improving the cooling capacity of building and in urban areas, while reducing soil sealing.

An impact assessment of short-listed win-win measures will need to be performed in the short term, to identify costs and benefits, including land use trade-offs, impacts on biodiversity, social impacts, etc.

5. OPTIONS FOR THE EU FRAMEWORK FOR ACTION

5.1. Identification of options for EU action

A broad range of instruments that can be implemented at EU level and cover the needs identified in section 2.3. has been examined, from the softer instruments to more prescriptive ones:

– Communication / Awareness raising / Capacity building

– Research and development (Innovation)

– Guidelines, governance and co-ordination

– Price signals, market -based instruments and private financing

[49] This includes upgrading of infrastructure with long lifetimes to reduce vulnerability. Even in the light of uncertainties it may be a better option to safeguard when investments have to be made anyway rather than to go ahead with business as usual and wait and see if potential threats materialise – and take a major write-off if they do and construct new less vulnerable infrastructure.

– EU Financing schemes

– New regulation and standards

A packaging according to the 3 operational objectives defined in Chapter 3 has been performed to define 5 sets, which will be used to build "strategic" options towards future EU adaptation policy.

Table 2 - Instruments screening for the selected option

<table>
<tr><td></td><td colspan="3">Operational objectives</td></tr>
<tr><td></td><td>#1: Improve the knowledge base on climate change impacts and adaptive capacity</td><td>#2: Ensure early implementation of no regret and win-win measures and avoid mal-adaptation</td><td>#3: Put in place a process for a better co-ordination of adaptation policies and the assessment of next steps</td></tr>
<tr><td>Communication / Awareness raising / Capacity building</td><td rowspan="3">Set #1 (knowledge base)</td><td>n/a</td><td>n/a</td></tr>
<tr><td>Research and development (Innovation)</td><td>n/a</td><td>n/a</td></tr>
<tr><td>Guidelines, governance and co-ordination</td><td rowspan="2">Set #2 (mainstreaming)</td><td>Set #5 (co-ordination)</td></tr>
<tr><td>New regulations and standards</td><td></td><td></td></tr>
<tr><td>Price signals and market - based instruments</td><td>n/a</td><td>Set #3 (risk management)</td><td>n/a</td></tr>
<tr><td>EU Financing schemes</td><td>n/a</td><td colspan="2">Set #4 (preliminary review EU financing schemes)</td></tr>
</table>

An important range for potential options was discarded at an early stage: it include any option <u>implying</u> substantial changes in EU financing schemes, which cannot be foreseen under current multi-annual financial framework, as well as any option implying pre-empting post 2013 multi-annual financial framework.

As a result, three main options for short-term action at EU level have been defined.

– **<u>Option A (Baseline)</u>**: this option would imply that the development of adaptation strategies is constrained to national level, while EU policies are unchanged.

– **Option B (<u>process towards an EU adaptation policy)</u>**. This option would imply that the findings of the present report are used as a way for the EU adaptation policy to enter a new phase of definition. Priority would be given to tapping the potential of on-going initiatives, in particular at national level or co-ordination and awareness raising actions, and to screen in detail the whole range of EU policies and instruments, while putting in place the "governance" of the EU adaptation policy as a way to monitor progress and lay the ground for future actions.

– **Option C (EU Adaptation Action Plan)** would complement the former, by giving priority to new legislative initiatives to promote sustainable adaptation actions in the areas identified in section 2.3. National and regional adaptation strategies would be revised and streamlined.

– Table 3 provides more details on the concrete instruments included in options B and C. More detail is provided in Annex 5.

Table 3 – Detail of instruments for strategic options for EU adaptation

Set of actions	Option B	Option C
#1 Improving the knowledge base on climate change impacts and adaptive capacity	1.1. Develop a consistent, comprehensive and regularly updated climate change and socio-economic scenarios (projection data) for analysis across Europe. 1.2. Build a structured information dataset to better understand the territorial and sectoral distribution of vulnerability to climate change impacts. 1.3. Set up a European wide Clearing House Mechanism (CHM) as a data repository and a platform for knowledge transfer. 1.4. Provide targeted awareness-raising, communication, education and training on climate change impacts and adaptation. 1.5. Cover knowledge gaps with 7th FP research projects, working upon analysis of climate change impacts at scales relevant to adaptation measures, identification of the limits to resilience, and investigation the potential of the ecosystem approach.	1.1. to 1.5. 1.6. Resort to Article 169 of the EC Treaty to streamline EU and national research agendas
#2 Mainstream Climate Change adaptation in EU sectoral policies	2.1. In order to address climate change impacts fully, systematic Climate Change Health Checks for the sectors affected need to be undertaken periodically to address how climate change impacts are integrated in all Community policy areas and legislation and vice versa. 2.2. Sectoral guidelines to integrate climate vulnerability considerations in the current policy and boost sustainable adaptation practices.	2.1, 2.2. 2.3. When a preliminary impact assessment, with a strong emphasis on the knowledge base and subsidiarity & proportionality issues, would conclude that a voluntary or a market based approach will not yield the desired benefits and improvements, introduce legally binding obligation or harmonised standards across EU to achieve the objective of guaranteeing the sustainability of Europe in the face of climate change.
#3 Financial Instruments for Risk management	3.1. Stimulate and support the insurance sector in the development of insurance schemes tailored to the needs of groups and sectors adaptation efforts to CC. 3.2. Establish EU wide guidelines for designing and implementing schemes for Payments for Ecosystem Services (PES) and for stimulating markets for these services (building-up the resilience of ecosystems & ecosystem-dependant economic sectors, financing adaptation measures based on green infrastructure).	3.1., 3.2.
#4 Funding of Adaptation Actions under the EU Instruments and addressing Climate Change adaptation needs under the EU Funds Review	4.1 Increase the awareness on climate change impacts of the partners dealing with the management of EU funded programmes; Increase uptake of adaptation actions under the current EU financing instruments (2007-2013): 4.2 Review the existing funding instruments to identify and improve their potential to be used for adressing climate change vulnerability; Include the climate change adaptation dimension in the Reporting on the use of EU funds 4.4. Prepare Long term funding: The forthcoming budget review could assess further the available options for future adaptation funding in the multi-	4.3. Climate proof National and EU public funded investment and condition the EU funding to an assessment of the climate impact on the proposed investment. 4.4.

Set of actions	Option B	Option C
	annual financial framework post 2013	
#5 Put in place a process for a better co-ordination of adaptation policies.	5.1. In order to improve the coordination of adaptation strategies in the EU, establish a new network of National Adaptation Focal Points linked to Eionet 5.2. Establish by 1 September 2009 an Impacts and Adaptation Steering Group (IASG) to strengthen co-operation on adaptation. 5.3 Encourage the development of National and/or Regional Adaptation Strategies by all Member States by 2012, and provide guidance for their preparation (or possible review).	5.1, 5.2 and 5.3. 5.4 Establish an EU legal framework for Adaptation Strategies, with strict deadlines and procedures and within that a Management Committee with executive powers to evaluate and assess the plans and to make recommendations to the Member States.

5.2. Assessment of options for short-term EU action

This section provides a proportionate assessment of the identified options, according to a set of specific criteria. The first three reflect the operational objectives, and compare with the reference scenario:

- How does the option improve the knowledge base on climate change impacts and adaptive capacity?
- How does it ensure early implementation of no regret and win-win measures and avoid mal-adaptation
- Does the option help to put in place a process for a better co-ordination of adaptation policies and the assessment of next steps?

In addition, the following screening criteria are reviewed for each option:

- **Subsidiarity**: Does the option focus on trans-national aspects of climate change vulnerability or adaptation, better tackled at EU level under the current Treaty? Do the corresponding EU policy instruments not go beyond what is necessary to achieve the objectives? Can we demonstrate that the common objectives can be better achieved by the Community action?
- **Knowledge base**: Is this option based on a sound knowledge base and on scientific evidence? Which preparatory actions should be foreseen? Will a detailed impact assessment be needed at a later stage?
- **Synergies, trade off and resources**: is this option a pre-requisite for further action? Are there any alternative, or trade-off identified at this stage? Would the option need a substantial reallocation of resources or additional funding?

Table 4 - Assessment of options for EU action

	Option B	Option C
Operational Objective #1: Improve the **knowledge base** on	J All these actions contribute to the improvement of the knowledge base needed for an effective implementation of the other sets of options. They will provide an	J Same as option B

	Option B	Option C
climate change impacts and adaptive capacity	acceleration and better focus of the on-going research activities, and build synergies and economies of scale between currently fragmented on-going or planned actions.	
Operational Objective #2: Ensure **early implementation** of no regret and win-win measures and avoid mal-adaptation	K The proposed system for monitoring and reporting on climate change impacts will help in gathering further knowledge irrespective of the impacts of climate change. Through the capacity building the cases for mal-adaptation practices will be flagged.	J The option strengthens aspects of water savings, energy efficiency and protection of ecosystem services which would have positive effects on the overall use of natural resources in Europe irrespective of the effects of climate change. The streamlining or EU and national research agendas will allow to prevent further cases of mal-adaptation.
Operational Objective #3: Put in place a process for a better **co-ordination** of adaptation policies and the assessment of next steps	J Under the current situation, as detailed in the Problem Definition section, this option provides an adequate mix between the need for a strategic vision to develop an EU adaptation policy and the need for a flexible and responsive choice of policy priorities; it seeks to put in place the foundations on which to build future adaptation actions at various levels, while making the most of existing initiatives and insisting on good delivery and enforcement	K This option would provide a strong political impetus to the EU adaptation policy, but such a top-down, legalistic approach would run the risk of an institutional and administrative stalemate, and would not allow developing an impact-driven and flexible approach to policy-making.
Screening criteria #1: Subsidiarity screening criteria	J Capacity building, exchange of information and guidelines will not interfere with the competences of Member States, and the EU would have a coordinating role. No hard measures are proposed but rather integration of adaptation concerns in other policies	K Some of the new legislation envisaged under this option address clear trans-boundary effects of climate change or adaptation policies as identified in Chapter 2, nevertheless a thorough subsidiarity analysis would be needed for the provisions therein.
Screening criteria #2: Knowledge basis screening criteria	J All actions included in this options can be undertaken with the adequate level of information.	L The problem definition has highlighted the current level of uncertainty on the vulnerability to CC impacts and on the costs and benefits of adaptation measures. In such a context, it is increasingly difficult to set out in advance a definitive blueprint for action. The case for action at EU level (e.g. for land-use or forestry) needs to be assessed in a more systematic way, and a wide range of adaptation actions is of national or local competence.
Screening criteria #3: Synergies, trade off and resources criteria	J All actions included in this options can be undertaken under current budget framework, and will not require additional funding.	K The actions included in the Option C would have to be subject to an impact assessment.

Options B provides a clear improvement against the Baseline for 2 out of 3 Operational objectives, as it falls short in ensuring early implementation of no regret and win-win measures and avoid mal-adaptation. Option C also does not provide a clear improvement with regard to the third operational objective (Put in place a process for a better co-ordination of adaptation policies and the assessment of next steps) as it triggers important risks from an institutional perspective and would not allow developing an impact-driven and flexible approach to policy-making. On that basis, the screening criteria are essential for guiding the selection of options, and the 2nd screening criteria (knowledge basis) is determinant for

preferring option B at this stage, as the problem definition has highlighted the current level of uncertainty on the vulnerability to CC impacts and on the costs and benefits of most of the adaptation measures envisaged under Option C.

5.3. Conclusions: towards an EU adaptation Strategy

The selected option B correspond to short-term building blocks (up to 2012) for building an EU framework for action: the package starts with the current state of implementation of EU acquis (including ongoing initiatives that have not yet achieved their objectives) and the development of adaptation strategies and corresponding actions by the EU Member States driven from their obligation under the UNFCCC. It assumes that autonomous or MS guided adaptation actions will take place, and proposes the use of certain soft instrument and support actions that in the short term can provide some support to adaptation and create EU value added for the actions. At this stage the main objective would be to raise awareness of the problem at all administrative levels and in all sectors, therefore the majority of the actions correspond to capacity and awareness building and communication of the issue to the major stakeholders and sectors; in addition this option calls for enhanced efforts in research so to develop further the knowledge needed for proposing specialised actions at national, regional or local level and to build proper responses from economy and society. It should be noted that these capacity building and awareness raising actions should continue on the longer term as well.

Option C is not formally discarded, as the measures included in this option may be needed at some stage. But preparations for these include a precise assessment of:

– The potential of overarching land use/management, biodiversity and water related measures to strengthen climate resilience of the EU.

– The need for measures to prevent or mitigate effects of climate related disasters, targeting the most vulnerable sectors, areas and social groups.

– The investment needs in the public and private sectors in relation to energy, transport, water and flood protection infrastructure.

– The needs for adaptation investments in developing countries.

6. MONITORING AND EVALUATION

6.1. Development of adaptation indicators

There is need to look towards developing adaptation indicators, that will effectively provide feedback on how well policies and actions are tackling the problems, evaluate their adequacy, efficiency and flexibility and that will assist the Commission in reporting on the progress made, while helping any future modifications and policy adaptation needed.

As a first step a set of process-based indicators (monitoring progress in implementing adaptation measures) could be set up to assess the progress across the 3 operational objectives defined in chapter 3:

– Degree of mainstreaming adaptation in EU policies

– Progress on the knowledge base on climate change vulnerability and on the costs and benefits of adaptation options.

– Progress in the co-ordination of adaptation policies.

At a later stage, once more comprehensive information become available, a set of outcome-based indicators (i.e. measuring the effectiveness of adaptation policies) can be defined, which will help identifying the degree of implementation of no regret and win-win measures, as well as the risks of mal-adaptation.

These adaptation indicators would complement the Climate Change Vulnerability Indicators that will be developed as part of the actions included in the selected option.

Work has started at DG Environment and at the European Environmental Agency[50] for the development of adaptation indicators, which faces a number of complex challenges: clear objectives will have to be set for both their adaptation policies and their evaluation efforts. Initial practical solutions can be formulated by capitalising on links and overlaps with existing monitoring frameworks in climate-sensitive sectors.

The benefits of developing indicators to monitor adaptation are considerable:

– They provide a framework with potential to develop links across sectors and at all levels through which to monitor and evaluate policy goals and outcomes.

– They provide a means to communicate with wider stakeholders.

– They are an essential step towards mainstreaming adaptation through links with related indicators (e.g. sustainable development).

The European Environment Agency, the Commission's Joint Research Centre and the World Health Organization have a role to continue and expand their work in environmental monitoring across Europe. However, indicators of climate impacts extend beyond the environmental sector, and the development of indicators therefore needs to take place in close collaboration with other key (international) organisations as well. Appropriate research and development will be required, in tandem with support processes (such as networks and training) to enable the adoption of indicator sets. Further investments in ICT tools such as integrated databases and models in the scope of monitoring of the adaptation progress should be made, and the proposed Clearinghouse Mechanism plays an essential role in this area.

6.2. Reporting on adaptation

The process of adaptation to climate change increasingly moves into the policy cycles of national and regional governments in Europe. There will be an ongoing need for having readily available information on adaptation activities, including a quality control mechanism, which can be made publicly available to facilitate the exchange of knowledge and good practices. In addition, the sharing of information on adaptation measures at different levels is needed to coordinate between these levels.

---

[50] European Topic Centre on Air and Climate Change (ETC/ACC), Climate change vulnerability and adaptation indicators, Technical Paper 2008/9, December 2008, available at: http://air-climate.eionet.europa.eu/docs/ETCACC_TP_2008_9_CCvuln_adapt_indicators.pdf

Taking as a basis the proposal of several European Environment Protection Agencies in May 2008, the following elements for the reporting framework can be identified:

- **Reporting on the existing adaptation plans and/or strategies, or those in preparation.** This should include providing information on when such plans were developed or are expected to be developed, as well as their objectives.

- **Reporting on the institutional and legal framework for adaptation activities.** This should include providing information on which public authorities have been given the mandate to undertake climate change adaptation activities. It should also include providing information on any regulatory measures that facilitate climate change adaptation activities.

- **Reporting on key climatic vulnerabilities,** based on risk assessments, for instance, by region and sector.

- **Reporting on research programmes and databases** that address climate change adaptation and risk assessments.

- **Reporting on policies and measures** that are undertaken as adaptation activities (both implemented and proposed).

- **Reporting on joint activities** with other Member States and developing countries, including joint implementation of measures, research activities or agreements.

To achieve an efficient reporting mechanism and avoid duplication, a standardised and harmonised reporting framework would be needed, including a European wide agreement on definitions and key adaptation indicators. A reporting mechanism on adaptation needs to be further elaborated and discussed with the relevant players, as it has to be coordinated with the development of the Shared Environmental Information System (SEIS) and the proposed Clearing House Mechanism (CHM) on Adaptation which will contain the most up-to-date and state-of-the-art information and will be both easily accessible and useful for policy activities at different levels.

It needs to be explored how it will be linked to the ongoing efforts to develop the Water Information System for Europe, a European Drought Observatory and a European Marine Observation and Data Network, and other European Environmental Data Centres.

A reporting framework is important and needs not be overly complicated; duplication of work should be avoided by building upon other reporting obligations, such as those under the Article 4 of UNFCCC[51]. In addition, at COP15 in Copenhagen (2009), the UNFCCC may agree on a comprehensive Framework for Action on Adaptation (FAA). This FAA is also

[51] Under this convention, a national communication needs to be submitted, including information on the expected impacts of climate change and an outline of the action taken to implement Article 4.1(b) and (e) of the convention with regard to adaptation. Parties are encouraged to use the Intergovernmental Panel on Climate Change (IPCC) Technical Guidelines for Assessing Climate Change Impacts and Adaptations and the United Nations Environment Programme (UNEP) Handbook on Methods for Climate Change Impacts Assessment and Adaptation Strategies. Parties may refer, inter alia, to integrated plans for coastal zone management, water resources and agriculture. Parties may also report on specific results of scientific research in the field of vulnerability assessment and adaptation. The signatory countries have to submit their reports by 1.1.2010. The reporting cycle is every 4 years

looking to advance further on the issue of monitoring, reporting and verification of the effectiveness of adaptation measures.

A harmonised approach could reduce the administrative burden and the uncertainties involved. Furthermore, it is important to build on the competences already present in European statistical offices, including Eurostat.

An annual report will be presented at the proposed Steering Group on Impacts and Adaptation. The first report will be issued in Spring 2010 and will i.e. take stock of how the outcome of COP-15 influence the scale of the need for adaptation, or the results of studies or research projects that were not available for the present Impact Assessment report.

7. APPENDIX

7.1. Support documents and References

This Impact Assessment report is based on two key documents: the 4th Assessment Report of the Intergovernmental Panel on Climate Change (IPCC, 2007) and the EEA/JRC/WHO report 'Impacts of Europe's changing climate' (EEA, 2008). Other sources are quoted in footnotes. The analysis is also based on a large number of research projects, mainly funded by the 5th and 6th EU Research Framework:

- the FP5 PRUDENCE (http://prudence.dmi.dk/) and FP6 ENSEMBLES (http://ensembles-eu.metoffice.com) projects have provided a better knowledge of the earth-climate system and climate change forecasts at regional levels, including uncertainties (high-resolution climate change scenarios for 2071-2100 for Europe using an array of climate and impact models).

- Effects on health, in particular of heat waves, have been studied in the framework of the cCASHh (Climate change and adaptation strategies for human health, http://www.euro.who.int/ccashh), PHEWE (Assessment and prevention of acute health effects of weather conditions in Europe) and INTARESE ((Integrated Assessment of Health Risks of environmental stressors in Europe) projects. The mid-term review of the European Environment and Health Action Plan (2004-2010) carried out in 2007 has also proposed health impacts of climate change as one of the research priorities.

- An in-depth assessment of the impacts has been performed on sectors like agriculture and water resources (CECILIA, http://www.cecilia-eu.org/) and vulnerability of ecosystems services (ATEAM, http://www.pik-potsdam.de/ateam/), and impacts and adaptation for the coastal sector (DINAS-COAST - Dynamic and Interactive Assessment of National, Regional and Global Vulnerability of Coastal Zones to Climate Change and Sea Level Rise, www.dinas-coast.net/).

- Regional integrated assessment studies on impacts and adaptation (e.g. CIRCE, Climate Change and Impact Research: Mediterranean Region (see http://www.circeproject.eu), or ASTRA - Developing Policies & Adaptation Strategies to Climate Change in the Baltic Sea Region (see http://www.astra-project.org/).

- Improvement of management practices as reflected by the NeWater project (http://www.newater.info), focusing on challenges of water management.

- Assessing the policy options for mitigation and adaptation policy for Europe (ADAM, see http://www.adamproject.eu/), including consideration of the role of adaptation in public policy, European country adaptation policy review and sector based assessment of adaptation decision making in practice.

- Global dimension of climate change and adaptation, studying strategies outside Europe through projects such as AMMA (http://www.amma-eu.org).

- The PESETA (http://peseta.jrc.ec.europa.eu/index.html) project, led by the JRC, has undertaken a multi-sector analysis of the impacts and economic costs of climate change in

Europe, and adaptation responses, as well as other JRC work progressing flood hazards and fire risk.

– The ALARM project (see http://www.alarmproject.net) "Assessing Large Scale Environmental Risks" provides models and maps on climate change impacts and models for various policy scenarios.

– The MACIS project (see http://www.macis-project.net/links.html) on "Minimisation of and Adaptation to climate change impacts on biodiversity" is to deliver – amongst other - an assessment of proposed climate change adaptation and mitigation measures.

– The COCONUT project (see http://coconut-project.net/objectives.html) "Understanding effects of land-use changes on ecosystems to halt biodiversity loss due to habitat destruction, fragmentation and degradation" is to deliver - amongst other – a report on GIS database and identification of threatened habitats and land-use projections for the EU 25.

– PICCMAT, a coordination and support action on mitigation of agricultural impact on climate changes (http://www.climatechangeintelligence.baastel.be/piccmat/index.php).

– ADAGIO (ending in June 2009), a coordination and support action on adaptation of agriculture to climate change (http://www.adagio-eu.org/)

– Adaptation response across Member States must be informed by a coherent body of research and it is CIRCLE´s prime objective (see http://www.circle-era.net) to contribute to such efforts by aligning national research programmes. This process will be a strong support for the overall goal: Implementing a European Research Area (ERA) for the field of climate change.

7.2. 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 are 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 assessment:** The practice of identifying options to adapt to climate change and evaluating them in terms of criteria such as availability, benefits, costs, effectiveness, efficiency and feasibility.
    - **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 policy framework/guidelines** - a structured process for developing adaptation strategies, policies, and measures to enhance and ensure human development in the face of climate change, including climate variability. The adaptation policy framework is designed to link climate change adaptation to sustainable development and other global environmental issues (UNDP, 2004[52]).
- **Baseline/reference:** The baseline (or reference) is the state against which change is measured. It might be a 'current baseline', in which case it represents observable, present-day conditions. It might also be a 'future baseline', which is a projected future set of conditions excluding the driving factor of interest. Alternative interpretations of the reference conditions can give rise to multiple baselines.(IPCC, 2007)

---

[52] United Nations Development Programme on behalf of the Global Environment Facility, Adaptation Policy Frameworks (APF) for Climate Change: Developing Strategies, Policies and Measures, available at http://www.undp.org/climatechange/adapt/

– **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, managerial) that are needed before adaptation actions can be undertaken[53]

– **Clearinghouse**: In common language the term 'clearinghouse' refers to 'a central agency or entity for collecting and giving out information'. A Data Clearinghouse is an organization or an organisational framework that acquires, maintains, and distributes data or provides information services about data for many different data users. Such an organization may also integrate the data, generate the data, or perform other types of data processing functions.

– **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)

– **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 approach:** The ecosystem approach is a strategy for the integrated management of land, water and living resources that promotes conservation and sustainable use in an equitable way. An ecosystem approach is based on the application of appropriate scientific methodologies focused on levels of biological organisation, which encompass the essential structure, processes, functions and interactions among organisms and their environment. It recognises that humans, with their cultural diversity, are an integral component of many ecosystems. The ecosystem approach requires adaptive management to deal with the complex and dynamic nature of ecosystems and the absence of complete knowledge or understanding of their functioning. Priority targets are conservation of biodiversity and of the ecosystem structure and functioning, in order to maintain ecosystem services. (IPCC, 2007)

---

[53] 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

- **Ecosystem services:** Ecological processes or functions having monetary or non-monetary value to individuals or society at large. There are (i) supporting services such as productivity or biodiversity maintenance, (ii) provisioning services such as food, fibre, or fish, (iii) regulating services such as climate regulation or carbon sequestration, and (iv)cultural services such as tourism or spiritual and aesthetic appreciation. (IPCC, 2007)

- **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).

- **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).

- **Human system:** Any system in which human organisations play a major role. Often, but not always, the term is synonymous with 'society' or 'social system' e.g., agricultural system, political system, technological system, economic system; all are human systems in the sense applied in the AR4. (IPCC, 2007)

- **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 to assess 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 to assess 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 to assess the actual need for public intervention for a specific sector or area

- **Indicators:** quantitative or qualitative parameters that provide a basis for assessing change, they are logically tied to stated policy goals and chart progress towards policy targets.

    - **Index / indices:** An aggregate indicator. An index combines several observable variables into one.

    - **Vulnerability Indicators**: An observable variable that provides some indication of the possible future harm a system of interest is facing

    - **Adaptation indicators**: A measure of progress towards the implementation of adaptation measures (process-based) or a measure of effectiveness of adaptation policies and activities in general (EEA, 2008)

– **Infrastructure:** The basic equipment, utilities, productive enterprises, installations and services essential for the development, operation and growth of an organisation, city or nation. (IPCC, 2007)

– **Large-scale singularities:** Abrupt and dramatic changes in the state of given systems, in response to gradual changes in driving forces. For example, a gradual increase in atmospheric greenhouse gas concentrations may lead to such large-scale singularities as slowdown or collapse of the thermohaline circulation or collapse of the West Antarctic ice sheet. The occurrence, magnitude, and timing of large-scale singularities are difficult to predict. (IPCC, 2007)

– **Likelihood** – See probability

– **Measure**: Technologies, processes, and practices that reduce GHG emissions or effects below anticipated future levels. Examples of measures are renewable energy technologies, waste minimization processes and public transport commuting practices (EEA, 2008).

– **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)

– **"No regrets" policy:** A policy that would generate net social and/or economic benefits irrespective of whether or not anthropogenic climate change occurs. (IPCC, 2007)

– **Opportunity costs:** The cost of an economic activity forgone through the choice of another activity. (IPCC, 2007)

– **Policies:** Objectives, together with the means of implementation. In an adaptation context, a policy objective might be drawn from the overall policy goals of the country – for instance, the maintenance or strengthening of food security. Ways to achieve this objective might include, e.g., farmer advice and information services, seasonal climate forecasting and incentives for development of irrigation systems (UNDP, 2004).

– **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).

– **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[54]. Some climate change glossaries consider vulnerability a part of risk, for example the UNDP guidance

[54] 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

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)

- **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).

- **Strategy**: A broad plan of action that is implemented through policies and measures (UNDP, 2004).

    - Strategy to adapt to climate change: A general plan of action for addressing the impacts of climate change, including climate variability and extremes. It may include a mix of policies and measures, selected to meet the overarching objective of reducing the country's vulnerability. Depending on the circumstances, the strategy can be comprehensive at a national level, addressing adaptation across sectors, regions and vulnerable populations, or it can be more limited, focusing on just one or two sectors or regions (UNDP, 2004).

    - Existing strategies (this project)– procedures that are formally adopted by governmental bodies, in form of plans of action or formally adopted processes.

- **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).

7.3. Results of consultation on the Green Paper

In 2007 the European Commission published the Green Paper COM (2007)354 'Adapting to climate change in Europe – Options for EU action.' This sets out the challenges which are faced and proposes a way in which the EU can tackle adaptation. The challenges of climate change are two-fold. Action is being taken to reduce the emissions of greenhouses gases that are responsible for the global warming observed in recent decades but some impacts are now unavoidable. Action must be taken to ensure that Europe is well adapted for the challenges our changing climate poses.

The Green Paper has since been widely consulted upon. A major conference launching the public debate on adaptation in Europe took place in Brussels on 3 July 2007. A web-based public consultation was open from end of July 2007 until end of November 2007. Four regional workshops took place in Finland, Portugal, UK and Hungary during the autumn of 2007. The public consultation undertaken to date indicates that there is widespread support for the Green Paper and the need for urgent action on climate change adaptation. Responses to the twenty eight questions outlined in the body of the Green Paper provide further insight into specific policy and economic tools that the European Commission could choose to outline in the eventual White Paper.

The questions set out in the Green Paper consider the impacts of climate change and the areas which should be considered as a priority for action, reflecting on the different roles of the EU, national, regional, local authorities and the private sector. These were the questions which elicited the greatest number of responses, perhaps because they relate to the problems posed by adaptation rather than identifying solutions. The questions then consider the four pillars outlined in the Green Paper:

– early-action;

– external relations;

– long-term action; and

– the importance of stakeholder consultation.

In response to the nine questions posed for the first pillar, stakeholders have indicated their respective positions on issues ranging from general EU adaptation policy to prospects for sustainable agriculture. In summary, the respondents believe that the EU must develop an overarching framework which considers the interdependency of all sectors (including those typically considered outside the environmental realm) and their respective adaptive capacity.

Responses to the five questions related to the second pillar, indicate that there is a broad recognition for the need to consider climate change impacts in relations with neighbouring states, the developing world and other industrialized nations. Considering the issues raised in relation to the first pillar, the respondents believe that the EU will need to have its own house in order prior to establishing itself as a world leader. The EU's potential to mobilize global action is noted with some enthusiasm. Responses obtained for the three questions raised against the third pillar further underline the EU's role as a central agency facilitating information exchange. These questions, and the responses to them, emphasize the need for further research into predictive climate change models and their potential role in longer term climate change policy.

With respect to stakeholder consultation, respondents clearly support existing efforts to consult with the general public. The total number (and varied scope) of submissions received in response to this exercise clearly demonstrate this fact. The establishment of a European Advisory Group has been widely supported by stakeholders and respondents to the consultation.

A report[55] on the stakeholder consultation presents information obtained as part of a consultation exercise related to the European Commission's Green Paper COM (2007)354 'Adapting to climate change in Europe – Options for EU action.' This consultation exercise involved soliciting input from European stakeholders using three media: web-based submissions, more formalized written submissions and stakeholder workshops. With the consultation having come to a close in mid-December 2007 there is a need to assess the responses in order to support progress towards the White Paper.

Furthermore, the Green Paper was also the subject of opinions and resolutions by the Committee of the Regions, the European Economic and Social Committee and the European Parliament:

- The Committee of the Regions has adopted its opinion in November 2007 (Rapporteur: Ms Twitchen)
- The European Economic and Social has adopted its opinion in December 2007 (Rapporteur Mr Osborn)
- The European Parliament has adopted its resolution on April 2008 (Rapporteur: Mr Sacconi)

[55] Available at http://ec.europa.eu/environment/climat/adaptation/index_en.htm

7.4. Implementation of the recommendations of the Impact Assessment Board

The recommendations of the Board[56] are based on an earlier version of the IA report[57]. The main changes performed in the current version have been 1) the greater consistency given to the problem definition section to better support the set of objectives; 2) moving the analysis of adaptation approaches to the 2nd half of the report and assessing their economic, environmental and social impacts; 3) performing a structured assessment of policy options according to operational objectives and screening criteria.

IAB recommendation (D 404) based on version 3	**Implementation in version 4 sent to inter service consultation**
(1) The problem definition section needs to be better linked to the objectives. – The problem definition section should analyse in more detail the problems which underpin the operational objectives (improving the knowledge base and co-ordination of adaptation policies). The IA report should analyse underlying drivers and take this analysis into account when proposing policy options. With regards to the knowledge base, the IA report should not only assess the quality of the science currently available (e.g. in terms of coherence and degree of detail of the models), but also state more clearly which level of quality is needed (to allow for better informed policy making), and what actions would be necessary to encourage this evolution.	Chapter 2 has been revised, and provide more details on the mentioned problem. More information can also be found in Annex 1, as well as in DG RTD document (SEC(2008) 3104)
– The practical implications of differences in the science on adaption and that on mitigation, in particular relating to the timing of necessary investments, should be made more explicit.	This topic is covered in Annex 1.
– Similarly, in relation to the co-ordination of adaptation policies among Member States and institutions, the IA report should analyse existing mechanisms and their deficiencies and provide examples of the impact and negative spill-overs that a lack of co-ordination may have on the vulnerability to climate change.	This is done in section 2.3, based e.g. on recent works from PEER (2009)
– Additionally, the IA needs to clarify how autonomous adaptation has been integrated into the baseline, including the adaptation by businesses and individuals, and the impact that this may have on the vulnerability assessment.	Clarified in section 2.3.3.
– Finally, the discussion on green and grey infrastructure should be moved to the section of the IA dealing with policy options	Done, moved to Chapter 4.
The justification for the selection of the win-win/no regret actions is currently insufficient and should be strengthened.	At this stage this report is only able to present a preliminary assessment based on literature review and National Adaptation Strategies such as UK-CIP. There is no information available allowing going further in terms of structured or quantitative assessment. Short term actions will allow a systematic assessment on costs and benefits, based on national/regional/sectoral assessments and modelling.
2) The IA report should better justify choice of the short term measures proposed in section 4.2.	All actions included in selected option B can be undertaken under current budget framework, and will

56 http://www.cc.cec/iab/i/docs/opinions/2009/climate_change_second_env.tif

57 Available on http://www.cc.cec/iab/i/docs/meeting_docs/2008/adaptation_ia_v3.doc (main report) and http://www.cc.cec/iab/i/docs/meeting_docs/2008/adaptation_ia_v3___annexes.pdf (annexes)

IAB recommendation (D 404) based on version 3	Implementation in version 4 sent to inter service consultation
– The IA report should clarify to what extent the list is exhaustive and to what extent proposed measures might be competing with each other, e.g. for the same budgetary resources, and would therefore need to be assessed from a cost-efficiency perspective.	not require additional funding. A detailed analysis on the resource and cost-efficiency aspects of the potential measures is included in Annex 6.
– Additionally, the discussion on risk management should be expanded and not limited to insurance only	As explained during the IAB meeting, the report also contemplate non-commercial risk management tools, the most evident being the set of vulnerability indicators.
– The three assessment criteria (knowledge base, subsidiarity, synergies/trade-offs) should be reconsidered or at least better defined, to allow a more consistent screening of the proposed measures.	This has been reviewed and improved in section 5.2
(3) Impacts of the policy options need to be assessed – At least a qualitative assessment of the impacts of the proposed measures should be presented, and used subsequently for the selection of preferred options or sub-options.	The new chapters 4 and 5 provides a quantitative assessment of both sets of options (overall adaptation approaches and short-term scope for EU action)
– The IA needs to assess the expected impacts of the policy options. This should be done both for general policy options (no new EU action, an action plan, white paper) as well as for more detailed measures discussed currently in section 4.2.	The main report focuses on the comparison of general policy options. In order to keep the length of the IA report closer to the IA guidelines standards, the detailed assessment of some concrete measures is provided in Annex 6.
– In line with the proportionality rule, the assessment can to a large extent be qualitative. Economic, social and environmental impacts should nevertheless be clearly presented.	Economic, environmental and social impacts of broad adaptation approaches is addressed in section 4.2.
– Identification of further impact assessment work for future actions should be provided.	This is addressed in the conclusions of Chapter 5.
– This assessment of impacts should be used as the basis for comparing policy options.	This is done in Chapter 5.

8. ANNEX 1 - THE FRAMEWORK FOR INTEGRATED ASSESSMENT OF ADAPTATION POLICIES

8.1. Climate change scenarios

This report integrates the key messages on climate change impacts from the 2008 EEA/JRC/WHO report 'Impacts of Europe's changing climate'[58], complementing it with numerous other sources, in order to perform and analysis of the need for early action at EU level, taking into account the likely impacts of autonomous policy actions, including national adaptation policies and strategies. Other main sources of input than the mentioned EEA/JRC/WHO report are quoted and are described in Appendix 7.1:

Despite efforts to reduce greenhouse gas emissions and the EU target to prevent temperatures from increasing to more than 2°C above pre-industrial levels[59], impacts of climate change in Europe and across the globe can already be perceived:

- Between 1901 and 2005, average temperatures in Europe rose by 0.9°C (IPCC, 2007), i.e. slightly higher than the global average. The increase of the annual average temperature from pre-industrial towards 2007 for the European land area has been 1.2°C and eight of the last 12 years (1996 – 2007) in Europe were in the 12 warmest years since 1850. Europe has warmed more than the global average.

- In recent years, warming has occurred at a considerably higher rate (+0.4°C/decade for 1979 to 2005) than the longer-term average.

- Temperatures are increasing more in winter than summer, and there has been increasing variability in daily temperature (due to an increase in warm extremes).

- Changes in precipitation (rainfall) have been more variable across Europe.

- Mean winter precipitation is increasing in most of Atlantic and northern Europe, while in the Mediterranean area, annual rainfall has been decreasing in the east, but remaining static in the west. 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%), and mean winter precipitation has increased in most of the Western and northern Europe (20 – 40%).

- Across Europe in general, there has been an increase in the amount of rain falling on wet days (heavy precipitation events).

- Sea-level rise has been observed, with, globally, a rise of 195 mm between 1870 and 2004, equivalent to average sea-level rise of 1.7 ± 0.3 mm per year in the 20th century[60]. In Europe rates of sea-level change ranges from -0.3 mm/year to 2.8 mm/year in the previous

---

58 Impacts of Europe's changing climate - 2008 indicator-based assessment, EEA Report No 4/2008, http://reports.eea.europa.eu/eea_report_2008_4/en/

59 Communication of 10 January 2007, entitled: "Limiting Global Climate Change to 2 degrees Celsius - The way ahead for 2020 and beyond" [COM(2007) 2 final - Not published in the Official Journal].

60 Church, J. A., and N. J. White "A 20th century acceleration in global sea-level rise", Geophys. Res. Lett., http://www.agu.org/pubs/crossref/2006/2005GL024826.shtml

century and recent results from satellites and tide-gauges indicated an accelerated average rate of global SLR of about 3.1 mm/year in the previous 15 years.

- North Sea waters have warmed by 1.1°C over the past 30 years. Sea surface temperature (SST) is increasing at a faster rate in European seas than in the global oceans and the rate of increase is larger in the northern European seas and smaller in the Mediterranean Sea. In the past 25 years sea surface temperature in all European seas has been increasing at a rate that is roughly 10 times faster than the average over more than a century (high confidence).

- Cold extremes have become less frequent in Europe, while the frequency of hot days has almost tripled between 1880 and 2005 and the number of warm extremes doubled.

- For Europe as a whole, the intensity of precipitation extremes like heavy rain events has increased in the past 50 years, even for areas with a decrease in mean precipitation such as Central Europe and the Mediterranean. However, the proportion of Europe experiencing extreme and/or moderate meteorological drought conditions has not changed significantly during the 20th century. Storminess in Europe has shown a considerable variation over the past century, but with no long-term trend.

There is now increased understanding of anthropogenic warming and cooling influences on climate, and as the observations above, unequivocal warming of the climate system (IPCC, 2007). There is also a much better understanding of future climate change, advanced through a broader range of models (IPCC, 2007). This includes regional climate change projections for the period 2071-2100 (PRUDENCE) in Europe. The change in European summer and winter temperature are shown in Figure 5 for the IPCC SRES B2 and A2 scenarios for the 2080s[61].

The projections of future climate change show:

– Projected increases in annual average temperature in Europe this century is 1 - 5.5°C (best estimate) with the greatest warming over eastern and northern Europe in winter, and over south-western and Mediterranean Europe in summer. There is therefore a strong distributional pattern of warming across Europe, i.e. between North and South and also differences between summer and winter. The greatest warming is predicted for Southern Europe and the Artic.

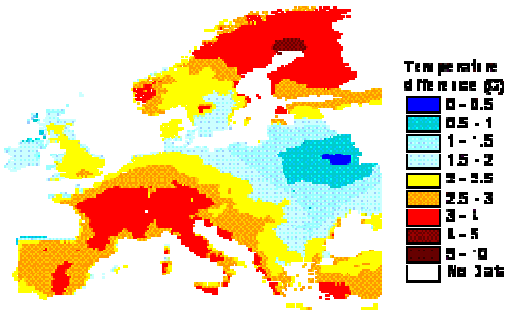
– Projections for the end of the 21st century which suggest an additional global sea level rise of 0.18 to 0.59 m above the level over the period 1980-2000 (IPCC, 2007).

– Models project an increase in winter precipitation in northern Europe and a decrease in summer precipitation in southern Europe. However, there are uncertainties on the magnitude and geographical details of the change.

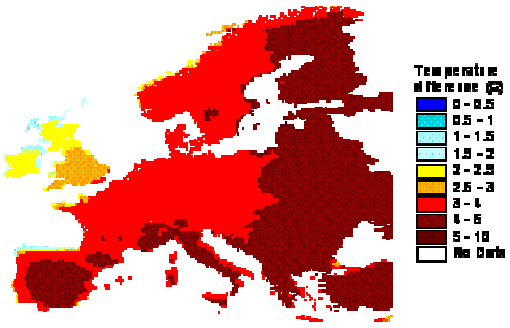
---

[61] The IPCC's Special Report on Emissions Scenarios (SRES) provides a range of storylines (taking into account potential demographic change, economic development, and technological change) to consider future emissions of greenhouse gases, and projected climate changes. In the A2 scenario, where the focus is on national enterprise, global emissions are assumed to increase more significantly, leading to approximately a tripling of average CO2 concentrations by the end of this century, compared to the pre-industrial concentration. The B2 storyline focuses on local stewardship and results in approximately a doubling of the atmospheric CO2 concentration (and can be very approximately considered to be equivalent to a mitigation scenario in terms of stabilisation levels). These emissions scenarios translate to a global mean temperature increase in 2071-2100 of 3°C for A2 and 2.2°C for B2, relative to 1961-1990.

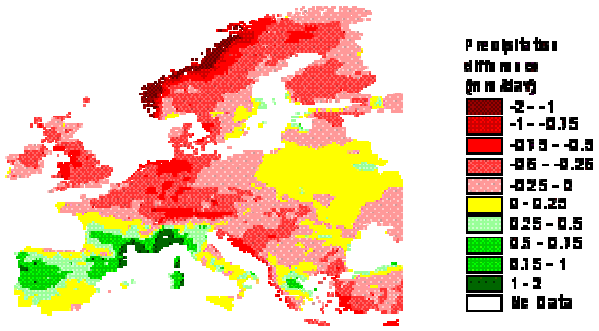
Figure 5: Changes in annual mean temperature and precipitation by 2071-2100 relative to 1961-1990 under the B2 and A2 scenario. Source Prudence, based on HadCM3.



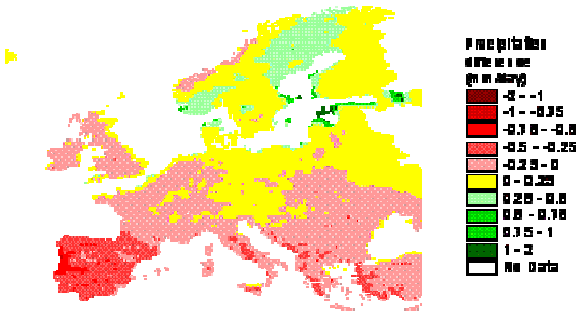
Change in annual mean temperature by 2080s, **B2** scenario



Change in annual mean temperature by 2080s, **A2** scenario



Change in annual mean precipitation by 2080s, **B2** scenario



Change in annual mean precipitation by 2080s, **A2** scenario

– For Europe as a whole, it is *likely* that heavy precipitation events will become more frequent. Dry periods are projected to increase especially in Southern Europe.

– For Europe as a whole heat waves are projected to increase in frequency, intensity and duration, whereas winter temperature variability and the number of cold and frost extremes will further decrease. European regions projected to be most affected are the Iberian Peninsula, central Europe including the Alps, the eastern Adriatic seaboard, and southern Greece.

– Projections of future storminess are still very uncertain and model dependent, though some models indicate a slight decrease in the number of storms and an increase of the strength of the heaviest storms, and projections show a significant increase of storm surge elevation for the continental North Sea and South East England.

The EEA/JRC/WHO report also looks at indicators to track trends and projections for the cryosphere (permanent or seasonal snow and ice deposits on land, in the seas, in rivers and lakes and in the ground (permafrost)). In Europe, the most vulnerable areas are the high mountain areas, and the Arctic. It reports:

– The vast majority of glaciers in the European glacial regions are in retreat. Since 1850, glaciers in the European Alps have lost approximately two thirds of their volume, with

clear acceleration since 1985. Glacier retreat is projected to continue. A 3°C warming of average summer air temperature could reduce the currently existing glacier cover of the European Alps by some 80 %. Glacier retreat has consequences for river flow.

– The northern hemisphere's snow cover extent has decreased at a rate of 1.3% per decade during the last 40 years. Model simulations project widespread reductions of extent and duration of snow cover in Europe over the 21st century.

– The sea ice extent in the Arctic has declined at an accelerating rate, especially in summer. The record low ice cover in September 2007 was roughly half the size of the normal minimum extent in the 1950s. The summer ice is projected to continue to shrink and may even disappear at the height of the summer melt season in the upcoming decades. There will still be substantial ice in winter. The ice loss from the Greenland ice sheet increased in the 1990s from a near balance to approximately 100 billion tons lost per year.

– A warming of mountain permafrost in Europe of 0.5-1.0°C has been observed during the recent 10-20 years. Present and projected atmospheric warming will lead to wide-spread thaw of mountain permafrost.

When considering adaptation, future socio-economic scenarios are also extremely important, as they determine the vulnerability of social and economic systems to climate change. The future socio-economic projections may lead to a significant change in vulnerability or exposure, as well as adaptive capacity. In many cases they will lead to increases in vulnerability even without climate change, for example, the impact of extreme events such as floods or storms will be determined by the increased future wealth of potential infrastructure affected, but also changes in relation to location related to land-use, even without climate change. Socio-economic scenarios also determine the global GHG emissions leading to the range of emissions scenarios used in the climate models.

It also must be stressed that there are major uncertainties in the future trends, and their distribution at higher levels of disaggregation. With all figures presented in this paper, it is highlighted that there is considerable climate model variability, especially in relation to precipitation projections. There is also much wider underlying uncertainty on the level of change, not least with respect to variation in climate sensitivity.

Finally, there are also major uncertainties over the future baseline from which to consider adaptation, i.e. in defining the effect of existing and planned policies and considering which emission and mitigation trajectory we are on. While there is an existing EU ambition level to limit global climate change to 2 degrees Celsius, this target is predicated on global action, and is associated with considerable uncertainty. For the latter, the global 50% reduction by 2050 in GHG outlined in the EC's 2 degree paper has only a 50% chance of achieving this target. It is therefore necessary to consider a wide range of projections in formulating possible adaptation policy.

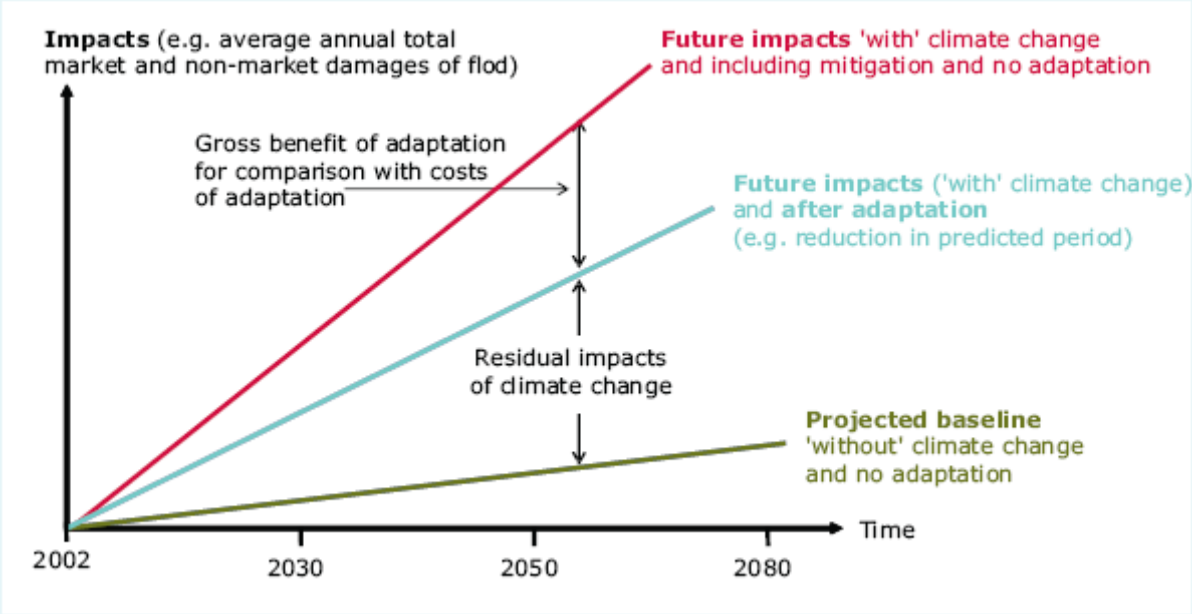
However, all scenarios and projections indicate a number of changes that can be expected with high confidence. Average temperatures will rise; summers are likely to become drier, particularly across southern Europe; winters are likely to be wetter, with more heavy rain likely.

8.2. Costs and Benefits of Adaptation

The economic impacts of climate change in Europe were recently reviewed for by the EEA (EEA, 2007) and the OECD (OECD, 2008). These reports show that there is still little quantified information on the costs and benefits of adaptation, and that most studies are constrained to a few sectors (primarily coasts in the FP6 PESETA project) and only take account of a limited sub-set of climate change effects. There is an emerging literature in Europe, however, and more comprehensive estimates are appearing with the FP6 ADAM project, which results will be publicly available during 2009. Some advanced findings are however presented below. In general, the benefits of adaptation are very large, and significantly reduce the costs of inaction. In most cases, the costs of inaction in the early period (2010 to 2040) are low.

When discussing costs and benefits of adaptation, it is important to define exactly what is included in the different estimates (Figure 6). It is also necessary to consider the effect of socio-economic change, as this defines the actual future baseline to compare costs and benefits against. In many cases, this is not made explicit.

Figure 6 - Costs and benefits of adaptation (Source: Boyd and Hunt, 2006[62])



Some sectoral estimates have been provided in the context of ADAM and PESETA 6th FP projects:

– Coasts: Because human activities are historically gathered near low-lying coasts for commodity reasons, the stakes could be high: in the Netherlands, 60% of the population live in so-called low elevation coastal zones[63]. It is estimated[64] that, with about 89,000 km

62 Boyd, R. and Hunt, A., 2006. Climate Change Cost Assessments Using the UKCIP Costing Methodology. July 2006. Report for Stern Review, UK HMT.

63 McGranahan G, Balk D, Anderson B (2007) The rising tide: assessing the risks of climate change and human settlements in low elevation coastal zones. Environ Urban 19(1):17–37

64 EEA (2006), The changing faces of Europe's coastal areas, EEA Report No 6/2006, European Environment Agency, Copenhagen.

of coastline, 68 million people could be affected by sea level rise in the European Union. Economies relying on agriculture will suffer the most from sea level rise[65]. Moreover, adaptation cost may be high relative to the GDP of coastal areas, as it is not guaranteed that protection costs will be absorbed fully at national level. Some redistribution effect of the losses from regions with relatively high damages to regions with relatively low damages may happen, implying that even countries without a coastline are likely to bare some burden of sea level rise due to spill over effects. Regarding the potential role played by adaptation in coastal systems in Europe, early results from the PESETA study[66] suggests that both physical and economic impacts can be largely reduced. PESETA has used the DIVA model, developed under the 5th FP DINAS-COASTS[67] project, which allows a comparison of the consequences of climate change in coastal systems without adaptation and with optimal adaptation, according to a cost-benefit framework. The range of impact estimates is large due to the uncertainty of the projected sea level rise. Under the A2 scenario, without adaptation around 2000 to 17000 km2 of land in Europe could be permanently lost by 2085, also leading to 0.1 to 1.3 million people undergoing coastal floods every year. Those physical effects are valued at a cost of 12 to 18 billion/year. When hard adaptation measures are considered the land loss fall to less than 1000 km2, and the residual economic cost to around one billion/year. The economic costs of the adaptation measures are some one billion/year, to be added to the residual damages. .

– Health: The human health analysis of the PESETA project has not explicitly analysed the costs and benefits of adaptation but has considered the potential role of acclimatisation via autonomous physiological and behavioural changes in individuals or populations. Acclimatisation can significantly reduce the temperature-related effects of climate change. However, there is not an explicit cost attached to acclimatisation and further research is needed in this respect. Accounting only for the climate change induced effect on mortality, i.e. ignoring the influence of the change of the socioeconomic scenario (mainly population growth and ageing), the PESETA project estimates that under the A2 SRES scenario and Hirham/HadAM3H climate models, average annual heat-related mortality for the 2071-2100 period would be around 100 000 without acclimatisation, and around 18 000 with acclimatisation. It should be noted that the PESETA human health study has not taken into account heat waves.

– The PESETA agriculture, river flood and energy studies have not made a cost-benefit assessment of adaptation.

There is not much data on costs of adaptation available in Member States. The recently published recommendations from the Dutch Delta Commission estimate that protecting the coast and the entire low lying part of the Netherlands against the consequences of climate change involves a cost of 1.2 to 1.6 billion Euros per annum until 2050, and 0.9 to 1.5 billion Euros per annum in the period 2050–2100.

Other studies have tried to estimate the costs of adaptation, based on simple metrics and investment flows. These estimates do not look at the costs of inaction, or the benefits of adaptation.

---

65 Bosello F., Lazzarin M., Roson R., Tol R.S.J., «Economy-Wide Estimates of the Implications of Climate Change: Sea Level Rise», Fondazione Eni Enrico Mattei, Note di Lavoro 96, 2004: http://www.feem.it/Feem/Pub/Publications/WPapers/WP2004-096.htm

66 http://peseta.jrc.ec.europa.eu/docs/Costalareas.html

67 http://www.dinas-coast.net/

– The UNFCCC has estimated the following global investment and financial flows into adaptation by 2030, with a proportion of investment in OECD countries (developed countries) between $21 and 104 billion/year, though this is mostly infrastructure. On the basis of a proportion 30% of GDP for EU-27, this would equates to around $6 to 31 billion. Note that to estimate this more accurately future GDP flows would be needed (UNFCCC, 2007).

– The Stern Review estimated that additional costs of making new infrastructure and buildings more resilient to climate change in OECD countries could range from $15 – 150 billion each year (0.05 – 0.5 % of GDP), with higher costs possible with the prospect of higher temperatures in the future (Stern, 2006). This approach can be used to scope European costs of adaptation. Based on EU27 GDP in 2006 (€11.606bn), costs of adaptation (making new infrastructure and buildings more resilient to climate change) are estimated between €5.8 and €58bn. Alternatively, if it is assumed that Europe invests 20% of GDP in fixed capital, and one-quarter of this goes into construction, and the extra investment to make this climate resilient will be 1 – 10 %, then costs of adaptation (extra investment in construction) would be between €4.6 and €46.4 bn. These are alternative estimates of the same likely investment, rather than additive. The values at the top end are reflective of a future, larger climate change scenario. For example, they could be considered to reflect the potential costs towards 2100, in a scenario without successful mitigation. The lower values are likely to be more representative of an earlier time period, e.g. the 2030s (note that in these earlier time periods, the estimates will not vary much between business as usual and mitigation scenarios).

Finally, there are figures on cost of inaction and cost of adaptation coming from top-down integrated assessment model (DICE/RICE, FUND, MERGE, PAGE, etc.) which do not properly reflect the strong bottom-up character of adaptation measures[68]. These models lack the level of spatial detail necessary to identify the costs and benefits of adaptation measures, which is better provided by process-oriented models with considerable physical detail.

These models are mainly used for calculating an optimum policy-mix between adaptation and mitigation, but this depends crucially on the assumptions in the model, and especially on the discount rate and the level of future damages. As it is suggested by the early outcomes of ADAM research project[69], the effects of including different adaptation scenarios within IAMs (to identify optimal policy mix) are minor compared to the range of uncertainty within these models.

Against that background, efforts should be focused the analysis (e.g. to build on the modelling framework developed for the UNEP GEO-4 or OECD Environmental Outlook 2030) on the assessment of vulnerability and distributive aspects, under a wide range of climate scenarios.

At EU level, the modelling effort could be focused on identifying no-regret and win-win adaptation actions, focusing on increasing the resilience of ecosystems and socio-economic systems. This means focusing on the further development of land-use and hydrological models, bringing together ecosystem services modelling (green infrastructure, water, etc.) at small scale detail (1 or 10 km2 grid) with a strong socio-economic component providing regional and sectoral details (sectoral models such as CAPRI, Transtools, etc.).

---

68 OECD working document ENV/EPOC/GSP(2008)17

69 www.adamproject.eu, results to be published in 2009

9. ANNEX 2 – CROSS CUTTING ISSUES: WATER, LAND, BIODIVERSITY AND ECOSYSTEMS

9.1. Biodiversity

9.1.1. Impacts

The impacts of climate change on European biodiversity/ecosystems are complex and include temperature increases, shifts in climatic zones, melting of snow and ice, sea level rise, droughts, floods and other extreme weather events. Particularly vulnerable areas include the Mediterranean (from water scarcity and heat stress), coastal zones due to pressure from sea level rise, mountain regions and the Arctic.

In the Arctic, perennial sea ice is thinning and being replaced by seasonal ice. Tundra habitats are likely to become highly fragmented and reduced in extent as northward movement is limited by the Arctic Ocean. On its southern border, tundra will be replaced by coniferous boreal forest and scrublands. The reduction in tundra and associated permafrost will reduce the reflectance of solar radiation and may increase the incidence of wildfires. Warming is also expected to release carbons stored in the permafrost.

The biodiversity of Europe's mountain tops has been identified as being very vulnerable to climate change, as snow cover reduces and ambient temperature increases. The snow pack on many mountains is close to its melting point and particularly sensitive to temperature change. The Alps will experience warmer, wetter winters and dryer summers, and have already witnessed the displacement of cold-adapted species as lower altitude species move uphill. Mediterranean biodiversity/ecosystems are also vulnerable and will suffer from water scarcity and heat stress.

Climate change will also act upon and often aggravate the impacts of other pressures on biodiversity/ecosystems, such as overexploitation, habitat fragmentation, degradation and loss, and invasive species.

Climate change will cause climatic zones to move. In consequence, the potential distribution of European species is projected to shift by tens to hundreds of kilometres by the end of the century (depending on the scenario used). The success of this movement will depend on various factors: the capacity of a species to migrate (e.g. migration will be easier for birds than for plants), the connectivity within the landscape structure (i.e. availability of stepping stones and/or habitat networks), and the presence of receptor habitats within the new climate range of a species. This is obviously problematic in densely populated areas and highly fragmented agricultural landscapes.

The potential future range for most European species is likely to be smaller in extent than their current range, and some species found in Europe will have no potential range by the end of the century. For certain species, there will be no overlap between their potential future range and their current range, making the threat of extinction more likely. The area of appropriate climate range for many Alpine and Arctic species will decrease dramatically.

Climate change and its consequences present one of the most important threats to biodiversity/ ecosystems and their functions and services. The current rate of change is far beyond that imposed by global climatic changes occurring in the evolutionary past. The rate of change will exceed the ability of many species to adapt, especially as landscape

fragmentation may restrict movement. Natural systems are vulnerable to such changes due to their limited adaptive capacity.

Changes in ecosystem composition and structure have important implications for the interactions between the biosphere and the climate system, as well as for ecosystem services on which society depends. Climate change is disrupting species interactions and ecological relationships, and also threatens managed ecosystems on which many sectors, including agriculture, forestry, fishery and tourism, rely.

Warm winters and extended growing seasons have resulted in large population increases of pests. Normally, ecological processes keep predator-prey relationships in balance, but asynchrony in these relationships may result in a breakdown of this delicate balance and an explosion in pest species. Weakened by drought and wilted by heat, crops become more susceptible to pests. For example, climate-stressed forests are infested faster and widespread climate and disease-induced forest dieback is a plausible scenario in many areas.

As biodiversity is impacted by climate change, so the resilience of the ecosystems can decline. Ecosystems with low resilience may reach thresholds at which abrupt change occurs. Biodiversity loss, ecosystem degradation and consequent changes in ecosystem services can lead to a decline in human well being. For example the decline in the resilience of the salt marsh ecosystems will results in the loss of coastal protection services against storm surge that together with the sea level rise, could create socio-economic impacts in low lying coastlines. Furthermore, the degradation of the associated wetland habitats will have negative implications for resident and migratory bird populations, and may result in the loss of tourist potential and the subsequent decline in economic benefits for coastal communities.

Temperature increase exerts further stress on freshwater and marine ecosystems (see other sections), compounding current over-exploitation and pollution. In the oceans acidification adds an additional pressure.

Ecosystems play a direct role in climate regulation through physical, biological and chemical processes that control fluxes of energy, water, and atmospheric constituents including greenhouse gases. Peatlands and wetlands provide the largest below ground store of carbon and tropical forests dominate above ground storage in biomass. Boreal forests, grasslands and agricultural land also play an important role. The oceans and terrestrial ecosystems are currently providing an important service to humanity by absorbing about half of the anthropogenic CO_2 emission. However, the combined effects of climate change and associated disturbance and other drivers of change including pollution, land-use changes and over-exploitation may reduce the resilience of many ecosystems during this century and affect their role in climate regulation. Although our detailed knowledge is limited, there is certainty about the existence of multiple positive and negative feedbacks between biodiversity-ecosystems and climate. These feedbacks are generally non-linear and have the potential to produce large undesirable effects, particularly at the regional level. These feedbacks, though agreed to be significant, are not included in present climate change models because of the high uncertainties. Therefore the current scenarios for temperature increase are likely to be underestimates.

9.1.2. External Dimension

The areas outlined above are also relevant for the external dimension, not least due to the potential shift in climatic zones and potential distribution of European species moving to areas

outside the EU. The demand for ecosystem services within Europe (e.g. provisioning services) will also affect pressures on biodiversity-ecosystems outside the EU. These external effects need to be further explored.

9.1.3. Adaptive capacity

Table 5- Potential planned adaptation options for Biodiversity / Ecosystems

Type of action	Description
Share losses	n/a
Mitigate the threat	Preserving an abundance of organisms (plants, animals, micro-organisms) and multiple groups performing similar functions is important for maintaining resilience. A diversified portfolio of "insurance" species provides back-up if some species decline. Crucially higher genetic and species diversity tends to make ecosystems more resistant and resilient to disturbance. This is because species are likely to be present with characteristics that will enable the ecosystem to adjust to change and to maintain the provision of critical services such as water purification. Biodiversity provides flexibility and insurance and spreads risks across temporal and spatial scales. This is valid for both managed and unmanaged systems. Integrated agricultural systems with a diversity of crops and surrounding ecological zones can provide strong defences in the face of weather extremes, pest infestations and invasive species.
Prevent effects	Introduce a biodiversity/ecosystems compliance check in a reinforced spatial planning to increase flexibility of managed and natural systems to accommodate and adapt to climate change including by reducing other pressures on biodiversity/ecosystems arising from habitat conversion, over- harvesting, pollution and invasive alien species and by developing appropriate management and structure of the wider landscape and seascape.
Change land use.	Strengthen nature conservation measures to conserve biodiversity/ecosystems in the future. Areas will have to be reserved for this purpose. Sufficiently large habitats must be provided to protect domestic and endemic species. Newly arrived 'non-native' species can help to maintain ecosystems, but they can also pose threats and need to be observed closely. Habitat mosaics should be created in landscapes where land management practice has led to the absence of sufficient suitable patches of unaltered or semi-natural habitat, thus ensuring permeability of the landscape and the required network connectivity. Connectivity may be achieved by establishing ecological linkages or by maintaining specific habitats to assist movement of species through an inhospitable environment. Maintain ecosystem function/services. For example, protecting upper-catchment forests and restoring wetlands can reduce the risks from climate-related floods and droughts, thereby protecting people's welfare and helping to minimise the loss of life, properties and other assets. These investments are likely to be highly cost-effective relative to structural alternatives such as dams and dykes. Also, preserve and restore floodplains, including reversion of arable land to flood meadows; promote climate-friendly agricultural use of peatlands and moorlands; and improve microclimate in urban areas by maintaining and increasing green spaces and fresh-air corridors.
Change location of economic activities.	n/a
Capacity Building	Investigate synergistic effects of climate change and other pressures on biodiversity and ecosystems. Investigate biodiversity/ecosystems underlying climate regulation services, in particular feedbacks that might work in our favour. Build awareness of the links between biodiversity/ecosystems and climate, and emphasise the large potential synergies when addressing biodiversity loss and climate change in an integrated manner.

9.1.4. Need for early action at EU level

The shifting of bioclimatic zones is already happening. Therefore the creation of ecological networks in fragmented landscapes (where land management practice has led to the absence of sufficient suitable patches of unaltered or semi-natural habitat) needs to happen swiftly to half the further loss of Europe's biodiversity. Shifting bioclimatic zones do not respect borders. This means we need to act in a co-ordinated manner, as otherwise actions by one Member State may be jeopardised by those of a neighbouring country.

Positive feedbacks and healthy ecosystems are essential for any strategy to adapt to climate change. Continuing, accelerating loss of biodiversity will compromise the long term ability of ecosystems to regulate climate, may accelerate and amplify climate warming and could lead to additional, unforeseen and potentially irreversible shifts in the earth system. Urgent action now to halt further loss and degradation of biodiversity will help to maintain future options for reducing the extent of climate change and managing its impacts. Failing on the biodiversity targets and continuing degradation of ecosystems compromises our efforts for emission reduction.

9.2. Water

9.2.1. Impacts

Freshwater resources have the potential to be strongly impacted by climate change. Water is a critical core sector and climate change will affect the water cycle and water ecosystems, and also the function and operation of existing water infrastructure (including hydropower, inland navigation, irrigation systems, drinking water supply and waste water treatment). Water is also important in energy supply and in tourism (see Annex 3).

Changes in water demand strongly depend on economic growth and societal development, as well as patterns of demand change from other sectors. Climate change may exacerbate the impacts of already existing stresses, such as impacts from households, more intensified economic activity and (unsustainable) land use change. Water-related climate drivers, such as floods and droughts will affect many sectors and combined with water availability, makes this a clear cross-cutting issue.

Future changes in precipitation, combined with rising temperatures, will have impacts on water quality and quantity, affecting many sectors. Limited water availability poses a problem in many parts of Europe, and this is likely to increase because of climate change (high confidence). IPCC (2007) predict that the percentage area under high water stress in Europe is likely to increase from 19% today to 35% by the 2070s due to climate change, with the additional number of people affected to be between 16 and 44 million. A particular concern here is the strong pattern of water availability across Europe, with the predicted declines greatest in the Mediterranean and Southern Europe.

Such effects are compounded by the general increase in wealth and the generally hotter and longer summers increasing overall water demand (e.g. cooling water, irrigation, water for recreational and tourism activities). Additional water demand for agriculture and industry will conflict with the additional demands for human consumption. Some of the autonomous adaptation responses will involve detrimental effects. Increased risk of (illegal) groundwater abstraction might result in reduced levels of aquifers, whilst increased desalinisation will increase energy use.

Poor water quality will also be exacerbated by climate change. For example, rising water temperatures will affect aquatic ecosystems considerably, conflicting with demands from other sectors, like tourism or industries for cooling water. High water temperature, low water flows and therefore less dilution of pollutants may have severe consequences for drinking water and recreation activities related to water. Because of sea level rise, saline intrusion in coastal aquifers may increase, affecting the suitability for drinking water.

Predictions of more intense and more frequent flood events and related economic losses were documented in the earlier infrastructure and coastal zones section. Building and high value agriculture in flood-prone areas is still continuing. This, together with climate change related changes in the precipitation regime, is contributing to higher flood levels. In other places, the natural retention capacity of the river basin is decreasing continuously. This may pose a particular problem in urbanised areas, where the retention capacity of the surface area may not be able to cope with more intense precipitation events, possibly leading to flooded urbanised areas and overflows of sewerage systems.

9.2.2. External dimension

As Europe shares river basins with non-European countries, Europe will be affected by any unsustainable water management practices implemented outside its boundaries, and European activities will be felt outside its borders.

It is also anticipated that water availability will be one of, if not the key effect, affecting neighbouring countries and regions.

9.2.3. Adaptive capacity

Deforestation and a large development of agriculture and urbanization have affected the infiltration of water at local level, increased the runoff of rainwater (with secondary effects like erosion of soil and nutrient flows), lowered groundwater recharge and reduced water availability for vegetation as well as evaporation. For some regions, without action, the process can lead to desertification.

In some agricultural regions, the development of drainage combined with irrigation has resulted in the disappearance of natural vegetation, emergence of salty soil and reduction of yields. In some cases, alterations and regulations of rivers with the shortening of their total length have tended to worsen the situation by accelerating the runoff of water from land and lowering land's ability to retain water. In urban areas, the mass use of cement and asphalt predominate. Rainwater is often carried away through public sewage networks, instead of saturating the soil and ecosystems. By draining the environment in which citizens live, water availability decreases and results in secondary effects: growth in temperature in cities, fall in atmospheric humidity and overall worsening of environment quality with possible health impacts. 74% of the European population lives in towns and this proportion is still expected to increase (80% by 2020).

Wetlands are vulnerable to climate change but, if properly managed, also have a certain resilience to climate impacts and maintain services of value to climate adaptation (Wetlands International (2007)). Their capacity to withstand and mitigate certain environmental changes, enables plants and animals to survive and helps wetland-dependent communities adapt to climate change. The role of wetlands in relation to water flows and storms, greatly increases their relevance to global adaptation efforts. As buffers between land and sea or between upstream and downstream areas, wetlands are able to reduce climate impacts many kilometres away. Therefore, wetland management is justified as a tool that is relevant to strategies for reducing climate change impacts in all regions of the world. Furthermore, restoration of already degraded wetland systems can be demonstrated to be a cost effective tool in adaptation strategies. For example, the re-establishment of services such regulation of floods through wetland restoration along rivers can increase the environmental security of downstream communities.

Wetlands exert a strong influence[70] on the hydrological cycle, and management of wetlands must be an important part of catchment management to reduce impacts of climate change. Where wetlands reduce floods, recharge groundwater and increase dry season flows, wetland hydrology is working in sympathy with water-resources managers and flood-defence engineers. Where wetlands have high evaporation demands or generate flood-runoff, they may create or exacerbate water management problems. Whatever the hydrological functions they perform, decisions on wetland conservation will inevitably be taken in a wider context and will also depend on water scarcity and on other functions, such as human health, fisheries, navigation, recreation, cultural heritage and biodiversity. Wetland management must therefore be an integral part of water body management if one is to mitigate successfully the impacts of climate change in terms of floods, ensuring minimum water flows.

Table 6- Potential planned adaptation options for Water

Type of action	Description
Mitigate the threat	Water supply measures (desalinisation)
	Certain land use practices that enhance flood risks should be addressed, for example by an obligatory climate change related long term assessment of the risks related to certain land uses in a river basin and coastal area to floods, both to reduce the potential damage of assets at risk as well as to ensure better use of land for reduction of the flood hazards
Prevent effects	Water demand management. As a first step, improved incorporation of current climate variability into water-related management would make adaptation to future climate change easier.
	Water management should turn from focusing on meeting the increasing demand and protecting people from extremes of floods and drought, to protection of water resources in an integrated manner
Change land use.	Land management and land planning need to adapt in order to progress towards optimally water saturated land. A stable water cycle is required. Basic ecological functions like the return of water and vegetation to land need to be reintroduced. The ability of land to retain water needs to be improved. This can be achieved by the restoration of wetlands. The priority should be to keep rainwater in places where it falls, particularly in areas with significant impacts due to human activities. An improved infiltration of water into the soil and progress towards soil saturation will help the restoration of groundwater and surface water resources and therefore the development of permanent vegetation accompanied by cooler temperatures. Efforts need to take place everywhere but more particularly in hot spots like highly cultivated areas and highly populated areas. Action includes technological measures like improvement of surfaces to help soil infiltration, anti-erosion measures, use of vegetation borders, grassy lands, limiting of non-vegetation hard surfaces in built-up areas, replacing impermeable areas with permeable ones, avoiding clear-cutting of forests, ensuring the quality and structure of forests, etc. Zoning and land planning need to evolve in order to make the development of such measures possible and effective. Many actors have responsibility in this respect: public authorities in charge of overall land planning, developers of building areas, construction companies, banks and insurance companies.

A report for DG Environment[71] has provided quantitative data on impact of desalination development to address water scarcity in the next three decades. Under the worst case scenario, energy requirements for desalination and transport would be equivalent to 43% of Greece's total energy production, 20% of Spain's and 16% of Cyprus and Bulgaria's energy production. Under more optimistic assumptions about desalination technology, these amounts would fall by over 50%. Looking at EU level, total energy use from desalination and water transport would range from an equivalent of 3% to 7% of total power production in 2030 of € 8.5 to € 15 billion/year.

70 Mike Acreman technical note for DG Environment on Hydrological functions of wetlands, 2008.

71 Available at http://ec.europa.eu/environment/water/quantity/scarcity_en.htm

9.2.4. Need for early action at EU level

Water management is a trans-boundary issue. Water is by nature trans-national and requires a coordinated approach within each river basin. This situation means that any action taken upstream of a river basin in a given country will have direct impacts downstream of the river basin in other countries. The absence of a coherent approach could lead to increasing conflicts between countries or regions in the context of climate change, be it scarcer water, more floods or impacts on water quality. Upstream regions could be tempted to carry on their economic development without looking into the problems that this may cause downstream. For example, an increase in abstraction from water resources regardless of the downstream context could leave downstream regions with serious problems of water shortage. Further, developing activities that minimise the retention capacities upstream, might lead to unnecessary floods downstream. These effects will have to be addressed at river basin scale.

Since 2000 water management the flagship for addressing water management at the (international) river basin level is the European Water Framework Directive, and the Floods Directive (2007) follows the same river basin approach to address flood risks. There is also other water legislation at the European level, thus factoring climate change in water management is a key priority at European level.

Furthermore, the many links between water ecosystems and water-dependent users (agriculture, navigation, energy, tourism, etc) also justifies action at European level.

Early action is needed to build capacity to adapt in the water sector, but also in other sectors that are water dependent (agriculture, transport, energy, tourism, industry, etc). Extreme events like floods and droughts are already a problem in Europe now, but their frequency and intensity will be exacerbated by climate change. Damages from these events are potentially large and justify early action. Moreover, recovery of natural water systems from unsustainable use (e.g. over-abstraction of groundwater aquifers) may take a long time and need to be prevented.

9.3. Soils and Land use

9.3.1. Impacts

Land use refers to the terrestrial natural and managed ecosystems systems and includes soil, vegetation, other biota and the ecological and hydrological processes in this system. Territorial and spatial dimensions are important.

There are increasing pressures for land in Europe. Land is a limited resource and is currently sought by urbanisation, agriculture, bio-energy production, forestry, nature conservation, recreation and tourism, industry and infrastructure. Therefore, there are competing demands for land, which in some places in Europe is becoming scarcer.

Land-use change is one of the relevant factors among the determinants of climate change and the relationship between the two is interdependent as changes in land-use may impact the climate whilst climatic change will also influence opportunities for future land-use.

Some research projects[72] have assessed the impacts of climate and market changes on agrarian land use in Europe. The main conclusion was that the effects of technology and market change are more pronounced than the effect of climate change. A wide variability in regional production in Europe is predicted, due to differences in productivity and competitiveness of regions. Surplus of land is predicted in the global economic scenario SRES A1 and a shortage of land in the regional environmental scenario B2.

Some land-use changes, led by economic and social considerations are increasing our vulnerability to climate change by rendering infrastructures and ecosystems more fragile. This is the case for instance of the urbanisation in flood plains or the change of forest and grassland to arable land.

On average the sealed area, the area of the soil surface covered with an impermeable material, is around 5% of the total area in Member States[73]. In many European countries the built-up area increased by 25 to 75% in the period 1950-1980. During 1990-2000 the sealed area in EU15 increased by 6%[74], and the demand for both new construction due to increased urban sprawl and better transport infrastructures continues to rise[75].Soil sealing through urbanisation dominates in the more densely populated regions and major industrial areas of Western Europe, in particular Belgium, Denmark and the Netherlands, where 16-20% of the surface is built up. Sealing results in the creation of a horizontal barrier between the soil, air and the water and thus has several severe consequences such as disruption of gas, water and energy fluxes, increased flood risks, reduced groundwater recharge, increased water pollution (due to runoff water from housing and traffic areas being normally unfiltered and potentially contaminated with harmful chemicals), loss in soil and terrestrial biodiversity (due to fragmentation of habitats).

The river Rhine has already lost four-fifth of its natural floodplains and similarly in the river Elbe only 15% of the natural flood plains remain[76]. This increases the damage caused by floods, as the buffering function of flood plains has been lost.

Moreover, in many cases the land uses approved are irreversible and preclude in the future any other land use, which limits significantly the possibilities to adapt in changing climatic conditions.

The following climate change predictions impact specifically on soil:

- Organic matter decline due to increased temperatures leading to increased GHG emissions from soil[77]. However, moisture is needed for mineralization of soil organic matter to take

---

72 Wageningen UR, presentation available at http://www.zalf.de/home_ip-sensor/conference/08_pdf/Audimax_02_Hermans_IALUC_Berlin_Apr08.pdf . See also ATEAM http://www.pik-potsdam.de/ateam/ateam_final_report_sections_5_to_6.pdf

73 Land accounts for Europe 1990-2000, EEA Report 11/2006

74 Land accounts for Europe 1990-2000, EEA Report 11/2006

75 Urban Sprawl in Europe - the ignored challenge, EEA Report 10/2006

76 Internationalen Kommission zum Schutz der Elbe (IKSE): Abschlußbericht über den Stand der Durchführung der im „Ersten Aktionsprogramm (Sofortprogramm) zur Reduzierung der Schadstofffrachten in der Elbe und ihrem Einzugsgebiet“ enthaltenen Maßnahmen (1996); BMU 2002: Arbeitsschritte zur Verbesserung des vorbeugenden Hochwasserschutzes)

77 P. H. Bellamy, P. J. Loveland, R. I. Bradley, R. Murray Lark and G. J. D. Kirk, Carbon losses from all soils across England and Wales 1978–2003, *Nature* **437**, 245-248 (2005); M.D.A. Rounsevell, F. Ewert,

place and increased dry periods may, to some extent, counteract the direct effects of increased temperature.

- Less soil organic matter may also mean more water run off (with increased flooding risks in case of extreme weather events) and less soil moisture (when there is too little soil moisture, rain-fed crops and natural vegetation wilt). Degraded ecosystems have lower water retention capacity. This aggravates the situation.

- Increased erosion risks due to changing rainfall intensity and patterns as well as management practices, resulting in more severe floods (roughly in the Northern part of Europe) and droughts (roughly in the Southern part).

- Organic matter decline due to increased rate of breakdown as decreased rainfall and increased evapo-transpiration lead to aerobic conditions leading to oxidation – leading to oxidation of peat bogs [78].

- Increasing soil temperatures may give rise to a more favourable habitat for sub-tropical soil-borne pathogens

- Change in soil biodiversity (species level, food web) due to both raising temperatures and changing rainfall intensity and patterns – maybe not so much a problem but no doubt a change – leading to changes in agriculture and nature.

- Salinisation due to intensified irrigation as a result of droughts and due to intrusion of seawater and brackish ground water in coastal areas as a result of sea level rise

- Desertification affecting the Mediterranean regions of the EU due to exacerbation of its environmental drivers (erosion, salinisation and soil organic matter (SOM) decline) as a result of climate change leading to farming becoming extremely difficult, decreasing rural income and land being abandoned[79].

- Disruption of the soil functions: biomass production and decomposition; storing, filtering and transforming nutrients, substances and water; acting as carbon sink and loss of soil biodiversity.

Some impacts will be very specific for certain parts of Europe, whilst other will materialise more generally:

- Loss of soil organic matter resulting in increased GHG emissions from soil: while increased temperatures are likely to promote a general trend to reduced SOM, the extent of the decrease will depend upon the soil moisture regime and also on land use. Under grass or other permanent crops increased productivity from longer growing seasons and CO_2 enrichment will lead to increased returns of organic matter to soil. No direct impact

---

[78] I. Reginster, R. Leemans and T.R. Carter, Future scenarios of European agricultural land use: II. Projecting changes in cropland and grassland. *Agric. Ecosyst. Environ.* **107** (2005), pp. 101–116
see: http://news.bbc.co.uk/2/hi/science/nature/6972504.stm, or: Evans, M. Warburton, J. and Yang, J. Sediment Budgets for Eroding Blanket Peat Catchments: Global and local implications of upland organic sediment budgets; Geomorphology 79 (1-2) 45-57 (2006)

[79] Jacqueline Karas: Climate Change and the Mediterranean Region. Greenpeace report (1997): http://archive.greenpeace.org/climate/science/reports/fulldesert.html

on the population in general is predicted; the agricultural and forestry sectors would be affected.

- Loss of soil organic matter resulting in a reduction of soil moisture holding capacity (i.e. the water stored in the soil within reach of plants) and decreased water storing capacity, which means that rain-fed crops will be more drought-susceptible. However, this impact will often be only marginal as soil water-holding capacity is determined mainly by the physical texture of the soil. This is likely to affect most areas, but not those in which total rainfall is forecast to increase as increased soil moisture reduces the rate of organic matter breakdown.

- Increased erosion risks due to changing rainfall intensity and patterns resulting in more severe floods (in the Northern part of Europe) and droughts (in the Southern part): flooding may affect the population in low areas/flood plains in N-EU as well as all economic sectors and ecosystems. Droughts/increased erosion will affect agriculture, forestry and ecosystems throughout S-EU

- Organic matter decline due to increased oxidation of peat soils: will affect the specific high value peat ecosystems in N-EU (notably in IE, UK, SE, FI, NL, DE) and agriculture in these areas

- Change in soil biodiversity (species level, food web) due to both raising temperatures and changing rainfall intensity and patterns: will affect agriculture (Northward shift of crops grown; crop yields will raise in N-EU and drop in S-EU; change in pests and pests control; soil fertility minerals management) ecosystems and nature conservation. However, the predominance of sandy soils of limited fertility in N Europe mean that the potential increases in crop yields from a longer growing season and increased CO2 concentrations may not be realised.

- Salinisation due to intensified irrigation as a result of droughts and due to intrusion of seawater and brackish ground water in coastal areas as a result of sea level rise: will affect agricultural productivity in drought affected areas

- Desertification will spread within the Mediterranean regions of the EU: decreasing crop productivity may result in (further) marginalisation of land and general landscape degradation, thus affecting the agricultural sector and ecosystems. Through a vicious cycle it may finally end in land abandonment, thus affecting the population in general.

- The disruption of soil functions will affect all economic sectors: agriculture (through soil fertility), forestry, nature conservation, but also drinking water supply etc. and ecosystems.

9.3.2. Adaptive Capacity

Climate Change aggravates land scarcity (need for food and biofuels production, need for natural areas and water management, sea level rise, floods and land abandonment), and reduce choices and opportunities. Some changes are irreversible

In Europe, most of the land is privately owned, therefore there are many choices that are going to be made by the landowners as they realise the effects of climate change. Additionally the local authorities and regional authorities in charge of spatial planning will also carry out a

planned adaptation when they perceive the effects of changing patterns in rain fall and temperatures.

One of the major roles of land use planning in the future will be to define best practice models for land use according to the soil characteristics and derived soil functions. The most obvious land use changes appear due to urbanization processes and the construction of transport infrastructure. Through this process, soil conservation and runoff and erosion processes may receive appropriate responses

Table 7- Potential planned adaptation options for Land Use

Type of action	Description
Share losses	Support the rural economies of desertification affected and threatened regions to limit/avoid land abandonment by keeping agricultural production and soil management viable
	Repay damage caused by flooding (directly or through insurance)
Mitigate the threat	Reduce/avoid the loss of soil organic matter by adapting existing cultivation practices (e.g. ploughing in crop residues, using "green manuring") and supporting the use of soil improvers and organic fertilisers (e.g. compost and manure)
	Control erosion by choosing from a wide range of existing measures
	Control organic matter decline due to increased erosion of peat by raising the ground water table
	Control salinisation resulting from irrigation by optimizing irrigation techniques
	Mitigating salinisation by changing to more halophytic crops
Prevent effects	Reduce/avoid the loss of soil organic matter by adapting existing cultivation practices (e.g. ploughing in crop residues, using "green manuring") and supporting the use of soil improvers and organic fertilisers (e.g. promote the use of compost and manure made from municipal green waste)
	preventing erosion by choosing from a wide range of existing measures
	preventing salinisation resulting from irrigation by optimizing irrigation techniques
	preventing organic matter decline by adding (external) organic matter (manure, compost, sludge etc.)
	contribute to halting biodiversity loss by changing crops and by allowing species to move , this enhancing the connectivity between nature conservation sites such as Natura 2000)
Change land use.	preventing organic matter decline by converting cropland into permanent grassland or forest
	Preventing organic matter decline due to increased erosion of peat by phasing out agricultural land use/dehydration and convert into natural areas
	Enhance connectivity at different scales allowing species to move and habitats to shift
	Avoid or limit soil sealing to keep soil functions intact to the extent possible, notably the water retention capacity
	Given that land is a limited natural resource, becoming increasingly scarce given the demand that are arising, the same principles which are applied to other scarce resources ought to be applied to land use: more rational use of the land, the need to recycle the land, the need to act on the increasing demand
Change location of economic activities.	Relocate human activities in areas with a high flood risk, by moving those to higher ground
Capacity Building	Adapt to climate change by providing the population with information and education on changing conditions.

9.3.3. Need for early action at EU level

The EU has a major role in supporting the economic, social and environmentally sustainable development of its regions through the structural funds. Moreover the EU has committed itself to ensure a territorial cohesion which will be put to the test with the unequal distribution of impacts of climate change. The decisions taken on land use planning can in many cases be irreversible, leading to the need to incorporate as soon as possible climate proofing considerations and long term considerations in the land use planning and spatial planning.

Soil degradation affects other environmental areas for which Community legislation exists. Indeed, soil is interlinked with air and water in such a way that it regulates their quality and soil functions enormously contribute to areas such as biodiversity and coastal management. Thus soil degradation brought about by climate change will have cascade impacts on all these environmental media.

There are substantial trans-boundary impacts: soil, though generally immobile, is not completely so and therefore degradation in one Member State or region can have trans-boundary consequences. Losses of soil organic matter in one Member State impair achievement of the EU's Kyoto Protocol targets. Dams are blocked and infrastructure is damaged downstream by sediments from massive erosion further upstream in another country. Therefore it is of outmost importance to act at source to prevent damage and subsequent remedial actions, otherwise costs to restore environmental quality may be borne by another Member State.

Effects of local land-use changes on climate change can be perceived at regional or even global scale, making clear i.e. the need for EU action in co-ordinated planning of land use, water and ecosystems. Around the Mediterranean Sea, the existence of a feedback cycle towards desertification by land use changes (deforestation), leading to large trans-boundary side effects, is suggested by numerous EC Research Projects (Millán 2007). Land-use changes, combined with air pollution, trigger changes and perturbations to the hydrological cycle, resulting locally in the loss of summer storms and tipping the regional climate towards desertification and drought. This propagates to the whole basin and adjacent regions, and ultimately to the global climate system, through other mechanisms, involving:

– An increase in Mediterranean cyclogenesis in autumn-winter through cumulative (greenhouse) heating of the sea surface by the water vapour and the pollutants (ozone) accumulated over the sea

– The export of the accumulated water vapour and pollutants to other regions at the end of each 3-10 day accumulation-recirculation cycle, which can contribute to summer floods in Central-Eastern Europe and

– Changes in the evaporation-precipitation balance over the Mediterranean, which increases its salinity and drives the Atlantic-Mediterranean salinity valve.

10. ANNEX 3 - SECTORAL PERSPECTIVE

10.1. Agriculture

10.1.1. Impacts

Agriculture is a climate sensitive sector, and will be affected by climate change, both positively and negatively.

The assimilation of atmospheric CO_2 by photosynthesis is required for biomass production. The opening of plant stomata is regulated by the concentration of CO_2 and therefore atmospheric CO_2 concentrations affect plant transpiration (the smaller the concentration of CO_2, the more the stomata need to be open and the greater will be the loss of water. As result, in theory, plants growing in increased CO_2 conditions will produce more biomass and consume less water, and will therefore be less drought-sensitive. However, there are only a very limited number of these experiments worldwide, hence the uncertainty in the model outputs. In addition, since increased CO_2 concentrations will be accompanied by increased temperature, especially at night, photorespiration will increase and hence some of the extra carbohydrate assimilated will be lost.

Changes in hydrological regimes will lead to differences in water needs by agriculture. Decreased availability of water may lead to crops suffering moisture stress, insufficient water being available for irrigation, possible risks of reduced water quality, increased risk of soil salinization and conflicts between users.

For crop production, a change in the seasonality of precipitation may be even more important than a change in the annual total. The water regime of crops is also vulnerable to a rise in the daily rate and potential seasonal pattern of evapotranspiration, brought on by warmer temperature, drier air, or windier conditions. Interannual variability of precipitation is a major cause of variation in crop yields and yield quality. Crop yields are most likely to suffer if dry periods occur during critical developmental stages. In most grain crops, flowering, pollination, and grain-filling are especially sensitive to water stress. Management practices offer strategies for growing crops in water-scarce conditions. For example, the effects of drought can be minimized by early planting of cultivars with rapid rates of development; fallowing and weed control can help to conserve moisture in the soil.

By reducing vegetative cover, droughts exacerbate wind and water erosion, thus affecting future crop productivity. Increasing demand for water is likely to lead to increased groundwater abstraction and depletion of those resources. The likelihood of these risks occurring is reported as high.

Excessively wet years may also cause yield declines due to waterlogging and increased pest infestations. High soil moisture in humid areas can also hinder field operations. Intense bursts of rainfall may damage younger plants and promote lodging of standing crops with ripening grain. The extent of crop damage depends on the duration of precipitation and flooding, crop developmental stage, and air and soil temperatures.

Of course, the impacts of medium and long-term climate change on agriculture and forestry are difficult to analyse separately from other influences (e.g. the effects of policies, market influences and technological development) related to management. Some care must also be taken when making general comments at the macro-regional levels, due to the specific

climate, soil, and agricultural management analysis, which is extremely diversified. Nonetheless, some broad trends in projections are emerging.

Potential positive impacts of climate change on agriculture in Europe in general are related to longer growing seasons and new cropping opportunities in Northern Europe (high confidence) from temperature change, and more efficient use of water as well as potential increased CO_2 fertilization of plants throughout Europe. Hence the interaction of these factors in response to a change of climate will have different impacts in different parts of Europe.

However, these possible benefits are counterbalanced by potentially negative impacts that include increased water demand and periods of water deficit, loss of soil carbon content, increased pesticide requirements and crop damages and less cropping opportunities in some regions in Southern Europe. There are likely to be more general negative effects from extreme events across Europe, especially from the intensification of the hydrological cycle (summer heat, heavy precipitation events and floods, storms). In some parts of Europe, e.g. the north-west, rainfall is forecast to increase in winter but decrease in summer, hence this may lead, even within the same region, to increased frequency of drought in summer and floods in winter.

Several studies show the likely spatial patterns outlined above, with a strong distribution of projected yield changes across Europe. IPCC (2007) summarises that climate-related increases in crop yields are expected mainly in northern Europe, the south-central European plain and in the south of European Russia, while the largest reductions of all crops are expected in the in the Iberian Peninsula, the UK, Benelux countries, north-west France and the south-west Balkans. The 6th FP PESETA project also projects regional yield changes for the 2020s to 2080s, with indications of the spatial pattern of changes in agriculture yields across Europe under different scenarios, and show results under an A2 scenario by the 2080s that are similar to reported by IPCC (2007). Potential increases in yields in Nordic countries and in east-central Europe, will be accompanied by productivity decreases in Southern parts of Europe, which are among the larger producers. The overall assessment, at least in the next decades (for low levels of temperature increase) is that the effects of climate change and increased atmospheric CO_2 are expected to lead to overall small increases in European crop productivity. However, these potential benefits in northern Europe will not always be fully realisable due to other limiting factors, the occurrence of extreme events or impacts to other resources (e.g. increased soil erosion due to temperature increase, insufficient water availability and in particular the inferior quality of the soil resources in the Nordic and Baltic regions compared with those of Western and some parts of Southern Europe) and they will in some cases require additional investment in equipment and training. These changes are summarised below.

Autonomous adaptation actions by farmers can counteract and even reverse some of the potential impacts of climate change which do not consider changes in agricultural management, technological progress and trends to better farming practices adaptation. However in some cases, autonomous adaptation options will also interfere with agri-environmental processes, and could lead to an increased use of pesticides to cope with more emerging and increasing pests, diseases and weeds, an increased use of mineral fertilisers[80] to

[80] The implications of climatic changes on use of fertilisers are very uncertain and will depend on the site-specific effects on agriculture. While fertilisation could increase following expectations of better yields (and the contrary), the shortening of crop cycle in parts of Europe may lead to a decrease of nitrogen fertilisers.

compensate for a loss of soil fertility, an increase in irrigation, as well as in extreme cases land abandonment (when changes in climatic conditions or frequent extreme events difficult agricultural activity). In the long-term, as climate impacts become higher, ecosystems could be affected by the changes, particularly from land abandonment, and significant NATURA 2000 areas and other High Nature Value areas managed by agriculture could be at risk.

Positive effects can also be expected from a range of adaptation responses of farmers, such as more diversified crop rotations and farm activities, increased use of organic fertilisers, and land use changes. The projected improvement of productivity of pastures in northern-western humid regions could lead to conversion of temporary pastures to permanent with a favourable effect for carbon sequestration. Farmer's management decisions in response to climatic changes will be largely influenced by the economic environment including market conditions and the policy environment, including training and advice opportunities.

Further efforts to improve and implement better plant protection and fertilisation management, and to improve the efficiency of water use are needed to avoid potential environmental pressures. Development of European agricultural research is necessary as promotion of innovation and technology transfer are crucial for improving adaptive capacity of the sector and deliver good adaptation.

Biotechnology developments, such as drought-resistant varieties requiring less water, or varieties requiring less fertiliser may offer a solution for some problems, but will have to be used under application of the EU regulatory framework.

The changes could also have wider social effects, for examples in regions where whole local rural population could be affected if the farmland was abandoned, or if the farming profitability reduced substantially. These impacts may be particularly serious in EU southern regions such as Spain and Greece where larger proportions of the population are engaged in agriculture than is the case for NW Europe. Below, the main impacts are represented in different categories.

10.1.2. External dimension

There will also be agricultural and economic consequence for Europe from changes in agricultural productivity in other countries. The impacts of climate change will lead to a change in agricultural productivity in many areas; while impacts on world food prices are difficult to predict, due to uncertainty over future demand, emergence of new cultivars and production technologies, there is a general expectation that world food prices will tend to rise in response to a warmer climate[81]. Under some scenarios and models, there could be significant declines in agricultural productivity in many world regions, increasing the incentive to farm new areas in Europe, and to generally increase farming intensity, which will put pressure on the environment in Europe.

The IPCC predicts that climate change will increase the global number of people at risk of hunger marginally, compared with overall large reductions due to socio-economic development. Nonetheless, the prospect of food shortages, and related concerns about food security, may bring a new element into WTO discussions as some countries seek greater

[81] Parry et al., Effects of climate change on global food production under SRES emissions and socio-economic scenarios - Global Environmental Change 14 (2004) 53–67, available at http://www.undp.org/gef/adaptation/docs/foodproduction.pdf

control over their agricultural markets and exports. The extent of problems relating to food security will depend not only on climate change , but also on other aspects of demand and supply, such as changes in dietary habits (meat needing much more land to produce than cereals), and demand for energy, including biofuels, which can compete with food production for a limited land supply.

Consequences for other countries of the adaptation measures which may be taken in Europe are not so obvious and would need to be further explored. There may be greater market opportunities for third country exporters in sectors which come under pressure in Europe.

The consequences for other countries from climate impact in Europe will depend on the overall impact on Europe's capacity to produce food. Some regions should see new opportunities to produce, or yields increase, but others may see output under pressure. There is a risk of greater fluctuations in productivity in Europe, as elsewhere, with the risk of more volatile agricultural prices, with economic and social effects. Under some scenarios and models, there is likely to be a tightening of the world market for cereals and other agricultural produce, but the impact of these changes will depend on the relative changes in imports and exports from Europe.

10.1.3. Adaptive capacity

Currently agriculture is beginning to adapt autonomously. Actions include use of various water resources for areas that experience droughts or shortages (like water from tertiary treatment facilities, or abstraction of ground water independently of planned water harvesting. Changes to crops is also taking place by substituting mainly tree crops in the South EU or looking to more heat resistant less water-demanding crops and/or varieties. Change in irrigation practices that may lead to water conservation and avoidance of losses may also happen to the degree that the needed investments will be subsidised. The degree of autonomous adaptation is expected to be variable. A major driver will be the capacity building of farmers and advisory services to provide support for autonomous adaptation, planning support by the authorities and financial resources, while Southern Europe is expected to be engaged in much more serious adaptation efforts. Central European agriculture is expected to adapt mid-term to risks related to flood prevention. Agricultural insurance may help to cover extreme weather related risks, like fires, floods, droughts and storm/hale.

In some cases, autonomous adaptation options will include an increased use of pesticides to compensate for more emerging and increasing pests, an increased use of mineral fertilisers to compensate for a loss of soil fertility due to climate change, and an increase in irrigation. This may lead to further water scarcity, a decrease in water quality, biodiversity loss or a reduced resilience to flooding. Land abandonment is an extreme adaptation option, when economic and climatic constraints don't allow the further use of land for agricultural production without substantial public subsidies.

In any case, considering technology development put the impact of climate change in perspective[82]. The strategy for climate change responses in agriculture needs to be consistent with safeguarding food security, viability of rural areas and the provision of environmental services. The challenge for agriculture over the coming years is the need to meet the demand

[82] Ewart et al., Assessing impacts and adaptation of European agriculture to changes in climate and market conditions, presentation from the Food Security and Environmental Change Conference, Oxford, 2-4 April 2008 available at http://www.gecafs.org/documents/GECAFS_Oxford_Reidsma.pdf

from increasing number of people – most of whom are in developing countries and will also suffer from worsened climatic conditions – while at the same time, conserving the local and global environment in the face of growing pressures associated with socio-economic development and climate change, that can exacerbate the current limited soil and water resources.

Table 8- Potential planned adaptation options for agriculture

Type of action	Description
Share losses	Agricultural production is costly to insure because the potential losses are so high in relation to income. Insurance has a role to play, but it runs the risk of moral hazard: any approach to sharing risks would have to incorporate safeguards to avoid inciting recklessness, which may itself be bad for the environment e.g. continuing to grow crops requiring irrigation, despite a significant risk of water shortages leading to crop failure – instead of growing less valuable crops which do not rely on irrigation.
Mitigate the threat	Changes in land use/management could attenuate some of the agronomic effects of climate change e.g. using frequently floodable land for grazing instead of arable production. Allowing farm land improvements to revert can also help, e.g. by allowing field drainage to go into disuse, the field will be flooded more (with significant agronomic costs) but it will contribute to downstream sectors/population by playing a water absorption role and enhance ecosystem resilience There are also ways to affect the climate locally e.g. shield crops from wind by tree planting, and possibly, on a larger scale, increase rainfall locally by tree planting. These changes can come at a substantial agronomic cost. So it may be necessary to provide incentives in cases where there is market failure to produce the public good.
Prevent effects	Many changes in agricultural practice can help to attenuate the impacts of climate change on the sector. Here are just a few examples e.g. changes from irrigated to non-irrigated crops; changes to crops needing irrigation less in dry periods; changes in crop varieties to withstand drought or pests or other pressures; changes in cropping patterns e.g. avoiding monoculture, going for longer rotations, taking sensitive crops out of the rotation; changes in tillage practices; changing to systems which may be more resilient e.g. mixed farming, organic farming. In addition these measures potentially contribute to biodiversity conservation and enhancing ecosystem reliance Reduce/avoid soil degradation (loss of organic matter, erosion, salinisation) by adapting existing cultivation practices (e.g. ploughing in crop residues, using "green manuring"), the use of soil improvers and organic fertilisers (e.g. compost and manure), optimizing irrigation techniques and changing to more halophytic crops, raising the ground water table In almost all cases, these changes will result in increased costs/loss of profits: in many cases, the replacement system is closer to traditional farming systems, which were generally abandoned for sound economic reasons. However, some of these changes (e.g. minimum tillage) may result in little or no loss of income, or in longer term benefits e.g. to soil quality. Besides their contribution to conserving biodiversity, thus enhancing ecosystem resilience essential for adaptation could be rewarded
Change land use.	Agricultural land use if often more favourable than other potential land uses in terms of climate change adaptation (e.g. better a farmed flood plain than one which has been concreted over). Some change of land use will happen in any case as a result of climate change, and of economic drivers, leading to the abandonment of some agricultural land; but this will be in areas where it is environmentally damaging rather than favourable, and cannot be expected to contribute to climate change mitigation. Preventing organic matter decline by converting cropland into permanent grassland or forest In certain cases the shift from agriculture to purely environmental services may be justified. This is often most cost-effective if achieved by public land purchase, but can also be achieved under long-term land management contracts with land owners.
Change location of economic activities.	This will to some extent happen spontaneously as a result of climate change; however, agriculture can only take place in suitable conditions (climate, soil, water availability).
Capacity Building	Farmers are expected to take a number of anticipatory measures relating to climate change adaptation on their own initiative. However, as substantial changes will be needed in many farming systems, farmers' efforts could be enhanced and made more environmentally responsive, by the use of training

Type of action	Description
	and farm advisory instruments, and by the explicit inclusion of climate change adaptation goals in the existing CAP instruments and in the rural development strategies of the Member States. As an anticipatory approach is desirable, both economically and environmentally, an early policy response in both cross compliance and in Rural Development is highly desirable; and an early response by MS/Regions to help farmers adapt in an anticipatory way is also advisable.

10.1.4. Need for early action at EU level

In the EU, the Common Agriculture Policy and its resources (both direct payments and rural development) provides a framework that can facilitate climate adaptation and adjustment of agricultural practices at EU level. Further consideration of climate change impacts and the adaptation needs has to be given in the CAP and non CAP instruments (especially environmental regulations or directives that apply to farmers). In regions where reduced resource availability requires priorities to be set, it is important to have instruments which can avoid adaptation action in the agricultural sector to negatively contributing to climate change or other environmental problems. Moreover, the climate change mitigation potential, and other ecosystem services contributing to adaptation could be further considered in the CAP.

In some regions of Europe the potential effects of climate change are starting to be very visible. We have suffered floods, droughts, heat waves. The agricultural sector is already suffering many of the consequences. Hence for this very climate-sensitive sector early action is needed to prevent further damages and costs.

10.2. Forests

10.2.1. Impacts

Climate change will bring many and complex effects for forests in different bio-climatic regions of the EU. Possible future responses of forests to climate change include:

– Increased risk of biotic (pests and diseases) and abiotic (drought/storms/fires) disturbances to forests health.

– Increased frequency of extreme weather events (storms, floods and droughts) leading to high risk of fire erosion problems, and damages to stands.

Simulation of the IPCC SRES A1B scenario for the period 2070-2100 shows a general trend of a south-west to north-east shift the ecologic conditions suitable for any given forest type potentially leading to natural afforestation in places where temperature was a limiting factor and/or massive dieback in mature stands that are not adapted anymore.

In a large part of Europe, forestry represents an important economic sector and also provides potential for carbon sequestration. Forests cover 44% of the land area of Europe (1 billion hectares) representing one quarter of the global forest area. Over past centuries, land clearance in Europe led to significant deforestation. However, this trend has been reversed and over the past 15 years, forest area in Europe has increased by some 13 million hectares. The wood volume in European forests amounts to 112 billion m^3 and is increasing, with harvesting still falling behind increment. Production of wood from European forests is increasing and more than 4 million people work in the forestry sector (1.1% of total employment in Europe). More than 20% of European forests are managed primarily to provide non-timber ecosystem services such as water and soil protection and protected forests now amount to 5% of total forest area. However, forests in Europe have suffered severe storms, droughts and fires,

amounting to the loss of hundreds of thousands of hectares in some years. These forests will continue to be affected by climate and climate change, in terms of their distribution, function and species composition.

Overall, projections of the net effects of climate change on forestry are complex (EEA, 2008). Tree growth may be enhanced by some processes (including CO_2 fertilisation, warmer winter weather and longer growing seasons, and reduced cold related damage), but might be negatively affected by others (such as from reduced summer rainfall in some areas, wind-storm damage, spring frost damage and elevated ozone concentrations). IPCC (2007) report that forest area or suitability in Europe might be expected to expand in the north, but contract in the south.

The impacts of climate change are likely to vary greatly between regions. In the northwest of Europe, where water supplies are, typically, non-limiting, growth rates are likely to be enhanced by a combination of rising carbon dioxide levels in the atmosphere, warmer winters and longer growing seasons, and increased nutrient availability as a result of atmospheric deposition and increased soil mineralisation. This contrasts with southern Europe and the Mediterranean region, where more frequent and severe summer droughts are likely to lead to reduced productivity, more extensive forest fires and, ultimately, to desertification in some areas. Species choice and the biodiversity associated with forests will also be affected. A changing climate is also likely to mean that the levels of damage caused by existing forest pathogens and pests changes, while new pests and pathogens, whether introduced by mankind from other parts of the world or moving through Europe as climate change progresses, have the capacity to cause serious damage to both protection and production forests.

An important issue that transcends policies relevant to both climate change mitigation and adaptation is the permanence of carbon stocks in forests. In southern Europe, the principal carbon stocks are in forest biomass, while in many boreal forests, the soils contain significantly more carbon than tree biomass. In both cases, these carbon stocks are vulnerable to the direct (and indirect) effects of climate change (lowering of water table, retreat of permafrost and forest fires, desertification, respectively). Adaptation of management practices should be considered to help protect these carbon stores, thus contributing to climate change mitigation.

Forests, and forest flora and fauna, will need to adapt to new climatic conditions (temperature, humidity, precipitation, winds) as well as to extreme events (storms, droughts, floods). Forests are likely to experience general stress caused by changing climatic conditions to which they are poorly adapted. The single most important determinant of the natural distribution of forests is climate, followed by soil conditions and hydrology (although the latter two are also heavily influenced by climate). Forests have evolved with the climate, gradually shifting their composition and structure as climate has changed over the millennia, due to their inherent adaptive capacity. Young forests that are adapted to today's climate will live under sub-optimal conditions in the relatively near future, and therefore may experience stress. This is likely to lead to changes in growth, health, biodiversity and stability, and will be exacerbated by a projected increase in extreme weather events. However, the mechanisms that have acted

in the past under natural climate change will also contribute in the future to the adaptation to human-driven climate change[83].

Damage to forests will also occur due to extreme weather events. Projections indicate an increasing frequency of extreme weather events in the future. This is partly caused by changes in the mean climate (frequency of hot days, enlargement of the fire prone area or lengthening of the fire season) and by increased variability (increased amplitude of changes, leading to unusual weather patterns). Extreme events such as storms can damage or destroy trees and stands, whilst droughts can make forests more vulnerable to secondary impacts (e.g. increased risk of fire and vulnerability to biotic damage).

Forestry is a sector with long life-times: stands established now should be able to withstand the next 50-100 years. Estimates from a JRC study forecast[84] that according to a typical +4° scenario, the ecological conditions where a given tree species now grows will shift somewhere between 500 and 1000 km north by 2100, though this does not mean that forests will be able to make these shift.

Changes in mean climate (especially temperature) will have serious implications for forests, but the increased variability (likely occurrence of extreme events and associated uncertainty) is probably more important: For example, even if long term precipitation projections are rather uncertain, more variability is very likely, and extended droughts or major floods are more likely to be caused by increased variability. Expected increase in the frequency of drought periods in central and southern Europe is likely to influence and alter the growth and competitive ability of certain tree species as was clear following the drought of 2003 for beech[85]. Increasing extreme weather events have a major long-term effect on forestry-reliant communities in Northern Europe[86].

The net effects of climate change on forests are complex and not yet well understood. While a new long term equilibrium may be reached in Europe, if climate stabilisation targets are met, the transition period is likely to be marked by a range of negative impacts (above), with these being exacerbated by outbreaks of pests and diseases in stressed environments. However, it should be noted that the impacts of climate change will vary geographically throughout Europe, 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. Furthermore, evidence to date suggests that productivity in northern and central Europe has increased and is likely to continue to increase, where water won't be the main limiting factor, as a result of warmer winters, rising CO_2 levels and increased soil mineralisation rates.

10.2.2. External dimension

Outside Europe similar factors are likely to be at play. Globally, forestry production is estimated to change only modestly with climate change in the short and medium term (IPCC,

---

83 EFI, 2008. Impacts of Climate Change on European Forests and Options for Adaptation, Report to the DG Agriculture and Rural Development, available from http://ec.europa.eu/agriculture/analysis/external/euro_forests/index_en.htm

84 Casalegno et al. Modelling Current and Future Distribution of European Forest Categories. Proceedings of the 6th European Conference on Ecological Modelling. November 27-30, 2007. Trieste – Italy, available at http://doga.ogs.trieste.it/doga/echo/ecem07/Main/27Nov/casalegno.pdf

85 ICP Forests Technical Report, 2004, available at http://www.icp-forests.org/RepTech.htm

86 Lange et al., BALANCE: an attempt to assess climate change impacts in the Barents Sea Region, Climatic Change, Volume 87, Numbers 1-2 / mars 2008

2007), however, in the case of the major tropical forest basins there is a risk of drastic rather than gradual change in the longer-term. Given these uncertainties the impact of climate change on the timber trade flows to and from Europe is difficult to predict. IPCC (2007) identified the significant abatement potential of the forestry sector. By 2030 the capacity to contribute to emissions reductions amounts to some 3 GtC per annum. Although sequestration resulting from afforestation and reforestation contributes to this abatement potential, fossil fuel substitution benefits, both direct (source of renewable energy) and indirect (timber replacing GHG-intensive materials) through sustainable forest management, has the potential to play a larger role in most regions of the world.

This mitigation potential, coupled to the urgent need for global efforts to address climate change, will provide an economic driver for climate change adaptation, while also determining – to some extent – the species that are planted in afforestation and reforestation programmes. In this context, adaptation and mitigation are linked and it will be important to consider adaptation when developing mitigation strategies. The potential for large volumes for biomass and bioenergy to be produced from forestry crops represent a particularly strong driver for forestry-based mitigation that is likely to lead to the widespread planting of fast-growing non-native species. It will be important to ensure that these are compatible with the local environment and play a role in helping both biodiversity and the landscape to adapt to climate change through not diminishing the ecosystem services provided by alternative land covers. This approach is achievable and, indeed, extensive Eucalyptus plantations in southern Europe are FSC certified.

10.2.3. Adaptive Capacity

For forestry, autonomous (or partially autonomous) actions have been identified. This list of measures is not intended to be exhaustive, but to outline the type of measures that might be considered. They focus on forestry/environmental measures that will achieve social, economic and environmental outcomes. Specific social and economic measures are not considered outside of those principles incorporated within Ministerial Conference on the Protection of Forests in Europe (MCPFE)[87] and standards for sustainable forest management:

- (Partially autonomous) Facilitate natural regeneration and forest growth in northern regions or high elevation areas (where low temperatures had been a limiting factor for growth) causing a shifting of the tree limit towards areas hitherto covered by grasslands or tundra.

- (Partially Autonomous) Increase diversity in forest (at genetic, species, age, stand and landscape levels). This may require explicit changes to forestry policy, respecting the principle of subsidiarity, as genetic diversification and the planting of species outside of their current natural range. At a more practical level, measures such as conversion to continuous cover systems of management will promote structural diversity.

- (Partially Autonomous) Favour more resilient species. Again, this may require changes to forestry/biodiversity policy at global/EU/national level. If non-native species are considered – either as a diversification measure in semi-natural forest or for commercial reasons in production forests/plantations, it is important to consider possible future impacts on on biodiversity. These impacts may include risks of invasiveness, the introduction of pests and diseases, inability to support local fauna and flora and incompatibility with

[87] www.mcpfe.org

existing natural/semi-natural ecosystems. Risks associated with such introductions should consider the impacts of climate change on such risks.

- (partially Autonomous) Enlarge woodlands and utilise topographical and edaphic heterogeneity in the landscape. The resilience of individual species to climate change is dependent on soil type, aspect and microclimate. Heterogeneity in the landscape may allows individual species to be retained if their specific requirements are considered. Larger woodland units also contain a larger and more varied genepool, promoting evolutionary adaptation processes.

- (Partially autonomous) Adapt management systems. Forest management has developed over time to accommodate extreme climatic events including wildfires and storms. Decision support tools are available but may need updating to reflect the projections of climate change. Fire and wind risk management plans may also need adapting to reflect the changing climate, ensuring that infrastructure is in place to cope with extreme events when they occur. At a practical level, a more flexible approach to management (adaptive management) will accommodate the impacts of climate change as they occur if supported by appropriate monitoring and guidance. For example, rotation length may need to be reduced to reflect increasing growth rates in northern Europe; fertiliser applications may change in response to changing growth rates and soil mineralisation rates; the planting window may need to change in response to changes in dormancy and water availability; and promoting regeneration through stand management and controlling agents that prevent regeneration will enhance the adaptive capacity of semi-natural woodland ecosystems.

- (Intervention required) Landscape approach to adaptation. The ecosystem services provided by forests can contribute to adaptation at the landscape level through the creation of habitat networks (aiding species migration and adaptation of biodiversity), flood alleviation and large-scale erosion protection. Such services provided by forests can provide a more holistic approach to adaptation that contributes to wider sustainable development objectives than 'grey infrastructure'. However, such an approach requires careful targeting and an appropriate planning framework to ensure that it is effective and maximises available resources.

- (Intervention required) Maintain and enhance forest monitoring. The development of climate change adaptation strategies and action plans is dependent on (a) identification of the impacts of climate change and (b) reporting on the success of adaptation measures. Both are dependent on a effective and comprehensive monitoring framework for forests including surveillance of the impacts of existing and introduced forests pests, pathogens and invasive species.

- (Intervention required) Communication, education, training and awareness raising. In many instances, climate change adaptation can be considered as embedding knowledge of predicted climate change within good forest management practices. Awareness-raising and communication of appropriate adaptation measures are therefore an integral part of adaptation. Communication of the likelihood and far-reaching impacts of forest fires in southern Europe – coupled to awareness raising of the risks to the public and the need for fire management plans to the sector – is a good example of implementation of this measure.

A recent study demonstrated[88] that mankind is significantly influencing the carbon balance of temperate and boreal forests, either directly (through forest management) or indirectly (through nitrogen deposition).

Given the high degree of uncertainty about the nature and direction of changes the best adaptation strategy is to keep as many options open as possible, which calls for diversity at species, age structure, stands and landscape levels. However, it will take at least a full rotation (from decades to well over a century) to alter the species composition of forests on the landscape level unless measures are taken to alter the composition before forests reach the age of regeneration (e.g., in the case of young forests falling victim of calamities). Measures to adapt the composition of existing forests represent the greatest challenge to the sector, with appropriate measures largely restricted to adjustments to existing good practice. For this reason, where opportunities for adaptation arise, early action is therefore crucial.

Table 9- Potential planned adaptation options for forestry

Type of action	Description
Share losses	We could refer to reforestation and reconstruction operations after large storms, many countries must have material on this. Put strategies in place to deal with large volumes of timber coming to market.
Mitigate the threat	As the forest microclimate is able to substantially compensate for macroclimatic changes, there is an added need for continuous-cover management, especially in semi-natural forests where natural regeneration is feasible (possibly requiring control of herbivore populations) (and desirable). Reducing other pressures including air pollution, habitat fragmentation and invasive non-native species will also make forests more resilient to climate change
Prevent effects	Diversified structures at the stand level (diversified species and age structure), may be difficult to implement because slow growth means long term investments, which may go against the short-term economic gains required by some commercial forestry operators. Prevention measures (changes species composition, genetic diversity, reduction of fuel loads to counter the threat of forest fires) are possible. The protective functions of forests are increasingly important in the context of climate change – for example flood alleviation and soil erosion control.
Change land use.	Diversified management approaches at the landscape level Changing land use to forest (afforestation) may be highly desirable for habitat restoration, to ensure connectivity (corridors) and to partially compensate losses of existing forests. Creating new forest through sequestration in growing biomass and the potential for timber and woodfuel to substitute directly and indirectly for fossil fuels. Protect biodiversity hotspots and climatic refugia. Such areas of special micro-climate that have allowed the survival of pockets of earlier vegetation through past climatic changes (normally connected to geographical features like caves, isolated hills, valleys) are likely to do so again in the future.
Change location of economic activities.	Changing land use may be an option under extreme circumstances (site becoming unsuitable for forests), otherwise it is generally not desirable
Communication, education and awareness raising	In many instances, climate change adaptation can be considered as embedding knowledge of predicted climate change within good forest management practices. Awareness-raising and communication of appropriate adaptation measures are therefore an integral part of adaptation.
Regulation and public	If measures consistent with climate change adaptation (for example, the requirement to address genetic

[88] Magnani et al., The human footprint in the carbon cycle of temperate and boreal forests, Nature 447, 849-851

procurement	and structural diversity) were introduced into Forestry Standards operating in Member States, the requirement for certification, particularly through public procurement, would promote the uptake of appropriate 'no-regret' actions.
Capacity Building	Preventive measures are likely to be of modest cost and may even save costs in the medium run but this longer term reasoning however requires integrated forest management and consolidation of ownership structures. The fact that wood and biomass are becoming more expensive and that increased productivity is needed, could be harnessed as an incentive to address fragmentation of forest ownership, long-time regarded as a major obstacle in economic terms. Supporting forest owner associations (FOA) and promoting shared management could be among the most important measures. Forest monitoring at EU level. In order to monitor the damages to (and the migration of) forests and issue clear policy messages, national forest inventories (NFI) must include new criteria (such as forest health, growth, diversity of tree species and ground vegetation, water and element budgets, reforestation/afforestation rates) and ensure their assessments are consistent/compatible/comparable with their counterparts in other Member States. The research community needs to gain better understanding of genes and seeds flows in forest ecosystems in order to learn how to facilitate such flows for adaptation (e.g. corridors or "stepping stones"). Research can also contribute to improvements in forest management and better targeting of intervention to achieve landscape scale adaptation.

10.2.4. Need for early action at EU level

A number of commitments have been made by Member States and the European Commission in MCPFE, which reflect the need for action on European forests, including adaptation to climate change.

The EU EU Forest Action Plan[89] provide direction for forestry policy, while respecting the principle of subsidiarity to allow Member States to implement specific actions that reflect local/regional environmental, social and economic circumstances. Importantly the Action Plan contains an Action directly relevant to climate change adaptation: "*Key action 6: Facilitate EU compliance with the obligations on climate change mitigation of the UNFCCC10 and its Kyoto Protocol and encourage adaptation to the effects of climate change. […] The Commission will continue to support research, training and studies on the impact of and adaptation to climate change. The Member States are invited to work on assessing the impacts of climate change, to raise awareness and to exchange experience, as well as to promote activities for mitigation and adaptation.*"

Rural Development refers to both MCPFE and the EU Forestry Strategy and funds already provide for a wide range of forest related possibilities, including support for restoration or re-establishing forests damaged by natural disasters/forest fires and for afforestation in support of a range of climate change objectives. It will, however, , be important to ensure that such measures introduced through Rural Development do not address adaptation (or mitigation) in isolation, but contribute to all aspects of sustainable development.

The forest sector has a crucial role to play in EU and global efforts to both mitigate climate change and protect biodiversity. This will require that adaptation measures are implemented to ensure both the productive capacity and ecosystem functions of European forests .are maintained. Unlike most other sectors, the planning horizon of forestry stretches from decades to centuries requiring that actions are taken now or in the near future to ensure the adaptive capacity of forests as climate change progresses. Actions must also be appropriate to both the current and future climate and reflect considerable uncertainty in the climate of the future.

[89] COM(2006) 302 final

The argument that this uncertainty should delay action is not a tenable position given the urgency for action. It does, however, mean that no regret actions should be sought that focus on increasing resilience, reducing other pressures including atmospheric pollution and forest degradation and embedding knowledge of the likely impacts of climate change in sustainable forest management practice.

In some regions of Europe the effects of climate change are starting to become evident and an increasing frequency of devastating forest fires have been recorded recently in both northern and southern Europe. Some less visible impacts of climate change are also becoming apparent, including declining crown condition in some species. Early action is required for this climate-sensitive sector to prevent further damages and costs. To support such early action, it is important to monitor the impacts of climate change on forests as they arise to both demonstrate the need for action and to inform developing adaptation strategies and action plans, as outlined in the EU Forestry strategy. National Forest Inventories can contribute to such monitoring efforts, as can EU instruments such as Life Plus under which ring-fencing for forest-related activities could be considered.

10.3. Fisheries and Aquaculture

10.3.1. Impacts

The future impacts of climate change are expected to result in a number of changes in the abiotic (i.e. sea level, sea temperature, acidity, salinity, stratification, light, and possibly thermohaline circulation) and biotic (i.e. primary production, food webs, etc) conditions of the sea. It is generally accepted that the reproductive success of marine organisms depends almost exclusively on these environmental conditions, and so these will affect fisheries.

However, fishing is a "harvesting" activity (rather than a "cropping" one involving seeding and nurture), and human activities also affect the reproductive success and abundance and distribution of marine organisms. Climate change is an additional pressure on fish stocks whose resilience is low, because of the impact of fishing activities and, to a lesser extent, pollution or physical destruction of habitats.

The impacts of climate change are already being observed in European Seas[90]. As outlined in the section 2.2.1, sea surface temperatures in Europe are rising, and this increase has led to many marine organisms in the European Seas appearing earlier in their seasonal cycles than in the past (EEA, 2008), for example, some species have moved forward in their seasonal cycle by 4-6 weeks (high confidence). These changes have important consequences for the way organisms within an ecosystem interact and ultimately for the structure of marine food-webs at all trophic levels, including fisheries. In addition, many species of fish and plankton have shifted their distributions northward, and sub-tropical species are occurring with increasing frequency in European waters whilst sub-arctic species are moving northwards. As examples: there has been a major northward movement of warmer water plankton in the north-east Atlantic (1100 km over the past 40 years) and a similar retreat of colder water plankton to the north (EEA, 2008) and this will have an impact on distribution of fish in that region (high confidence); rate of north-ward movement of a particular species, the sailfin dory, has been

[90] Halpern et al., 2008, A Global Map of Human Impact on Marine Ecosystems, available at www.sciencemag.org/cgi/content/full/319/5865/948/DC1

estimated at about 50 km/year (high confidence). Such changes affect the composition of local and regional marine ecosystems.

These observed changes in distribution, and the ones that are likely to occur with future climate change do not necessarily reduce the overall fishery potential, but might lead to changes by region or changes in the commercial value by region. Recent studies[91] have shown that the northward movement of southerly species has caused species richness to increase in the North Sea. However, this increase may have negative ecological and socio-economic effects; the three large species that have decreased their range the most in the North Sea are all commercially relevant species, while only one of the five most increasing species and less than half of the all the species that expanded their range are of commercial value. A climate change induced shift from large to smaller species is thus likely to reduce the value of North Sea fisheries. The changes in distribution may also affect the management of fisheries and have implications for allocations of quotas.

The other impacts of climate change on fisheries potentially include food chain effects, diseases, and for marine ecosystems, increased ocean acidity, though the levels of catch (and sustainability) of commercial fisheries are likely to remain a more direct factor affecting fisheries. The changes from climate are therefore likely to increase the vulnerability of fisheries.

It is too early to ascertain any actual impact of climate change on abundance of commercial stocks, because fishing (resource exploitation) dominates the pressure exerted over marine biodiversity. It is also not currently possible to predict whether northward shifts in distribution will have a positive or a negative effect on total fisheries production With time, such effects are expected to be more directly observable, though further changes in distribution and potentially the abundance of marine species are likely. Further work is needed, however, to establish causal relations between changes in stocks and climate change parameters. These changes are likely to include:

- Changes in the abundance and distribution of fishes and zooplankton, related to changes in sea temperature. Fish communities will move in order to reach areas where the temperature is within their tolerance range.

- Rising sea temperatures could allow some invasive species to become more frequent in EU waters, related to changes in temperature too. New species may be better adapted and displace autochthonous communities.

- Changes in the food webs' components, resulting in changes of geographical distributions: fishes migrate, following their prey.

- In a few situations e.g. early retreat of sea ice in Arctic areas, there may be increases in fish catch[92].

- There are other factors in relation to regional seas, e.g. temperature is projected to increase and run-off to the Mediterranean Sea to decrease; for the Baltic sea, both

---

91 Hiddink, J.G. & ter Hofstede, R. (2008) Climate induced increases in species richness of marine fishes. Global Change Biology 14: 453-460, available at http://www.bangor.ac.uk/~ossc06/

92 Impacts of a Warming Arctic –synthesis report of the Arctic Climate Impact Assessment, 2004, available at http://www.acia.uaf.edu/

increasing run-off and decreasing frequency of Atlantic inflow is likely to decrease salinity (EEA, 2008), in turn affecting sea ice cover and stratification – the latter may impact on commercially relevant regional cod fisheries.

These projected changes in the location and availability of fish stocks will have strong economic impacts, as well as localised employment and social consequences, in coastal areas where fishing activities constitute the most important source of revenue. However, the marine environment offers less barriers to dispersal of species in response to climate change than the terrestrial environment, i.e. marine species generally have a larger potential for migration (autonomous adaptation).

As with other activities, environmental drivers may affect the outcome of aquaculture, namely as regards the availability of adequate resources upon the exploitation of which aquaculture is developed, such as clean water, feed, etc. Likely impacts of climate change on marine and freshwater aquaculture may be both negative and positive. Negative impacts include stress due to increased temperatures and oxygen demands; increased susceptibility to pathogens; uncertain supply of freshwater; sea level raise; extreme whether events such as flooding and storm. On the other hand, positive impacts would include increased growing seasons, growth rates, feed conversion and productivity for some species; as well as opportunities for new species. Deeper knowledge, data and research on the impacts of climate change on aquaculture are needed in relation to marine and freshwater ecosystems and social and economic consequences for the industry

10.3.2. External dimension

One illustration of external action in fisheries is the commitment of the Community to contributing to the sustainable development of fishing activities at the international level (WSSD /Johannesburg). This commitment needs to be strengthened via bilateral fisheries agreements, regional Fisheries Organisations and the UN Convention on the law of the Sea. Ambitious agreements at global level are a key addition to any action at European level, as the fisheries market is a global market and the recovery of fish stocks in the European seas is only relevant if this happens at the global scale as well. There may be external factors if important commercial species migrate out of EU waters.

10.3.3. Adaptive Capacity

Autonomous adaptation consists in adapting to new and constantly changing conditions for fishing. Fish species will occur in areas where they did not occur before. This creates the risk of the development of unregulated fisheries and early measures need to be taken to manage emerging fisheries, which results a more cost-effective approach than try to reverse over-fishing at a later stage.

The potential adaptation actions are:

– Maintain (or rebuild) resilience of marine ecosystems and fisheries. This means that we should do effectively what we try to do anyway - to reduce the fishing pressure and fisheries impacts on ecosystem. Climate change is an added stress on marine ecosystems and fish stocks on top of over-fishing, pollution etc. Climate change therefore makes the need to reduce fishing pressure even more urgent. The first priority is therefore to do effectively what we try to do already to move to sustainable fisheries – to reduce overall fishing pressure and reduce capacity

– Ensure that adequate measures will be taken as changes appear by developing a responsive and responsible decision framework . Climate change has highlighted that we have been operating within a false mindset of nature being constant - climate change and considerations of ecosystem linkages require management to be adaptive in a changing environment. Proper monitoring and scientific analysis needs to be in place which enables early warnings of changes and also of regime shifts. However, warnings about regime shifts are very difficult to get because science does not have good methods to identify such shifts in the early stages. Management plans must be made such that they are adaptive. This is what we already are trying to do with most recent plans. The discussion paper for the next cod recovery plan does specifically mention the changing environment as a reason to propose a new approach. We need to develop a responsible and responsive decision process which do not lead to complacency in times of little change and can react rapidly when required.

– Prepare response to distribution issues as fish stocks change distribution or new fishing conditions appear. Questions of distributions of access will be raised in international fora as the geographical distribution of stocks change. We need to discuss and get decision rules for this early on, preferably before the changes in the sea have taken place. Another case is 'new' stocks, when fish species occur in areas where they did not occur before. This creates the risk of the development of unregulated fisheries and early measures need to be taken to manage emerging fisheries – it is difficult to reverse overfishing. We must establish mechanisms which introduces regulation (and distribution of access) in such cases. The increased access in the Arctic due to reduced ice cover is a specific case of 'new' resources becoming available to fisheries which need mechanisms to distribute access. We need to use a sort of precautionary approach, not to repeat the same kind of activity that led to current overfished situation.

Table 10- Potential planned adaptation options for fisheries and aquaculture

Type of action	Description
Share losses	Compensations for decreased productivity
	Taxes on ecological costs of fish, charges
Mitigate the threat	Switch to new species
	Increase imports
	Reduce production inefficiencies and waste
	Improve efficiency of fishing operations by more energy effective fishing gear and methods and by removing overcapacity in the fleet
	Reduce fishing pressure
Prevent effects	A formulation of the best choice generally accepted is that the resilience of marine ecosystems vis-à-vis climate change should be increased with a view to making it easier for them to endeavour the changes induced by human activities and to recover to a "normal" situation.
	Since fishing itself is the most important pressure, it should be managed in a way that the cumulative effects of all pressures diminish, with the aim to allow the recovery up to an adequate level of resilience. That is, fisheries managers should increasingly take into consideration the impacts of climate change and ensure the lowering of the impact of fishing activities in particular. This option could be applied to many (not to say all) commercial stocks. Allocate species combinations and access at ecosystem level

Type of action	Description
Change location of economic activities.	Development aquaculture
Capacity Building	Changes in consumer preferences, eco-labelling and certification

10.3.4. Need for early action at EU level

Fish communities do not know borders, although fishing activities are thoroughly organized at national, European and worldwide levels.

Marine ecosystems (including also commercial stock s) affected by climate change spread over maritime frontiers, and the level of the actions required to tackle climate change are likely to do so. If, on top of that, one takes into account that fisheries management measures fall within the Common Fisheries Policy, an exclusive EU competence, the European dimension comes out as an undisputed playing field.

Taking into consideration the poor status of commercial stocks, early action is needed to cope with additional pressures from climate change on fisheries. Scientific agencies assess each year whether the stocks are at risk that their future reproduction will be compromised, *i.e.* whether they are outside "safe biological limits". Largely because of inaccurate catch reports, the state of some 57% of stocks is unknown. Of those stocks for which the state is known 68% are at high risk of depletion, and only some 32% of stocks are known to be fished sustainably. In 88% of stocks, overfishing is so serious that more fish would be caught if there was less fishing. This number is way above the situation outside the EU where the global average is 25% of stocks being overfished. Some 19% of stocks are in such bad state that scientists advise that there should be no fishing.

There is also overcapacity in the fishing fleet with too many vessels chasing a dwindling resource. This leads not only to poor economics abut also to poor energy-efficiency.

Adding climate change stress on top of this means that there is an urgent need to reduce the overall fishing pressure on marine ecosystems and to reduce the overcapacity in the fishing fleet in order to contribute both to a lower fishing pressure and to lower greenhouse gas emissions.

It is an integral aspect of the precautionary approach that fisheries should be conducted in a way which is robust to environmental change and thus that fish stocks should never be exploited to a point where they are not resilient to environmental change[93].

10.4. Energy

10.4.1. Impacts

Climate change (and most of subsequent mitigation or adaptation options) is expected to have a direct effect on both the supply and demand side for energy

[93] COM(2008)187 final

10.4.1.1. Energy supply

The changing climate may have significant effects on most energy technologies, particularly affecting hydro-electric resource, and water abstraction availability for cooling of thermal plants:

- Decreased precipitation is expected to have a negative impact on the electricity generation sector where rivers provide cooling water. Power stations may have to be shut down when water temperatures exceed certain thresholds. Electricity production has already been reduced in various localised locations in Europe during very warm summers. This will affect countries which use the largest percentages of abstracted water for cooling in energy production. Rising temperatures and lower river levels may combine to result in a lower efficiency of thermal power plants, due to higher power demand for pumps to maintain desired condensing temperatures and due to changes from wet to dry cooling towers. Note that these effects may coincide with periods of high demand for cooling.

- The share of hydropower to the total electricity generation (excluding generation from pump storage) was 9.3% in 2006 for EU-27[94]. If Norway and Switzerland are also included in this calculation the share would be 13.1%. Increasing precipitation in countries north of the Alps and Portugal, as well as melting glaciers in the Alps may increase run-off water and increase the potential for hydro electricity generation. Even in countries with little change in the annual amount of precipitation, patterns are changing which may result in varied run-off and water resource availability for hydro generation during extended periods of low precipitation. In Mediterranean/Black Sea countries, hydropower generation is likely to suffer from reduced annual precipitation, due to changing climate patterns. The projected change in river runoff due to climate change is estimated to increase hydropower production by up to 25 % or more in northern Europe and decrease it by about 25 % or more in the south (EEA, 2008) and the hydropower potential in the continent is expected to decline by 6% by the 2070s.[95]. Dam safety may be affected under changed climatic conditions with more frequent extreme flows and possibly natural hazards

- Higher temperatures and atmospheric CO_2 concentrations in moderate climates (north of the Alps) may be beneficial for the growth of biomass. This may favour electricity/fuel generation from agricultural crops, manure and wood chips. However, reduced water availability or extreme events in some regions, notably in Southern Europe, might have detrimental effects on crop yields and therefore the potential for growth of biomass for energy purposes.

- Efficiency of photovoltaic plants could slightly be reduced due to higher temperatures, particularly during heat waves, though climate could also have other effects (e.g. increased or decreased cloud cover at different times).

- Increasing average wind velocities improve the electricity output of wind converters. However, the extent of increasing wind velocities for Europe is still unknown, and higher frequencies of heavy storms may negatively affect total annual wind power generation.

- Extreme weather events, including storms, damage electricity transmission lines. These may be vulnerable to incidences of increased storm frequency or magnitude from climate

94 Eurostat's 'Yearly Energy Statistics 2006'

95 IPCC Fourth Assessment Report WG II, Chapter 12, p.556.

change. Climate change is also likely to result in (albeit limited) electricity transmission losses due to higher average temperatures. Increased temperature and heat waves may increase the resistance of power lines. The vulnerability of electricity transmission may vary across different member states and regions depending on the age of this infrastructure, the nature (e.g. overhead or underground cabling) and the remoteness of regions.

10.4.1.2. Energy demand

Energy use for space heating is currently much higher than use for cooling in Europe (particularly in the North). Future projections suggest reductions in winter heating demand, but increases in summer cooling (EEA, 2008). However there are strong distributions of effects between regions in Europe. Both heating and cooling demand changes will be driven by autonomous adaptation in the absence of planned policy, and will be affected by wider socio-economic and technical trends, as well mitigation policy, affecting demand. The IPCC WGII Europe Chapter reports reductions in winter heating demand of 10% by 2030 in the south-east Mediterranean region and 20-30% by 2100 in Finland under a business as usual scenario – though the reductions will be lower in the longer-term projections under a mitigation scenario. These reductions are most significant for Northern countries due to the high levels of winter heating. Conversely, it reports increases in summer cooling demand, with examples of up to around 30% increase by 2030 and 50% increase by 2080s in some Mediterranean countries, again under a business as usual scenario. These increases are also important in relation to mitigation efforts. These demand changes are expected to be largely autonomous, though they will be affected by socio-economic trends (e.g. population, housing density and insulation, design, planning, efficiency, income). There may also be an emerging issue of increased energy demand for water supply (pumping, desalination, etc).

The net change in European energy demand is uncertain, but there will be strong distributional patterns, with significantly reduced space heating demand in northern Europe compared to significantly increased space cooling demand in Southern Europe. The actual net economic costs are more complex to estimate, as winter heating demand is primarily from fossil fuel use, whilst summer cooling is from electricity, and there may be additional issues of peak electricity demand across Europe, especially in Southern Europe in the summer. This may result in serious problems for the grid dimensions.

There may also be some supply-demand linkages. Increasing summer peaks for cooling, combined with heat extremes, will potentially change plant margins, requiring extra system capacity to meet peak summer extremes (with higher prices for marginal electricity at peak). The electricity supply mix and distribution systems will be important here, and could have potentially positive or negative effects, e.g. the availability of renewables for peak supply (intermittency) or decentralised energy might in some cases exacerbate these peak issues (though it might have other benefits in relation to lower vulnerabilities to other supply disruptions).

10.4.2. External dimension

There are linkages with other external generation networks (e.g. non EU European countries), and external electricity production and transmission (e.g. Maghreb). Moreover, security of supply maybe an important external issue, for example with the potential effects of climate change on infrastructure supplying Europe such as international gas supply pipelines and impacts on fossil fuel extraction in areas that supply Europe. These external effects need to be

further explored. The potential impact of permafrost melting on gas supply from Russia is also a topic which needs to be explored in detail.

10.4.3. Adaptive capacity

Table 11- Potential planned adaptation options for Energy

Type of action	Description
Share losses	Insurance products for energy infrastructure to incentivise rapid recovery of energy services.
	The social, social, economic, or environmental losses as a result of a crippled energy infrastructure system may be too great for any private capacity to undertake remediation therefore responses to be coordinated through public structures, as in the case of natural disasters.
Mitigate the threat	Anticipate demand changes to ensure that sustainable buildings incorporate adaptation considerations.
	Promote efficient cooling systems where these are necessary.
	Improve multi-site coordination
	Adapt nuclear plants maintenance planning by reducing coastal planned shutdown for maintenance during summer periods
	Invest and install extreme peak load facilities, or alternatives (storage, better connectivity between grids)
Prevent effects	CCA criteria on new investments. New regulation policy to ensure sustainable generation and distribution
Change land use.	Promote decentralised sustainable energy generation where appropriate to local conditions.
Change location of economic activities.	The location of energy supply will move to less vulnerable locations (areas not affected by sea level rise, floods, decrease water availability, changes in water quality, extreme weather events, etc.)
	More decentralised or dispersed energy supply infrastructure may be used to reduce risk.
	Major investments in relocation and reinforcement of the Energy Grid and connections
Capacity Building	Review vulnerability of current and planned power generation and distribution systems within and outside of EU for all energy flows to, from and within EU, including potential future changes in plant production (including intermittency), peak supply, and plant margins, at cross sectoral level (including demand from new sectors such as water).
	New market players may see opportunities for new types of energy supply investment in a more vulnerable energy market.
	Review energy mix for mitigation and RES targets: focus on energy efficiency
	Enhancing commercial deals with high consumers for reducing loads
	Enhance capacity of staff to anticipate and plan for extreme events and rapid reaction response plans

The adaptation of energy supply system to CC impact may trigger building new infrastructure for the protection of existing infrastructure, as well as building new power plants and distribution grid. These projects will have substantial environmental impacts, to be addressed under environmental impact assessment, and should be compared with alternative solutions such as energy efficiency improvement and infrastructure protection through green structural approach.

10.4.4. Need for early action at EU level

As mentioned before, there are solidarity issues in relation to demand issues, because of the strong distributional pattern of future demand change.

There is a need for further research to improve understanding of the inter-relations between projected climate change scenarios, impacts (including humidity) and electricity demand

There is a need for building adaptive capacity in the energy sector and mainstreaming climate change throughout EU energy policy (including supply choices)

The need for trans-boundary co-ordination and of greater inter-connections between regions and countries to help electricity flows. There is a role for co-ordination of network regulators.

There is a need to encourage innovation in terms of energy storage or building design to store energy, as well as smarter grids and systems to use energy more effectively.

As regards the security of supply (increase resilience energy system), there is a need to increase the resilience of existing energy infrastructure and ensuring new energy infrastructure is resilient to future climate impacts, including extreme events;

As regards the trans-boundary dimension of water management aspects, there is: need to consider water supply for energy in the perspective of changes in overall water availability / trade off with other uses (see water section)

There are links with mitigation and it is necessary to avoid mal-adaptation (through energy policy or autonomous responses) that would cause an increase in energy consumption and GHGs emissions (e.g. air conditioning)

Early action is needed to build capacity to adapt in the energy sector. Energy infrastructure (plant and transmission) has long life-times, and so climate risk needs to be considered and integrated as early as possible. Some autonomous adaptation is already taking place, so there is a need to assess situation, highlight issues with member states, and address trans-boundary issues.

10.5. Infrastructures and Buildings

The main vulnerability of the built environment including infrastructure is to extreme events (floods and storm events, sea level rise, coastal erosion rates, and to a lesser extent also heat-waves and droughts). These pose a specific threat to the urban environment, and may particularly materialise in coastal areas and river basins. It is likely that extreme weather, including heavy precipitation will increase in frequency and intensity in Europe, though the most severe effects are expected in the second half of the century. Coastal zones in Europe contain large populations. One third of the European Union (EU) population is estimated to live within 50 km of the coast, and some 140,000 km2 of land is currently within 1 m of sea level (EEA, 2006). Climate change is an additional pressure and will impact in the frequency and/or intensity of extreme weather events, such as storms and associated storm surges, as well as sea level rise.

Infrastructure and building are likely to be able to withstand climate changes within a given set of boundaries and thresholds, enabling some resilience in relation to climate changes. However, planned options are required to deal with market failures (infrastructure provision

as public good, principal agent problem in buildings, etc.) and to face more extreme climate scenarios. Whilst some new building may have some integrated adaptation measures (improved insulation, more air-conditioning, water harvesting), the location and site of buildings may not take into account the impacts of climate change on the site itself (for example when building on flood plains). Autonomous changes in buildings are not likely to be able to cope with, nor necessarily take into account the more erratic or extreme climate changes, such as increased frequencies of extreme events. In the case of these events losses are more likely to be incurred.

As pointed out in Nordregio (2007)[96], there may be advantages securing functionality rather than on protecting individual infrastructures, in other words in extending critical infrastructure protection to critical infrastructure resilience (CIR), of which CIP is an important part. This concept is based on the statement that complete protection can never be guaranteed, that a small amount of extra protection might introduce a large amount of additional costs, that very often, achieving the desired level of protection is simply not cost-effective in relation to the actual threats. "*What is especially important here is to create "societal resilience" capacity relying on joint efforts, training, continuity planning etc, of the whole society, including communities and businesses*"[97].

Climate change damages to Europe's infrastructure and buildings may affect the proper functioning of the European internal market (e.g. closure of ports, airports, road and rail infrastructure). Infrastructure networks are often trans-boundary and therefore adaptation needs to be coordinated. Furthermore, there is a significant amount of EU funds available for infrastructure projects, in which climate adaptation considerations should be integrated. As infrastructure and building investments may have a long lifetime (>50 years), and so are likely to experience a changing climate. Climate mainstreaming for new infrastructure and buildings will most likely be cost-effective and proportionate.

10.5.1. Impacts

The main potential vulnerability of the built environment and infrastructure is from extreme events, such as floods and storm events, and to a lesser extent also heat-waves and droughts and to their impacts on soil stability (landslides, coastline erosion). These extreme events will affect all regions, but pose a specific threat to the urban environment, where infrastructure and the built environment are most concentrated. Climate-related hazards will mostly increase, although changes will vary geographically (very high confidence) (IPCC, 2007). Socio-economic factors are instrumental in the vulnerability to climate impacts from these extremes, including changes to population growth, occupancy, land-use policy, economic growth, etc.

In Europe, 64 % of all loss events since 1980 are directly attributable to weather and climate events (storms, floods and heat-waves) and 25 % are attributable to wild fires, cold spells, landslides and avalanches, which may also be linked to weather and climate; 95 % of the overall losses of catastrophic events result from these weather and climate related events (EEA, 2008). Overall losses caused by weather and climate related events have increased during the period 1980-2007 from a decadal average of less than €7.2 billion (1980-1989) to

---

96 Nordregio Report 2007:5 Towards a Baltic Sea Region Strategy in Critical Infrastructure Protection, Christer Pursiainen (ed.) with the assistance of Patrick Lindblom and Per Francke

97 Boin and McConnell (2007) Preparing for Critical Infrastructure Breakdowns: The Limits of Crisis Management and the Need of Resilience. Contingencies and Crisis Management, Volume 15 Number 1, March 2007, pp. 50-59. in: Nordregio (2007)

about €13.7 billion (1998-2007). However, while overall losses resulting from weather and climate related events have increased clearly during the last 27 years, better reporting, social change and economic development (land-use changes) are mainly responsible for increasing losses (high confidence). The most important economic losses are from flooding. The 2002 flooding of Austria, the Czech Republic, Germany, Slovakia and Hungary resulted[98] in overall losses of about € 16.8 billion and insured losses of about €3.4 billion.

It is very likely that extreme weather such as heat waves, droughts and heavy precipitation will increase in frequency and intensity in Europe, for example (EEA, 2008) project that the hydrological cycle will increase the occurrence and frequency of flood events in large parts of Europe (medium confidence), even though that estimates of changes in flood frequency and magnitude remain highly uncertain. Within the next 20 years projected changes in the intensity and frequency of extreme events- depending on the time scale and hazard- remain uncertain. The most severe effects of human-caused climate change are expected in the second half of the century. Some preliminary estimates[99] indicate that annual flood losses in Europe could rise to €100 – 120 billion (tenfold) by the end of the century. More detailed disaggregated work under the PESETA project has modelled changes in river flows in a changing climate in Europe, studying two river catchments (Upper Danube and Meuse) in detail. For the Upper Danube the estimated total damage of a 100-year flood is projected to rise by around 19 % from current levels under a low emission scenario (B2) by 2100, and 40% (an increase of €18.5 billion) under a high emission scenario (A2). The number of people affected in the Upper Danube is projected to increase by 242,000 (around 11%) for the A2, and 135,000 (around 6%) for the B2 scenario.

Coastal zones in Europe contain large human populations and significant socioeconomic activities related to infrastructure and buildings. Section 10.8 deals specifically with coastal zones. Climate change is an additional pressure and is likely to have significant impacts on coastal zones, particularly via changes in the frequency and/or intensity of extreme weather events, such as storms and associated storm surges, and sea level rise.

There are projections that the losses from extreme European storms will increase by at least 5% to €25 – 30 billion by the 2080s (ABI, 2005), and Swiss Re estimate that in Europe the costs of a 100-year storm event could double by the 2080s with climate change ($50/€40 billion in the future compared with $25/€20 billion today).

The effects of heat extremes and drought have important effects on buildings and infrastructure (including transport infrastructure), and the recent hot summers have been linked to large economic damages associated with building and infrastructure from ground subsidence (high confidence). Notwithstanding the absence of a general trend in Europe as a whole, the EEA (2008) report considers that climate change has likely increased the frequency and/or severity of droughts in some regions (medium confidence). It also reports that climate change is projected to increase the frequency and intensity of droughts in many regions in Europe due to higher temperatures, decreased summer precipitation, as well as more and longer dry spells (high confidence) particularly for southern and south-eastern Europe – discussed further in the cross sectoral water section. Heat extremes may be particularly important in larger urban areas, because of exacerbation of the existing 'urban

[98] Münchener Rück, 2008

[99] Association of British Insurers, Financial Risks of Climate Change, June 2005, available at http://www.abi.org.uk/Display/File/Child/552/Financial_Risks_of_Climate_Change.pdf

heat island effect'. There will be increased fire risks or wider fire risk areas, which are likely to be particularly important for the Mediterranean region in relation to significant increase of fire potential, an enlargement of the fire prone area and a lengthening of the fire season.

Average temperature changes may also affect building and infrastructure. In some areas of the Alps, the gradual warming of permafrost and subsequent increased ground instability will also have implications for existing buildings and infrastructure.

There are distributive effects in relation to the impacts of climate change. Coastal regions across Europe and large plains in Central Europe are more vulnerable to flooding impacts than other regions, whilst the risk of storm related damages are higher in north-west Europe. These effects will have greater impacts on socially deprived groups, which will often be compounded because of their higher vulnerability and lower adaptive capacity. Deprived groups have lower levels of flood awareness, for example, and so are likely to be less well prepared. Social capital is also thought to be weaker in deprived areas and so provides less of a resource to deal with the flood and consequence.

It is also probable that more frequent, intense or unpredictable extreme climate events will increase insurance claims, which is likely to translate into higher risk premiums and possibly to increased levels of uninsured and under-insured assets. The rising cost of insurance is likely to have significant equality effects. Uninsured and under-insured households and businesses are likely to be those with lower adaptive capacity, further exacerbating the vulnerability of high-risk companies and communities. The autonomous response of insurance markets will therefore cause inequalities throughout Europe, both on an inter- and intra-MS level.

10.5.2. External dimension

Port infrastructures are among the most vulnerable to climate change impacts (sea level rise and subsidence in some regions, higher frequency of violent storms and flooding) and this may affect the growth and geographical distribution of global freight transport. This external effects need to be further explored.

10.5.3. Adaptive Capacity

As explained in OECD (2008), Infrastructure is a high-valued asset which is particularly vulnerable to climate change on account of its long lifetime over which climate change impacts will become progressively more pronounced. Adaptation costs for infrastructure, therefore, could have two interlinked but different meanings: 1) the costs of infrastructural solutions that serve as adaptations in many climate sensitive sectors or regions; and 2) the costs of "climate-proofing" infrastructure itself to the impacts of climate change. With regard to the former perspective, many of the cost estimates for adaptation in coastal zones, water resources, energy, and (to some extent) agriculture are in fact, infrastructure costs. This includes costs of protective structures in coastal zones, storage or irrigation infrastructure for agriculture and water supply, as well as energy supply infrastructure.

Table 12- Potential planned adaptation options for Infrastructure and buildings

Type of action	Description
Share losses	Insurance schemes for key infrastructure in vulnerable areas
	Green-Building insurance

Type of action	Description
	Public infrastructure e.g. road, shared water ways, bridges etc. may incur losses met by insurance or public purse.
	Specific financial support for coastal regions
Mitigate the threat	Coasts: increased investments in coast protection promoting a combination of 'hard' (defences) and 'soft' (managed realignment or retreat) adaptation measures. This combination of coastal management will increase coastline inundation in specified locations.
Prevent effects	Review climate resilience (water availability, sea level rise and floods, extreme weather events) of the transport network and the need to update it
	Review of integrity of other infrastructure, property and defence assets in terms of resistance and resilience to climate impacts.
	More requirements for urban planning (e.g. prohibition of building in flooding areas, more space for ecosystems and water retention to reduce flash flooding, green spaces for passive shading) – coordinate with proposals for land use
	Buildings: adapting planning and building codes to ensure minimum adaptation standards for new build to include site selection, materials and techniques ; new markets for climate-proof existing and new buildings,, material and products;
	Educating building owners and occupiers on what to consider in relation to preventing impacts on private buildings.
	Water/Energy efficient passively ventilated buildings and urban green space management to reduce heat stress (urban heat island effect, water resources)
Change land use.	Soft adaptation measures such as "making space for water" through managed retreat option and altering land use at the coast. This can bring benefits to biodiversity, i.e. creation of new saline habitats to replace existing inter-tidal habitats currently at risk due to sea-level rise.
	Review land-use planning and management to better integrate risks and constraints on buildings and infrastructure related to climate change.
Change location of economic activities.	Relocation of critical vulnerable infrastructures and buildings which provide essential services to communities.
Capacity building	Investment appraisal procedures and plan/infrastructure assessment should be updated to integrate potential Climate change impacts (e.g. longer planning horizon, including climate change impacts).
	Availability and training of the workforce in the sector are challenging pre-requisites for adaptation; public policies (building codes, urban planning) have a key role in driving adaptation in this sector.

10.5.4. Need for early action at EU level

There is a need for trans-boundary coordination, e.g. in relation to floods and an assessment of key vulnerable zones needs to be undertaken and trans-boundary issues addressed and highlighted to affected member states.

Climate change damages may affect the proper functioning of the European internal market (e.g. closure of ports, airports) and infrastructure networks are often trans-boundary and therefore adaptation needs to be coordinated.

Climate change resilience needs to be mainstreamed into major investments in infrastructure, financed by the EU

The uneven distribution of damages needs to be addressed, related to the European solidarity principle.

Early action is needed to build capacity to adapt in the infrastructure and buildings sector.

– Infrastructure and building investments may have an extreme long lifetime (>50 years), and so are likely to experience a changing climate. Climate mainstreaming for new infrastructure and buildings will most likely be cost-effective and proportionate.

– Many existing buildings are not resilient to current weather and associated impacts, therefore the need for considering existing buildings is required and will take time to establish and implement. Without such policies and programmes, the vulnerability of such buildings will increase over time as the impacts of climate change increase.

– Early planning for new infrastructure and displacement of vulnerable infrastructures would enable the related investments to take place over a long period in an orderly manner (reacting to disasters is usually more costly than anticipating and preparing for them).

10.6. Industry and Services

10.6.1. Impacts

10.6.1.1. Tourism

Mass summer tourism is closely associated with climate, in terms of the source of tourists and their preferred destination. At present, the predominant (summer) tourist flows in Europe are from north to south, to the coastal zone. The Mediterranean region is the world's most popular holiday region: it attracts some 120 million visitors from Northern Europe each year, the largest international flow of tourists on the globe and their spending is in excess of 100 billion Euros (EEA, 2008). There is also a major winter sports tourism industry in Europe, contributing close to EUR 50 billion in annual turnover to the economy of Alpine countries[100]. Coastal and mountain tourism are the segments that are most vulnerable to climate change in Europe.

The effect of climate change (EEA, 2008) is likely to make outdoor activities in northern Europe more attractive, while summer temperatures and heat waves in the Mediterranean, potentially exacerbated by limited water availability, may lead to a redistribution or a seasonal shift in tourism away from the current summer peak, either to a bi-modal distribution either side of the summer peak, or a transfer to other more northerly regions of Europe, which become more attractive, as shown in modelling work within the PESETA project[101]. The potential shift in the major flows of tourism within the EU will be important in regions such as some Mediterranean regions, where tourism is a dominant economic sector, though autonomous adaptation responses will be critical.

There are projected reductions in snow-cover over the 21st century (IPCC, 2007), which will affect the winter sports industry in Europe and its financial viability, because of the availability of natural snow or suitable conditions for making snow. The OECD (2007) report that the number of snow reliable ski areas in Austria, France, Germany, Italy, and Switzerland are projected to drop from approximately 600 to 500 if temperatures rise by 1°C, to

---

[100] OECD, 2007 - Climate Change in the European Alps: Adapting Winter Tourism and Natural Hazards Management, available at http://www.oecd.org

[101] http://peseta.jrc.ec.europa.eu/docs/Tourism.html

approximately 400 if temperatures rise by 2°C, and to approximately 200 in a +4°C scenario. Note that some autonomous adaptation (snow machines) by winter sport resorts may impact on the availability of fresh water and increase energy use.

There is also an issue of cultural heritage and the potential threat of climate change (which includes but is wider than tourism alone). This is an emerging area, though it is clearly important for many European cities.

10.6.1.2.Industry

The most vulnerable industries are (IPCC, 2007) those in coastal and river flood plains, those whose economies are closely linked with climate-sensitive resources (such as agricultural and forest product industries, water demands and tourism), and those in areas prone to extreme weather events (see infrastructure section). This may lead to an increased risk for buildings and production assets, further needs in insurances and increased related financial costs. Water scarcity is likely to increase the difficulty and cost of using water resources, with important consequences for resource-intensive industries such as food and paper industries in affected regions. There is a decline of industrial water abstraction in OECD countries in recent years, which is primarily the result of increased water use efficiency but may also reflect a shift of water-intensive industries (for other reasons, like other industries exposed to international competition) to third countries. However, the emergence of new water-intensive industries (e.g. certain types of biofuel production) or the growing importance of existing water-intensive industries such as electronics will be conditioned by water availability and be subject to delocalisation to areas without water stress.

Small and Medium-sized Enterprises may have more difficulties than larger companies to assess the risks and consequences of climate change for their business.

There are also a set of wider issues related to the concentration of economic activity in the industry sector. These include potential effects that climate change may have on the physical assets used for economic production and/or services, on the costs of raw materials and inputs to economic production, on the subsequent costs to businesses, and thus on competitiveness (or comparative advantage) and wider economic performance, and employment patterns. There are also the wider issues for the financial service and insurance sectors.

10.6.2. External dimension

For EU services and industry in general, the external dimension may be positive: the need for expertise and technologies to support adaptation measures throughout the world should create many opportunities for EU companies to develop outside Europe, export or transfer technologies and know-how. This should be particularly the case in the water sector (urban water supply including development of desalination, technologies for water saving and re-use), energy sector, construction (design and engineering activities) and insurance.

Opportunities and threats also exist from international competitors in the tourism industry. There are potential external dimensions for tourism, with some studies predicted large increases in global tourism (i.e. visitors to Europe) due to population and economic growth in the rest of the world, but also competition for European tourists. This might be particularly important in relation to winter snow sports. Additional visitors may add to existing pressures (e.g. water availability) in some regions.

10.6.3. Adaptive Capacity

The most relevant autonomous adaptation response will be for tourism activity: If summer remains the predominant season for tourism activities in Europe, major shifts of tourist flows may eventually occur from the Mediterranean to more northern areas in Europe as an autonomous adaptation. However, other societal changes (e.g. ageing population), may allow for a more flexible timing of holidays among a large share of the population, offsetting some of these changes, and other studies show strong overall increases in tourism in Europe from international tourists (an important external dimension), thus it is the rate of growth by sub-region that is affected, as well as a greater shift towards domestic tourism in regions with increasing attractiveness, although these also pose sustainability and environmental problems (such as energy related emissions, water use) and these are likely to increase in the short term. These responses do have economic costs, for example, in France almost half a billion Euros were spent between 1990 and 2004 on artificial snow-making installations, while in Austria, approximately EUR 800 millions were spent between 1995 and 2003. The introduction of these machines is also driven by other socio-economic factors (increasing the reliability of resorts to increase revenues and expand their ski areas beyond previous natural limits),

Autonomous adaptation from industry and services most affected by water or snow scarcity will be in the short term to increase investment in water supply or snow-making equipments, together with relocation of activities in more favourable areas. Both categories of projects will have substantial environmental impacts, to be addressed under environmental impact assessment.

Against that background, planned adaptation options can be considered to ensure the competitiveness of European industry and services, and mitigate potential environmental and social side-effects.

Table 13- Potential planned adaptation options for Industry and Services

Type of action	Description
Share losses	For all activities located in vulnerable areas (coastal zones, flood plains, regions vulnerable to drought), insurance schemes may be the first option, at least in the short term, resulting in higher financial costs and/or higher liabilities if risks are not properly assessed and covered by insurances
Mitigate the threat	in the short term, ski resorts are likely to increase investments in snow-making equipments, develop high-mountain extensions (cost estimates included in OECD paper);
Prevent effects	Improve climate risk assessment in strategic decisions such as production investments, location of activities.
	Assist SMEs in correctly assessing risks and adaptation actions
	Further increase the efficiency in the use of raw materials, water and energy in the production processes" (this is a measure beneficial both for mitigation and adaptation). We have recently adopted a Communication on "Innovative and Sustainable Forest-based Industries in the EU" COM(2008)113 that has as one of its main policy objectives "Further improving resource efficiency in the use of raw material". - We think the "autonomous adaptation" will lead to innovation in efficient energy and materials technology (add it in table 18).
Change land use.	
Change location of economic activities.	in the longer term, abandon a number or ski locations (locations in the Alps are likely to be more affected than Scandinavia); for Mediterranean countries, shift the touristic season to spring and autumn (may mean reduction of mass tourism due to summer holidays, focus on richer customers); additional investments for water supply and sanitation, redirection of beach tourism to regions bordering the Atlantic, North and Baltic Seas

Type of action	Description
	Accompany relocation of water/energy intensive activities
Capacity Building	Review vulnerability
	Research into new technologies and new methods of adaptation for businesses, in particular in risk assessment and management, building design, materials and equipments, water management and treatment, production processes saving water and energy.
	Promote the flexibility of tourists and institutions such as school holiday

10.6.4. Need for early action at EU level

As adaptation for the tourism sector will largely be autonomous, private and local, there is not a clear role for EU action in planned adaptation. However, in some areas, there are links with cross cutting themes which will involve tourism. This includes the use of EU funds for tourism related infrastructure or development, and in wider policy appraisal such as in strategic environmental assessment.

– most impacts (see above) are trans-boundary, e.g. floods, storms, snow availability, heat-weaves.

– it should not be forgotten that tourism is a major employer and important economic sector in some regions or sub-regions.

The impacts of climate change are likely to differ significantly between regions and economic sectors. Industries have the responsibility to assess and manage the risk related to climate change for their activities, and to integrate this risk in their decision making and financial management, for example to plan for new investments or anticipate on the relocation or climate-proofing of industrial facilities. As the difficulty is higher for SMEs to properly assess and manage their risks, an appropriate support should be given by Member States and may be part of planned national adaptation. In addition to this autonomous or planned adaptation, the scale of adaptation measures and possible impacts on the regional cohesion in the European Union justifies EU action to:

– facilitate the conversion of regions and economic activities impacted by climate change;

– promote solutions favourable to both adaptation to climate change and to competitiveness, with the development of innovative and less resource-intensive activities.

Tourism development often implies very significant investments in infrastructure and services and requires a high degree of certainty, therefore early action is needed to incorporate as soon as possible climate proofing considerations and long term planning and to build capacity to adapt in the tourisms sector. More generally, early adaptation is needed as some sector restructuring or relocation may be needed. Early planning and support measures are likely to be more cost-effective than late or reactive measures. Early planning by public authorities, including land-use planners and permitting authorities, would also facilitate the autonomous adaptation by other economic actors and reduce the risk of increased disparities between regions or social groups affected by climate change.

This is particularly the case for resource-intensive industries, such as the food industry, pulp and paper, chemistry or energy production, where clear and stable messages by the permitting authorities, including in the framework of the implementation of the Integrated Pollution

Prevention and Control Directive, should allow orderly and cost-effective adaptation measures by the concerned industries (such as the relocation of unsustainable activities), thus reducing the ultimate economic and social cost for the regions in which these industries are located.

10.7. Health

10.7.1. Impacts

Climate change is likely to affect human health, either directly related to the physiological effects of heat and cold, or indirectly, for example, through the increased transmission of food or vector-borne disease, or through other climate change effects like flooding. These health changes will have economic consequences, e.g. through medical costs, lost time at work, and less obvious costs that can be estimated by approaches including willingness to pay to avoid pain and suffering. An increase in some of these impacts has already been observed over the recent decades in Europe (e.g. the summer heat waves in 2003 alone are estimated[102] to have led to in excess of 35 000 premature deaths and possibly as many as 70 000). There are also other potential impacts from climate change on health through indirect pathways affecting other sectors discussed in this annex (e.g. water, food, etc).

The primary concern in Europe is related to heat related mortality and morbidity, from annual temperature increases and heat extremes[103], though these are also influenced by socio-economic changes from population growth, age distribution (the aging European population) and other factors. In EU countries, mortality is estimated to increase by 1–4% for each one-degree rise in temperature. The PESETA project estimates that heat related mortality[104] could rise by 30000 deaths per year by the 2030s and 50,000 to 110,000 deaths per year by the 2080s, depending on the scenario (B2 and A2-business as usual, respectively, low confidence). However, autonomous adaptation will be important here as populations will partly acclimatise to future temperatures. With autonomous adaptation factored in, the numbers above are estimated at around 5000 deaths per year in the 2030s and 20,000 deaths per year in the 2080s (A2, low confidence), with estimated economic costs of €10 to 20 billion/year. There is a very strong distributional pattern in the impacts, and the elderly are most at risk of death from heat-stroke and cardiovascular, renal, respiratory and metabolic disorders[105]. Whilst total deaths are strongly related to population, the change in death rates are much greater in Southern and South-Eastern Europe, not least due to the greater warming signal in these regions. It is also highlighted that heat related health concerns themselves are likely to drive interactions with energy use and air conditioning for cooling.

In addition, climate sensitive infectious diseases, such as food borne disease like Salmonella, have the potential to increase under a changing climate. Some emerging work (PESETA, based on Kovats, 2003) shows that the disease burden in Europe could be significant, with potentially an extra 20 000 cases per year by the 2030s and 25,000 to 40,000 cases per year by the 2080s (though these may significantly underestimate the numbers by a factor of ten or

---

102 Robine J-M et al. Death toll exceeded 70,000 in Europe during the summer of 2003. Comptes Rendus Biologies, 2008, 331(2):171–178.

103 Note that there will also be a reduction in cold related mortality in Europe, which will be at least as great as the increase in heat related mortality, though this is less important for adaptation.

104 Heat waves have not been considered

105 WHO Regional Office for Europe, Heat-health action plans - Guidance (2008) available at: http://www.euro.who.int/document/e91347.pdf

more, due to under-reporting of current cases), and estimated economic costs (with under-reporting factored in) of several billion Euro a year. As mentioned in the recent report from the FAO[106] (2008) "Climate change: implications for food safety", other food-borne pathogens could have an increase impact: there is potential for increased mycotoxin contamination, algal blooms/biotoxins in fishery products and environmental contaminants with significance to the food chain. Autonomous adaptation would be expected to reduce these numbers, though there is also a strong role for planned adaptation.

There is the potential for changes in vector borne disease – though these are more important in relation to external context (outlined below). The IPCC (2007) projects that climate change could lead to changes in infectious disease transmission by vectors such as mosquitoes and ticks, as a result of changes in their geographic ranges, seasons of activity and population sizes, though socio-economic factors are also important, including the movement of people and goods, and changes in land use. While some climate change related models estimate a potential increase of malaria risk in parts of Europe, there is agreement that the risk of transmission of malaria related to localized climate change is very small, especially where there is adequate health services and management of mosquito control (EEA, 2008). Nonetheless, new challenges can emerge, as with the Chikungunya virus outbreak in Europe; and the presence of a suitable vector might allow for future local outbreaks. There are also observed changes in vector distribution - the limit of tick distribution in the EU is shifting northwards and to higher altitudes: and a shift towards milder winters may enable expansion of the range of Lyme disease. Similarly, the vector-borne disease leishmaniasis, transmitted by sandflies, has been reported in vector hosts further north, and there are reports of changes in the geographical distribution of the sandfly vector. The role of climate change in the future epidemiology of other diseases is uncertain.

While flooding is the most frequent weather related risk in Europe, the number of direct deaths and injuries is low, and likely to remain so even with projected increases in riverine and coastal flooding. However, flood events do have important effects on wider well bring (mental health, stress and depression). The PESETA study has estimated the wider health risks of coastal flooding in Europe (see coastal section), and estimates – in the absence of adaptation – that these indirect health effects could have economic costs of €0.8 to 1.4 billion per year by the 2080s (B2 and A2 scenarios respectively, with high sea level rise)

A number of water related issues are also important (see also other sections). Heavy precipitation has been linked to a number of drinking water outbreaks (from mobilising pathogens or water contamination), and waterborne diseases may rise with increases in extreme rainfall. Reductions in summer water flows may increase the potential for contamination. Higher water temperatures may also result in increased occurrence of harmful algal blooms, and increase the faecal bacteria and incidence of pathogens, which could affect drinking water intakes and water bodies used for recreation.

Finally, there are a number of other emerging health issues from climate change in Europe, where quantification and valuation have not been explored on a Europe wide based. A warmer climate may also have important effects on air quality in Europe, in terms of concentrations and dispersion of air pollutants. Whilst air pollution levels have reduced dramatically in recent decades in Europe, the health risks of air pollution are still significant, primarily from

[106] FAO, Climate Change: Implications for Food Safety, Rome, 2008, available at http://www.fao.org/docrep/010/i0195e/i0195e00.htm

particulate matter and ozone, see the Thematic Strategy on Air Pollution. Climate change has some potential to affect air pollution, leading to a possible increase in respiratory diseases and mortality, though these changes will be strongly determined by future air quality policy and climate policy (mitigation). The effects of climate change are most likely to be important in relation to ozone – a major pollutant in many parts of Europe. The EEA (2008) reports that climate variability and change has contributed to an increase in ozone concentration in central and South-Western Europe, and the climate-induced increase in ozone levels might hinder current ozone abatement. There may also be correlations between heat waves and high air pollution more generally that have implications for health. There are no detailed projections for the future effects of climate change on air pollution in Europe - and even recent studies on air pollution (e.g. TSAP) have not factored in how climate change might influence air quality levels[107]. Nonetheless, there are some individual country studies which suggest this could be important, for example, it has been estimated for the UK that there could be around 800 additional ozone-related deaths by 2020 per year due to climate change (UK Department of Health and Health Protection Agency, 2008), and US studies indicate potentially significant increases in ozone concentrations and related mortality (5%) from climate change (5%) by the 2050s.

There may be changes in solar ultraviolet (UV) radiation from climate changeand in turn changes in induced cortical cataracts, cutaneous malignant melanoma and sunburn . Higher ambient temperatures will influence clothing choices and time spent outdoors, potentially increasing UV exposure in some regions and decreasing it in others.(IPCC, 2007) though this will be strongly influenced by behaviour. There is also the potential for the seasonality and length of allergic disorders ('hay fever') to change under a future climate, with implications of direct costs in terms of over the counter medications for allergic rhinitis, and wider economic costs to individuals. Finally, there will be a range of indirect health effects from climate change acting on other health determinants.

The health effects of climate change will be unevenly distributed across regions of Europe. Health and well being are also strongly related to socio-economic drivers, such as income, housing, employment, education and lifestyle. In combination with climate change, these will alter health inequities within and between countries, and lead to uneven distribution and additional stresses for lower income groups and certain vulnerable groups, e.g. children, the elderly, and those with existing illness. As an example the evidence on current heat related mortality has been shown to have strong socio-economic dependence. For some effects, e.g. heat related and air pollution related mortality, there is a greater vulnerability for the elderly, and there maybe additional factors for this group in relation to socio-economic status. These inequality issues are even more pronounced in relation to external factors (effects outside the EU).

10.7.2. External_dimension

Climate-induced changes in the potential distribution of malaria and other vector borne diseases are projected mainly in poor and vulnerable regions globally. In Europe localised outbreaks are possible in areas, even in cases where the disease has been eradicated, but vectors are still present. A major factor here will be the external dimension, either from risk from Europeans travelling in endemic areas, or through migration.

---

[107] There are an estimated 21000 premature deaths from ozone each year in the EU, as well as over an estimated 100 millions respiratory symptoms days, see the TSAP.

10.7.3. Adaptive Capacity

Table 14- Potential planned adaptation options for Health

Type of action	Description
Mitigate the threat	Revised air and water quality controls e.g. tighter controls on emissions leading to ozone formation.
	Increased frequency of microbiological testing of foods and other measures to mitigate the risk of food poisoning.
	Development of heat health action plans (heat-wave early warning and public health response), the strengthening of emergency medical services, improvement of climate-sensitive disease surveillance, and actions to increase accessibility to key determinants of health, such as clean water, energy and sanitation.
Prevent effects	Much adaptation can be achieved in the context of pursuing wider development objectives—for example, improved health and education services.
	The maintaining / strengthening of public health infrastructure is often viewed as the "most important, cost-effective and urgently needed" adaptation strategy. This includes the reinforcement of public health policies that recognise climate risk, public health training, more effective surveillance and emergency response systems, and sustainable prevention and control programs. Education of public and health professionals.
	As vulnerability to climate change can be exacerbated by other stresses, including lack of preparedness or high burden of disease, it is important to include risks from climate into public health policies, thus strengthening health services' preparedness and enhancing international cooperation
Change land use.	Greening urban areas, Green roofs
Change location of economic activities.	It is advisable for critical activities for public health (water treatment works; energy supply; hospitals) to be based in locations at less risk from extreme weather events.
Capacity Building	The main determinants of a community's adaptive capacity are: economic wealth, technology, information and skills, infrastructure, institutions, and equity. Adaptive capacity is also a function of current population health status and pre-existing disease burdens.
	So far, little research has been conducted on estimating the cost of the current climate sensitive disease burden, or of health-specific adaptation strategies.
	Research and sharing and implementation of best practice in building design to minimise excess temperatures within buildings.
	Monitor changes in vector-borne disease distribution
	Research on physical and mental stressors in old age (links the aging population and climate change).

10.7.4. Need for early action at EU level

The appropriateness of various adaptation measures depends on local circumstances, taking into consideration the projected severity of the effect considered, the degree to which the population is affected, the age distribution of the population, the level of distribution of economic resources, the proportion of population living in urban centres, the type of, housing and the systems in place (if any) to protect vulnerable groups.

While most of adaptation measures regarding health would be most appropriate at national, regional and local level, it has to be taken into consideration that some impacts are trans-boundary (e.g. floods, storms, disease spread) and in extreme cases, could temporarily affect the proper functioning of the European internal market (food availability / security) and so action needs to be undertaken at EU level; in addition, in case of severe damages the European solidarity principle should be applied. There are also specific health related areas with strong EU competence, e.g. in relation to air and water quality.

Improvement of international surveillance systems are needed to facilitate national and regional preparedness to epidemic-prone disease and to reduce their vulnerability to them

Economies of scale could be made with respect the exchange of information; in this respect, EU action would be most appropriate in terms of:

– Building adaptive capacity

– Coordinating early warning systems,

– Setting up a comprehensive communication strategy

– Reviewing and, where necessary, updating relevant EU legislation

– Supporting key actions with a view to ensure that the specificities of particularly vulnerable groups are taken into account within the policy making process.

In general, early adaptation actions with regard to health would be relevant when:

– action measures have already been shown to be effective under current climate conditions;

– severe impacts are possible (for example, high mortality from heat waves);

– multisectoral alliances, partnerships and networks are in place;

– adaptation measures have a long lead time (for example, changing infrastructure to reduce the extent of an urban heat island effect);

– decisions have long-term effects (for example, building settlements in areas that are at risk of flooding); and

– there is a need to reverse trends that threaten adaptive capacity in the health sector.

10.8. Coastal areas

The impacts of climate change on coastal zones have been mentioned in other parts of the report. However, because of their importance, the effects on coasts are also reported in this separate section.

Coastal zones in Europe contain large human populations and significant socioeconomic activities. They also support diverse ecosystems that provide important habitats and sources of food, as well as providing other ecosystem services. One third of the European Union (EU) population is estimated to live within 50 km of the coast, and some 140,000 km^2 of land is currently within 1 m of sea level (EEA, 2004).

Significantly inhabited coastal areas in countries such as the Netherlands, England, Denmark, Germany and Italy are already below normal high-tide levels, and more extensive areas are prone to flooding from storm surges. Climate change is an additional pressure and is likely to have significant impacts on coastal zones, particularly via sea level rise and changes in the frequency and/or intensity of extreme weather events, such as storms and associated surges. The most threatened coastal environments within Europe are deltas, low-lying coastal plains, islands and barrier islands, beaches, coastal wetlands, and estuaries. Direct impacts from sea

level rise include inundation and displacement of wetlands, lowlands, coastal erosion, increased storm flooding and damage, increased salinity in estuaries and coastal aquifers, and rising coastal water tables and impeded drainage. Potential indirect impacts include changes in the distribution of bottom sediments, changes in the functions of coastal ecosystems and impacts on human activities.

There are emerging estimates of the potential physical impacts (area lost, people flooded) and economic costs to coastal sectors in Europe from sea level rise and from storm events. There have also been recent studies of the exposed assets in major European coastal cities (port cities).

- Results using the DIVA database and model produced from the DINAS-COASTS DG research have been developed for Europe in the PESETA project. Under the A2 scenario, without adaptation around 2000 to 17000 km^2 of land in Europe could be permanently lost by 2085, also leading to 0.1 to 1.3 million people undergoing coastal floods every year. Those physical effects are valued at a cost of 12 to 18 billion/year. When hard adaptation measures are considered (dike building and beach nourishment) the land loss fall to less than 1000 km^2, and the residual economic cost to around one billion/year. The economic costs of the adaptation measures are some one billion/year, to be added to the residual damages. The optimal protection level is determined by the equalisation of marginal costs and benefits. Two hard, engineering adaptation measures are considered. First of all, dikes are built to protect the coast. The costs of dikes are compared to the benefits in terms of lower sea flood damages, river flood damages, salinisation costs and migration costs. The second measure is beach nourishment, which is decided by comparing the nourishment costs (basically a function of cubic metre of sand) with its benefits. The benefits depend on agriculture land value if there are not tourists, and in case there are tourists, the benefits depend on the number of tourists and their expenditure.

- Recent work for the OECD[108] has also looked at current and future major coastal cities with sea level rise (0.5 metres global average) and storm surge, and assessed exposure to a 1 in 100 year flood event, looking at population and asset value exposed now and with sea level rise in 2100 for Amsterdam, Rotterdam, Hamburg, London, Copenhagen, Helsinki, Marseille, Athens, Napoli (Naples), Lisbon, Porto, Barcelona, Stockholm, and Glasgow. For these cities, the exposed population rise from 2.3 million to 4.0 million, and the exposed assets from $360 to $2220 billion (though the values are dominated by London, Amsterdam, and Rotterdam).

In addition, the coastal zones of Europe are important in tourism potential and recreational value (see tourism and industry section), and the role of seas and oceans are essential for ecosystem services including fisheries (see relevant section) and climate regulation, as well as for transportation. Coastal areas will also have interactions with water availability, either a source of water (desalination) or from the potential risks of salinisation affecting water sources in coastal regions.

---

[108] OECD (2007) Screening study: Ranking Port cities with high exposure and vulnerability to Climate Extremes. Interim analysis: Exposure Estimates. ENV/EPOC/GSP(2007)11, prepared by Nicholls, R.J., Hanson, S., Herweijer, C., Patmore, N., Hallegatte, S., Corfee-Morlot J., Chateau, J., and Muir-Wood, R.

Finally, there are specific biodiversity-ecosystems issues for Europe's coastline, with projected climate change and sea level rise a particular threat to coastal ecosystems, especially those in the Baltic, Mediterranean and Black Seas (see ecosystems section). These habitats could be severely reduced or disappear during the 21st century because of the low tidal range in these areas and the limited scope for onshore migration. Alcamo et al (2007) report that sea-level rise is likely to cause an inland migration of beaches and the loss of up to 20% of coastal wetlands. In addition, rising sea levels may cause saline intrusions on aquifers in the coastal areas.

Traditionally, most shore-line management policies tend to reduce the flexibility of the coastline, to minimize its natural dynamics because of the inconvenience it raises for human activities. Seawalls and dykes are measures that try to fix the coastline so that land use can be orderly planned, houses built and harbours maintained. But there are also clear disadvantages to this kind of management. Maintenance costs are high and the ecologically important gradients from land to sea have disappeared. Hence, we see in many countries a shift in thinking about sustainable management of the coastal zone towards a more flexible approach, which works with the natural processes instead of against it. Examples are the now often used sand nourishments, buffer zones (setback lines) and managed realignment of the coast.

A problem with the application of the concept of resilience in this context is that most coasts are evolving systems and do not necessarily are in equilibrium (Klein et al., 1998). Because of this, resilience should refer preferably to coastal functions: compatibility and adaptability of uses to coastal erosion management which allows natural fluctuations of the coastline. The CONSCIENCE project[109] focused on a pragmatic way to develop resilience indicators and indices.

Coastal protection and other adaptation strategies are being implemented to avoid or diminish threats from climate change impacts. The Floods Directive[110] provides the legal instrument on flood risk management, requiring Member States to carry out certain measures such as risk assessment, mapping, risk reduction measures etc, including coastal floods.

For years, MS have implemented coastal defence programmes which budgets are been increased to better tackled the new threats posed by climate change. Infrastructure (dikes, locks, etc.) in the Netherlands have been dimensioned to last for 50 years taking into account the worst-case IPCC scenario. They are re-assessed every 5 years by the local authority to see whether the structure still meets the design criteria. Most defences were built with a precautionary approach and are currently well within safety limits even though they were designed before the current concerns with global warming. They are expected to provide sufficient protection for well over 50 years. The local authorities are also required to leave room for future reinforcements of sea defences taking into account 200-year level rise.

Guidelines in England and Wales have been have been issued[111] recommending sea-level rise be taken into account in flood and coastal defence projects grant aided by the Department for Environment, Food and Rural Affairs (Defra).

---

109 CONSCIENCE 6th FP Project, see http://www.conscience-eu.net

110 Directive 2007/60/EC of the European Parliament and of the Council of 23 October on the assessment and management of flood risks entered into force on 26 November 2007

111 Flood and Coastal Defence Appraisal Guidance FCDPAG3 Economic Appraisal Supplementary Note to Operating Authorities – Climate Change Impacts October 2006

However, climate change adaptation is not always considered within the coastal management plans of national or sub-national governments. According to information presently held by the Commission, climate change impacts, adaptation and their economic perspectives are only considered in the design of the coastal infrastructure projects in a few Member States and the costs of the options differ widely. Relatively little is known about the costs and the benefits of the adaptation options and uncertainty levels are very high, partly because effective adaptation measures are highly dependent on specific, geographical and climate risk factors as well as institutional, political and financial constraints.

In this light, many recent studies[112] highlight the need for further work to target the assessment of risk management strategies, most notably the cost and effectiveness of adaptation options.

The promotion of coherent and integrated planning and management tools of the maritime and coastal areas can provide the appropriate instruments to better manage activities that compete for the same space while, at the same time, provides the needed provision to incorporate climate change adaptation in the planning. In this regard, a new maritime spatial planning framework is being analysed at EU level, while, at the same time, the important role of the networks of exchange of knowledge and best practices in ICZM that currently exist is promoted.

The EU needs to accurately forecast climate change and reduce uncertainties in oceanographic forecasts. It is needed to bring forward the introduction of effective climate or weather forecasts which would be of benefit to nearly all economic activities. To this end, deeper research, long-term datasets and high resolution prediction models will help to better know and better predict impacts of climate change. Joint calls on marine research projects in the FP7 context should be applied for climate change studies addressing a complexity of interrelated factors that can not be analysed independently. The EU's Global Monitoring for Environment and Security (GMES) initiative will ensure continuity in space-based measurements and a progressive improvement in the delivery of services based on them. The European Marine Observation and Data Network (EMODNET), proposed as part of the maritime policy, will focus on improving access to researchers and service providers to existing data, identifying gaps and proposing what further monitoring is required.

10.9. External dimension

In addition to the external aspects of climate change impacts in Europe, or on how the EU transfers problems outside the region, this section very briefly describes the global climate change impacts and possible implications to global security.

10.9.1. *Global climate change impacts*

The observations and potential future impacts of climate change outside the EU have been recently documented (see working group II, summary for policy makers, IPCC, 2007). The IPCC report cites observational evidence from all continents that shows that many natural systems are being affected by regional climate changes, particularly temperature increases, and that other effects of regional climate changes on natural and human environments are

[112] "Ranking port cities with exposures and vulnerability to climate extremes" OCDE Environment Working Paper nº 1. January 2008.

emerging, although many are difficult to discern due to adaptation and non-climatic drivers. It also reports on potential future impacts.

Clearly the potential effects vary by region, but as an overall summary (summarised from WGII summary, IPCC, 2007):

– Freshwater resources. By mid-century, water availability is projected to decrease by 10-30% over some dry regions at mid-latitudes and in the dry tropics, some of which are presently water-stressed areas. Drought-affected areas are likely to increase (in extent). Heavy precipitation event are very likely to increase in frequency, increasing flood risk.

– Ecosystems. The resilience of many ecosystems is likely to be exceeded this century by an unprecedented combination of climate change, other disturbances, and other global change drivers (e.g., land-use change, over-exploitation). Changes to ecosystems are predicted to have predominantly negative consequences for biodiversity, and ecosystem goods and services. Approximately 20-30% of plant and animal species are likely to be at increased risk of extinction if increases in global average temperature exceed 1.5-2.5°C. Increases above this are expected to lead to major changes in ecosystems structure and function.

– Agriculture. Crop productivity is projected to increase slightly at mid- to high latitudes (for local mean temperature of up to 1-3°C depending on the crop), and then decrease beyond that in some regions. At lower latitudes, especially seasonally dry and tropical regions, crop productivity is projected to decrease for even small local temperature increases (1-2°C), which would increase the risk of hunger. Globally, the potential for food production is projected to increase with increases in local average temperature over a range of 1-3°C, but above this it is projected to decrease. Moreover, increases in the frequency of droughts and floods are projected to affect local crop production negatively, especially in subsistence sectors at low latitudes.

– Sea level rise. Many millions more people are projected to be flooded every year due to sea-level rise by the 2080s. Those densely-populated and low-lying areas where adaptive capacity is relatively low, and which already face other challenges such as tropical storms or local coastal subsidence, are especially at risk. he numbers affected will be largest in the mega-deltas of Asia and Africa (e.g. potentially in excess of 1 million people potentially displaced by sea level trends (IPCC, 2007) in the Nile delta, the Ganges /Brahmaputra delta and the Mekong delta by 2050), while small islands are especially vulnerable.

– Health. Climate change-related exposures are likely to affect the health status of millions of people, particularly those with low adaptive capacity. For these groups, this includes potential effects from increases in malnutrition and consequent disorders, increased deaths, disease and injury due to heatwaves, floods, storms, fires and droughts, the increased burden of diarrhoeal disease, and the altered spatial distribution of some infectious disease vectors. Studies in temperate areas project some benefits (e.g. fewer deaths from cold exposure), but overall it is expected that these benefits will be outweighed by the negative health effects of rising temperatures worldwide, especially in developing countries. In relation to vector borne disease, climate change is expected to have some mixed effects, such as a decrease or increase in the range and transmission potential of malaria in Africa.

It is also clear that the impacts of future climate change will be mixed across regions. The main impacts of climate change damage (at least in the short to medium term, and under stabilisation scenarios) will be felt in developing countries (IPCC, 2007), and within the

poorer regions. Climate change is a serious challenge to poverty reduction in developing countries and threatens to undo development gains. There are several reasons for this: many of the greatest impacts of climate change are projected to occur in these countries; their economies rely more on climate-sensitive activities; and many operate close to environmental and climatic tolerance levels. The effects are likely to be greatest for the poor persons within these countries, and they potentially exacerbate inequities in health status and access to adequate food, clean water, and other resources. Poor communities in these countries depend highly on the direct use of local natural resources. They have restricted choice for their livelihoods and limited capacity to cope with climate variability and natural disasters. Furthermore, the ability to adapt for these countries and communities is likely to be more limited because of technical, economic and institutional limitations.

10.9.2. *Impacts on global security*

Global security could be potentially threatened by the impacts of climate change in a number of ways.

– Conflict over resources: Climate change will alter rainfall patterns and reduce available freshwater in certain regions (see above), and increasing water shortages have the potential to lead to conflict. Agricultural productivity is expected to drop worldwide above certain temperatures under some scenarios and models (as outlined above), and in such projections, there are potential concerns over food security, particularly in less developed countries. These potential effects will be more intense in areas under strong demographic pressure, and have the potential to exacerbate existing conflicts over depleting resources, especially where access to those resources is politicised.

– Economic Damage (risks to coastal cities and critical infrastructure): Coastal zones are home to about one fifth of the world population, a number set to rise in the years ahead. Mega-cities, with their supporting infrastructure, such as port facilities, are often located by the sea or in river deltas. Sea-level rise and the increase in the frequency and intensity of extreme events (e.g. storm and sea surge) pose a serious threat. Recent work (OECD, 2007) estimates that by the 2070s, the total population exposed to a 1 in 100 year flood event could grow more than threefold to around 150 million people globally due to the combined effects of climate change (sea-level rise and increased storminess), subsidence, population growth and urbanisation, with the asset exposure growing even more dramatically by more than ten times current levels to roughly 9% of projected annual GDP in this period. The risks are likely to increase most in developing countries and by 2070, 9 of the top 10 cities exposed to coastal flooding in terms of population exposure are in Asian developing countries. In countries where development levels remain lower, increases in disasters and humanitarian crises will lead to increased pressure on the resources of donor countries, including capacities for emergency relief operations.

– Loss of territory and border disputes: Receding coastlines and submergence could result in loss of territory, particularly for countries such as small island states. Disputes over land and maritime borders and other territorial rights are possible. Existing international law, particularly the Law of the Sea, may prove inadequate in resolving territorial and border disputes. A further dimension of competition for energy resources will be in potential conflict over resources in Artic region which will become exploitable as a consequence of global warming. Desertification could increase migration and conflicts over territory and borders, particularly when multiple factors, e.g. poor governance, conflict, are in play

(fragility) and climate change may be an additional influence on the political stability of countries and regions.

– Environmentally-induced migration: Those parts of the populations that already suffer from poor health conditions, significant unemployment or social exclusion are rendered more vulnerable to the effects of climate change, which could amplify or trigger migration within and between countries. The UN predicts that there will be approximately 50 million "environmental" migrants by 2020, though there is a low confidence associated in these numbers. Climate change is one of the potential factors in this phenomenon. Some countries that are extremely vulnerable to climate change are already calling for its international recognition. Environmentally-induced migration may increase conflicts in host, transit and destination areas, for internally displaced people and external migration. Europe might also expect increased migratory pressure.

– Pressure on international governance: The multilateral system is at potential risk if the international community fails to address the threats outlined above. Climate change impacts could fuel the politics of resentment between those most responsible for climate change and those most affected by it. Impacts of climate mitigation policies (or policy failures) could thus drive political tension nationally and internationally. The potential rift not only divides North and South but there will also be a South - South dimension, e.g. as the Chinese and Indian share of global emissions rises. The already burdened international security architecture will be put under increasing pressure.

10.9.3. *Need for early action at EU level*

The EU is bordered by and imports goods and natural resources from countries, which are not resilient to existing let alone future impacts of climate change. The EU will be indirectly affected by failure of these countries to adapt to climate change particularly if the frequency of extreme events increases.

Adaptation presents a particular challenge for policy makers around the world, given the environment of uncertainty with limited information regarding the actual timing and scale of the consequences. At the same time, consequences of climate change are increasingly worrying and represent parameters that must be integrated, as soon as possible, in the planning, budgeting and executing phases of external policy making. The EU acknowledges that more work needs to be done urgently to forecast, analyse, and communicate the actual consequences and associated adaptation costs in partner countries. Integrating adaptation policies, programmes and aid programmes internationally requires understanding of (non-climate related) priorities of other countries and establishing new dialogues on adaptation.

There is a lack of conclusive studies on climate change and migration patterns: it is currently difficult to put numbers on future flows of displaced people due to impacts of climate change, since non-climate drivers are also important (government policy, resilience to natural disaster etc.). There are no reliable estimates of the numbers affected, and this is a research priority. There are wider issues on definitions and obligations of the international community under international law in relation to migration status.

Being responsible for most of the historic accumulation of anthropogenic greenhouse gas emissions in the atmosphere, developed countries will need to support adaptation actions in developing countries. Adaptation will be fundamental in securing the achievement of the UN Millennium Development Goals after 2015, especially in sub-Sahara Africa. The EU has the

possibility through its development and cooperation funds to compensate for the unequal distribution of climate impacts, to support developing countries in their efforts to adapt to climate change.

Just as it has in Europe, the EU can have a coordination role to foster trans-boundary cooperation among developing countries to combat jointly the impacts of climate change

The EU has a very strong position to support developing countries capacity building, research, information and data gathering, knowledge and technology transfer exchange of best practice.

Many developing countries are already suffering very dramatically the consequences of climate change and there is a need to improve their resilience and their capacity to adapt and mitigate the effects as early as possible to avoid further negative consequences and higher costs. There is a need for immediate and urgent action on adaptation and to ensure the availability of both financial and technological resources, by supporting action on adaptation in the most vulnerable countries, in particular to Least Developed Countries, Small Island Developing States and Africa.

11. ANNEX 4: REVIEW OF NATIONAL ADAPTATION PLANS

In addition to the national communications to the UNFCCC, a number of Member States have recently produced national adaptation plans. For the purpose of this Impact Assessment, relevant reports containing information on adaptation at national level have been reviewed for the Denmark, Finland, France, Netherlands, Spain, Hungary, Germany and United Kingdom[113]. In addition to these publicly available reports, some more Member States are currently preparing national strategies, which may become available in the coming months. In addition, in some Member States adaptation strategies are available at regional level. These have not been reviewed at this stage.

Table 15: Overview of national adaptation strategies, plans or programmes in the EU

Member State	Impacts, vulnerability & adaptation assessments	NAS under preparation	NAS adopted	link (copy from either EEA or table below)
Austria	StartClim reports (2003-2009) Anpassungsstudie			http://www.austroclim.at/index.php?id=40 http://www.umweltnet.at/article/archive/7098
Belgium	Sustainable Spatial Development (SSD)	2012		
Bulgaria	Second National Action Plan on Climate Change 2005-2008			http://www2.moew.government.bg/recent_doc/international/climate/NAPCC_Final_English.doc
Cyprus				
Czech Rep.	National Programme to Abate the Climate Change Impacts in the Czech Republic	2009		http://www.env.cz/AIS/web-pub-en.nsf/$pid/MZPOBFKFL7JL/$FILE/N%C3%A1rodn%C3%AD_program_EN.pdf http://www.env.cz/AIS/web-en.nsf/pages/Climate_Change
Denmark	Ministry of Climate and Energy		2008	http://www.kemin.dk/NR/rdonlyres/1247B5C0-0BAD-464A-9997-2EAB952D9494/56490/klimatilpasningsstrategi.pdf www.klimatilpasning.dk
Estonia	ASTRA	2009		www.astra-project.org
Finland	FINADAPT		2005	http://www.ymparisto.fi/default.asp?contentid

[113] Although the UK does not have a specific "UK strategy" as such, the Government (DEFRA) plays a leading role, acting as co-ordinator for the many strategies being developed at regional and local levels. This includes in particular liaising closely with the authorities in Wales, Scotland and Northern Ireland who are also developing strategies. DEFRA ensures coherence between the strategies and elaborated the Adaptation Strategy for England " Adapting to Climate Change in England" – released in July 2008.

Member State	Impacts, vulnerability & adaptation assessments	NAS under preparation	NAS adopted	link (copy from either EEA or table below)
				=227544&Ian=EN http://www.mmm.fi/attachments/5eWDKveQh/5h0aZ7Iid/Files/CurrentFile/Finlands_national_adaptation_srtrategy_julkaisu.pdf
France	Gestion et impacts du changement climatique (GICC)		2007	http://www.ecologie.gouv.fr/adaptation-au-changement.html
Germany	KomPass; Klimazwei; KLIMZUG		2008	http://www.anpassung.net http://www.klimazwei.de http://www.bmu.de/english/climate/downloads/doc/42841.php
Greece	Ministry of Environment & Athens Academy			www.minenv.gr/welcome_en.html
Hungary	VAHAVA		2008	http://www.kvvm.hu/cimg/documents/nes080214.pdf
Ireland	ERTDI; CCRP National Climate Change Strategy			http://www.environ.ie/en/PublicationsDocuments/FileDownLoad,1861,en.pdf http://www.epa.ie
Italy				http://www.conferenzacambiamenticlimatici2007.it http://www.apat.gov.it/site/en-GB
Latvia	ASTRA	2009		http://www.vidm.gov.lv/eng http://www.astra-project.org
Lithuania	ASTRA			http://www.astra-project.org
Luxembourg				
Malta	Global Environment Facility (GEF)			http://www.mepa.org.mt/environment/index.htm?climate_change/mainpage.htm&1
Netherlands	National Programme for Spatial Adaptation to Climate Change (ARK), CcSP, Knowledge for Climate		2008	http://www.vrom.nl/pagina.html?id=2706&sp=2&dn=7222 http://vrom.nl/pagina.html?id=2706&sp=2&dn=7502 http://www.climatechangesspatialplanning.nl
Poland				
Portugal	SIAM			www.siam.fc.ul.pt/siam.html
Romania	National Strategy and National Action Plan on Climate Change	2009		www.mmediu.ro

Member State	Impacts, vulnerability & adaptation assessments	NAS under preparation	NAS adopted	link (copy from either EEA or table below)
	2005-2007			http://www.mmediu.ro/departament_mediu_en/climate_change.htm
Slovakia				
Slovenia				
Spain	ECCE + Impacts on coastlines		2006	http://www.mma.es/portal/secciones/cambio_climatico/areas_tematicas/impactos_cc/eval_impactos.htm http://www.mma.es/portal/secciones/cambio_climatico/areas_tematicas/impactos_cc/imp_cost_esp_efec_cc.htm http://www.mma.es/portal/secciones/cambio_climatico/areas_tematicas/impactos_cc/pnacc.htm
Sweden	SWECLIM; SWECIA; CLIMATOOLS			http://mistras.internetborder.se/mistra/english/researchresults/researchprogrammes/completedprogrammes/sweclimswedishregionalclimatemodellingprogramme.4.1eeb37210182cfc0d680007760.html http://www.mistra.org/mistra/english/researchresults/researchprogrammes/activeprogrammes/mistrasweciaclimateimpactsandadaptation.4.a791285116833497ab800017356.html http://www.foi.se/FOI/Templates/ProjectPage____5846.aspx http://www.sweden.gov.se/sb/d/574/a/96002 www.regeringen.se/sb/d/8756/a/91682
United Kingdom	UK National Risk Assessment + UKCIP studies		2008	http://www.ukcip.org.uk/ http://www.defra.gov.uk/adaptation www.defra.gov.uk/Environment/climatechange/uk/legislation/index.htm

Details for adopted National Adaptation Strategies

Member State		
Denmark	Title	Strategy for Adaptation to Climate Changes in Denmark
	Year	2008
	Level of progress	The strategy, published by the Danish Government, proposes measures in several sectors. All relevant authorities and sectors are expected on an ongoing basis to monitor and act when they see it necessary to mitigate the impacts of climate change. Some measures refer specifically to adjustment of the existing EU legal framework, or to the need for more regional trans-boundary action. After the launching of the strategy 1) a Coordination Forum on Adaptation with representatives from relevant ministeries, the municipalities and the regions has been created. This Forum is responsible for coordination and co-operation across sectors and authorities, 2) a new information centre on adaptation in the Ministry of Climate and Energy is responsible for the new web-portal and 3) a coordination unit for research in adaptation KFT) under one of the major Danish universities, the University of Aarhus, has been created. Many adaptation measures are already taking place in different sectors, at national and local level.
	Sectors addressed	Water Management, Agriculture, Biodiversity/ecosystems, Forestry, Fisheries, Human Health, Coastal Zones, Energy, Land use, Insurance/finance, Construction, Nature and Nature Management, Planning, Emergency and Rescue Services
	Instruments / themes addressed	Coordinated research, Knowledge and information sharing, Financing adaptation, Planning tools, Coordinated action across MS/stakeholders
	Internet link	'Strategi for tilpasning til klimaændringer i Danmark': http://www.kemin.dk/da-DK/KlimaogEnergipolitik/DanskKlimaogEnergipolitik/Klimatilpasningsstrategien/Documents/klimatilpasningsstrategi_03032008.pdf

Finland	Title	Finland's National Strategy for Adaptation to Climate Change
	Year	2005
	Level of progress	The strategy describes climate change vulnerability and potential impacts in a range of different sectors and suggests measures to improve adaptive capacity in these sectors. The objective of the National Adaptation Strategy is to reduce the negative consequences of climate change as well as to take advantage of its potential opportunities. Ministries are responsible for the implementation of the NAS in their own fields of activity. Some ministries have started to prepare sectoral assessments and action plans to include adaptation into policies that fall within their responsibility.
	Sectors addressed	Agriculture and Food production, Forestry, Fisheries, Reindeer and Game Husbandry, Water Resources, Biodiversity, Industry, Energy, Transport, Land Use and Communities, Building, Health, Tourism and Recreation, and Insurance.
	Instruments / themes addressed	Mainstreaming (incorporation of climate change into all relevant sector policies), observation and warning systems,, research and development, insurance systems, using opportunities
	Internet link	http://www.mmm.fi/attachments/5eWDKveQh/5h0aZ7Iid/Files/CurrentFile/Finlands_national_adaptation_srtrategy_julkaisu.pdf
Hungary	Title	National Climate Strategy 2008-2025
	Year	2008
	Level of progress	The strategy, developed by the Ministry of the Environment and Water of Hungary, indicates that the proposed measures in the document have to be integrated in activities of every sector as well as in every relevant government decision. The implementation of the Strategy will be ensured by National Climate Change Programmes elaborated and updated every 2 years. It is planned to establish a Climate Change Committee, a consultative body that will bring together, among others, members of the government, Hungarian Academy of Science, an ombudsman and environmental NGOs.
	Sectors addressed	Water Management, Agriculture, Biodiversity/ecosystems, Transport, Industry, Forestry, Human Health, Energy, Land use, Insurance/finance
	Instruments / themes addressed	Awareness-raising, International Cooperation, Mainstreaming adaptation in policy, Observation/warning systems, Knowledge sharing, Planning tools, Coordinated action across MS/stakeholders, Financing
	Internet link	http://www.kvvm.hu/cimg/documents/nes080214.pdf

France	Title	National adaptation strategy to climate change
	Year	2007
	Level of progress	The National Adaptation Strategy, written by the National Observatory (ONERC) is the result of an extensive consultation in which representatives of different activities and civil society were involved, highlighting France's main priorities. The National Adaptation Strategy contains only recommendations, which will probably be translated into a real National Adaptation Plan, comprising concrete proposals for measures and action in 2010 or 2011. The 2007 "Grenelle de l'environment" provides further follow-up.
	Sectors addressed	Agriculture, energy and industry, transport, building and housing, tourism, banking and insurance, towns; cross-cutting approaches through water, risk prevention, health and biodiversity.
	Instruments / themes addressed	develop knowledge, improve the observation system, inform and train all stakeholders, make them aware of the adaptation's stakes, develop adapted approaches for territories, finance adaptation actions, use legal and regulation tools, put forward determined approaches and dialogue with private stakeholders, take into account specifics of overseas territories and, finally, take part in international exchanges.
	Internet link	http://www.ecologie.gouv.fr/adaptation-au-changement.html
Netherlands	Title	National Programme on Climate Adaptation and Spatial Planning
	Year	2008
	Level of progress	The programme formulates guiding principles and does not explicitly identify sector-specific adaptation measures; instead it adopts an innovative and inter-sectoral approach which places spatial planning at the heart of the adaptation strategy. The National Implementation Agenda "Make Space for Climate", which is currently under development and is scheduled for publication in early 2009, describes how the strategy will be implemented.
	Sectors addressed	Water Management, Agriculture, Biodiversity/ecosystems, Transport, Tourism, Industry, Energy, Land use, Public Health
	Instruments / themes addressed	Awareness raising, Identifying knowledge gaps, Mainstreaming adaptation in policy, Knowledge sharing, Coordinated action across MS/stakeholders
	Internet link	http://www.vrom.nl/pagina.html?id=2706&sp=2&dn=7222

Spain	Title	National Plan for adaptation to Climate Change
	Year	2006
	Level of progress	The Plan has been drafted by the Commission for the Coordination of Climate Change Policies and the National Climate Board. The Plan intends to provide continuous support to all the interested stakeholders in assessing the climate change impacts in Spain in their respective sectors/ systems of interest. In addition, it will bring together all the knowledge and available elements, tools and methods of assessment with the aim of ensuring the involvement of all stakeholders, thereby defining the best climate change adaptation options.
	Sectors addressed	Water Management, Agriculture, Biodiversity/ecosystems, Mountainous regions, Transport, Tourism, Industry, Forestry, Coastal zones, Human Health, Energy, Land use, Insurance/finance, Hunting and continental fishing, Soils, Marine ecosystems and Fisheries, Construction and Urbanisation
	Instruments / themes addressed	Awareness raising, Mainstreaming adaptation in policy, Knowledge sharing, Planning tools, Coordinated action across MS/stakeholders
	Internet link	'Plan Nacional de Adaptación al Cambio Climático': http://www.mma.es/secciones/cambio_climatico/areas_tematicas/impactos_cc/pdf/pna_v3.pdf
United Kingdom	Title	Adapting to Climate Change in England - a Framework for Action
	Year	2008
	Level of progress	The development of a NAS by the government has been preceded by four key stages: the establishment of the UK Climate Impacts Programme (UKCIP) in 1997, the UK Climate Change Programme in 2000, the publication of the Consultation over the Adaptation Policy Framework and the adaptation provisions within the Climate Change Bill in 2008. The cross-government 'Adapting to Climate Change' (ACC) Programme is led by the Department for the Environment, Food and Rural Affairs (Defra). In Phase 1 (2008- 2011) the necessary groundwork to implement Phase 2 is developed, which should from 2012 implement a statutory National Adaptation Programme, as required by the Climate Change Bill, reporting progress to Parliament on a regular basis.
	Sectors addressed	Flood management, water resources, coastal erosion, high temperatures, biodiversity conservation
	Instruments / themes addressed	Providing evidence, raising awareness, ensuring and measuring progress, embedding adaptation
	Internet link	**http://www.defra.gov.uk/environment/climatechange/adapt/pdf/adapting-to-climate-change.pdf**

Germany	Title	National Climate Change Adaptation Strategy
	Year	2008
	Level of progress	The strategy has been adopted in late 2008; a national action plan is to be delivered by 2011 setting out i.a. principles and criteria for prioritising requirements for action, prioritisation of federal measures, an overview of concrete measures by other actors, information about financing, especially through integration of adaptation in existing assistance programmes, suggested concepts for progress review, and further development of the strategy and next steps.
	Sectors addressed	health, construction, water management and flood protection, soil, biodiversity, agriculture, horticulture, fisheries, energy, finance, transport, industry, tourism and spatial planning
	Instruments / themes addressed	new governance structures as catalyst for an integrated adaptation approach (i.a. an interministerial working group), an extended participation process which increases integration between industry, local authorities and other actors from the various fields by means of discussions between specialists, conferences, consultative bodies, expert committees, improvement of the knowledge base by an extensive research programme comprising i.a. the development of meaningful vulnerability indicators and, subsequently, a comprehensive monitoring system that integrates existing systems of bio- and soil monitoring
	Internet link	http://www.bmu.de/files/pdfs/allgemein/application/pdf/das_gesamt.pdf http://www.bmu.de/files/pdfs/allgemein/application/pdf/das_zusammenfassung_en.pdf http://www.bmu.de/klimaschutz/downloads/doc/42783.php

12. ANNEX 5: ACTIONS INCLUDED IN THE OPTIONS FOR ACTION AT EU LEVEL IN THE SHORT-MEDIUM TERM

This annex present more details on the actions envisaged under Options B and C, and includes an additional screening of some sub-options.

12.1. Improving the knowledge base on climate change impacts and adaptive capacity

6 actions have been considered to tackle the first operational objective:

- Action 1.1. Development of consistent, comprehensive and regularly updated climate change and socio-economic scenarios (projection data) for analysis across Europe. This could build upon existing research and ensure continuity and commitment to the supply of core data needed for adaptation whilst at the same time highlighting the uncertainties that need to be retained and represented in the EU climate data. It requires improving the link between atmospheric, land use and socio-economic models, at global, EU and regional scale; developing options for adaptation strategies and measures at sectoral and cross-sectoral level and the assessment of their ecological, social and economic potential, benefits and costs and identify options for initial no regret measures as starting point for adaptation avoiding costly mal-adaptation. This requires ensuring interdisciplinary cooperation to link the different research approaches to sustainable development.

- Action 1.2. Build a structured information dataset to better understand the territorial and sectoral distribution of vulnerability to climate change impacts (vulnerability being defined as a function of 1) the exposure to CC impacts, 2) the sensitivity and 3) the adaptive capacity of a system or a territory. The approach would be threefold:

    - Vulnerability assessment of the energy and transport networks overall EU, with view to provide elements for further strategic choices with regard to infrastructure building and security in service provision, following extreme events.

    - Regional vulnerability indices

    - Sectoral focus on changes in sustainability of production and consumption under various climate scenarios

- Action 1.3. Setting up a European wide Clearing House Mechanism (CHM) as a data repository and a platform for knowledge transfer on impacts, adaptation measures in place and best practices, contributing to the Shared Environmental Information System[114] (SEIS). Its purpose would be to promote understanding of climate change impacts across Europe and to equip stakeholders to adapt and it could include: communication and dissemination of scientific research on impacts to enable planned proactive adaptation action; exchange of adaptation best practice in or between sectors or regions; tools and guidance for adaptation strategies. This initiative interlinks with GMES for obtaining better information on the state of the environment, to point out past and current trends on climate including the likelihood of extreme events and climate-related disasters."

[114] COM(2008)46final

– Action 1.4. Provision of targeted awareness-raising, communication, education and training on climate change impacts and adaptation: This might include campaigns aimed at European citizens, recommendations to Member States to build capacity among all parties involved. A strategy for adaptation must include a strong notion of the importance of human capital. 'Human capital' comprises aspects ranging from awareness for the challenges linked with adaptation to climate change, starting from (pre-)school age, to very concrete training and qualification initiatives to make sure that Europe has the skills and competences to adapt to climate change. With the European Social Fund (ESF), the EU has an instrument that provides Member States and regions with the opportunity to invest in human capital. The current programming period 2007-2013 calls for ESF co-funded interventions in this area. ERDF and Cohesion Fund also support capacity building through various means going from direct financial support. Awareness raising should be facilitated also through other EU Funds (Structural, Rural development, Development, research), thereby ensuring that advice and training is provided to foster good autonomous adaptation by public authorities, third countries, individuals and economic operators. The development of Knowledge and Innovation Communities (KICs) within the framework of the European Institute of Innovation and Technology (EIT)[115] would also represent a key element for further research on adaptation, and generally for sustainable economic growth across Europe.

– Action 1.5. The Green Paper already identified a large number of areas which will be considered in the research agenda of the EU. Research activities should also focus on developing countries. Nevertheless a number of additional knowledge gaps should be worked upon: (1) - Further improvement of the quality and coverage of the analysis of climate change impacts for major sectors at scales relevant to adaptation measures (2) - Identification of the limits to resilience beyond which human systems and ecosystems are no longer capable to maintain the required functions and providing the needed services to society (3) -Investigation of how to use the ecosystem approach can be used for adaptation efforts as alternative to infrastructure projects.

– Action 1.6. Define a strategic research agenda, with a focus on climate change adaptation research, building on the achievements of the existing ERA-Net schemes to propose cross-national research schemes and by the pooling of national public funding through ERA-NET+. In addition to the RTD Framework programme, the prioritisation of climate change adaptation research is necessary in other Community and European schemes which support research related activities such as research exchanges and networks of scientists, such as the EUREKA and COST programmes supported by the European Council. This action would need to be assessed in more details at a later stage: the Commission will choose the appropriate instruments available for EU wide or regional mitigation and adaptation research (including potential implementation of Article 169 of the Treaty by building on ongoing initiatives and joint programming efforts defined and implemented).

12.2. Mainstreaming in sectoral policies

– Action 2.1. In order to address climate change impacts to the full extent, systematic **Climate Health Checks** need to be undertaken periodically on how climate change impacts are integrated in all Community policy areas and legislation and vice versa. Although this impact assessment already proposes short-term actions in policy areas where

[115] : http://ec.europa.eu/eit/

serious impacts will occur (see below) , more detailed checks are needed to address the ability of policies in place to address CC impacts and adaptation needs. This will entail an initial health check of those European policies (current and specifically planned policies to respond to CC impacts and adaptation needs) across the Commission. It should include an assessment of how policies affect Europe's vulnerability to climate change (vulnerability mapping), as well as how climate change might affect the success of policies. It is a necessary precursor to mainstreaming policies to CC response and to integrate both mitigation and adaptation to climate change actions into the corresponding sectoral policies. These periodic checks and assessments can precede the beginning of a new policy circle (like for instance a new budgetary period) or be tailored to timelines of other policy circles (reviews of Strategies, Action Plans, Regulations and Directives), or can be performed to support reviews (either mid-term or full reviews) of key sectoral policies (CAP). The checks should based on progress made to the knowledge base and will take on board feed from reporting on response of the policies and progress made to adapt to CC on the basis of established indicators, whether possible.

- Action 2.2. On the basis of the baseline identified in section 2, soft short-term measures can already be identified to mainstreaming adaptation into sectoral policies, implementing the principles for sustainable adaptation identified in section 5. They would consist in guidelines addressing the following topics:

    - Integrate the effects of climate change in the management of Natura 2000 sites

    - Integrate climate impact considerations in the river basin management plans and in the implementation of the Floods Directive. Develop guidance on effective water pricing. Assess the need for further measures to enhance water efficiency in agriculture, households and buildings. Explore the potential for policies and measures to boost ecosystem storage capacity for water in Europe.

    - Ensure that climate change is taken into account in the framework of the Integrated Maritime Policy, the Marine Strategy Framework Directive and in the reform of the Common Fisheries Policy.

    - Integrate climate change adaptation aspects in policies such as in the Strategic Energy Review, the Common Transport Policy.

    - Supporting Member States in mainstreaming adaptation to climate change in the implementation of the Directive on Environmental Impact Assessment and the Directive on Strategic Environmental Assessment.

    - Develop new EU Guidelines for State Aids geared to adaptation to climate change in order to prevent mal-adaptation. Develop guidance for State Aids in Agriculture such as for irrigation projects and irrigation technology, and rather favour projects that make more water/energy savings, integrate adaptation in land reclamation projects.

    - Explore ways, with the WHO, to ensure adequate surveillance and control of health impacts of climate change such as epidemiological surveillance and the control of communicable diseases or effects of extreme events.

- Promote further health governance and co-ordination with specific focus on core EU competences: infectious diseases, UN conventions, Animal health

- Communication/Green Paper due to be adopted in 2010 outlining a long term commitment and proposing 3 options to improve forest protection at EU level.

- Develop guidelines for climate proofing spatial planning integrated with land and water management and nature conservation, addressed to local and regional authorities in order to secure, inter alia, the connectivity of ecosystems, the sustainable management of soils and in general the use of "green infrastructures" (allow for natural water retention, exploit the cooling and filtering capacities, protecting its qualities and carbon content, avoid erosion and leaching, etc.) an fully exploit a proper functioning, provision, and recognition, of ecological services (agriculture, forestry, ecosystems).

- Mainstreaming adaptation in the **EU external policies**, notably development cooperation, security and migration actions while ensuring that: 1) bilateral and regional agreements (e.g. Country and Regional Strategy Papers) include a climate change vulnerability assessment and 2) the effects of climate change in migratory flows are considered in the broader EU reflection on security, development and migration policies. Mainstreaming adaptation in the EU's trade policy, notably in the liberalisation of trade in environmental goods and services and in FTAs. Ensuring that external EU policy actions and instruments make a substantial contribution to adaptation in third countries. These include water management (the EU Water Initiative and the EU-ACP Water Facility), energy, desertification, biodiversity, forests, coastal erosion, disaster prevention, agriculture and health.

- Action 2.3. When a preliminary impact assessment, with a strong emphasis on the knowledge base and subsidiarity & proportionality issues, would conclude that a voluntary or a market based approach will not yield the desired benefits and improvements, introduce legally binding obligation or harmonised standards across EU to achieve the objective of guaranteeing the sustainability of Europe in the face of climate change. The areas in which this assessment would be performed are:

    - Biodiversity: addressing adaptation issues not only to Natura 2000 sites but also in the wider country and seaside and underpinning the establishment and management of a green infrastructure to tackle climate change impacts.

    - Land Use and Land Management: recommending or ensuring that any revision of the land use and spatial planning programs includes and assessment of the climate change impacts in the area and that the decisions reflect the adaptation needs, aiming, in particular, at minimising negative impacts on soil functions, maintaining/enhancing soil organic matter, improving water retention, and protecting biodiversity. Ensuring a better management of land as a scarce resource suffering multiple and competing demands and could include concepts of recycling of land, increasing multifunctional land use: flexible landscapes that would provide the necessary space and elements for the green infrastructure, acting on the demand of land use, and how to foster dual or multi -purpose of land: e.g. agricultural/ flood plain / nature/recreation.

– Water efficiency in buildings.

– Revision of EIA/SEA Directives to ensure that plans and projects falling under this scope require climate proofing as a pre-condition.

– Revision of Decision No 2119/98/EC setting up a network for the epidemiological surveillance and control of communicable diseases

12.3. Risk management instruments

Climate change risks and extreme events can be reduced using market or non-commercial means involve strategic planning to factor in the probability of risk as well as measures to strengthen the preparedness of key institutions. Risk reduction measures have been implemented using financial security (insurance) products. Making creative use of insurance and financial security products, like captives, bonds, etc. is a pro-active means of planning for and dealing with the adverse impacts of climate change that can complement other adaptation measures and can increase the uptake of adaptation actions. Increasing their use and promoting their development should be part of an adaptation strategy, but should duly take into account possible impacts of social and territorial exclusion. Due to the cross-boundary effects of climate change, there may be benefits in promoting EU wide insurance solutions versus national or local schemes. Joining a financial or insurance scheme is a private decision however in some cases it may be necessary that certain private actors/sectors (like those providing public or utility services, critical infrastructures or sectors very vulnerable to weather conditions) are covered under a standard weather-related compulsory insurance product.

As highlighted by (OECD, 2008), "*From a public policy point of view, the main issue is whether the adaptation action taken by the insurance industry results in the right outcome in terms of the availability and level of cover and the distribution of risks. […] First, as long as climate impacts are uncertain, insurance companies, which are risk-averse themselves, will overcharge for climate risk or refuse coverage of risks that might otherwise be insurable. Second, budget constraints, inertia and cultural factors will prevent people from adapting fully in the short-term, especially if the optimal response is relocation. Third, insurance cover is by no means universal. Among poor households and in poor countries in particular it can be patchy*."

In this context 3 sub-options for promoting the role of insurance in EU adaptation policy have been identified:

– **Insurance fostering:** Stimulate and support of the insurance sector in the development of insurance schemes tailored to the needs of groups and sectors adaptation efforts to CC.

– **Insurance taking-up:** Support society to insure against specific risks related to extreme weather events and especially support insurance uptake by key sectors more vulnerable than others to climatic variations, like agriculture and forestry (awareness, market availability, or guidelines, co-financing may be made available).

– **Compulsory Insurance:** Assess the feasibility of introducing compulsory insurance for climate related adverse impacts, e.g. flooding, heat-waves, etc.

Due to the cross-boundary effects of climate change, there may be benefits in promoting EU-wide insurance options as opposed to national or local schemes. Undoubtedly, taking up insurance is a private decision, however it may be necessary that certain private actors/sectors

(such as those providing public services, critical infrastructures or sectors very vulnerable to climate conditions) are covered by compulsory, but affordable for companies and especially SMEs, standard weather-related insurance. In cases where insurance products are not available, for example for buildings located in flood plains, publicly supported insurance schemes may be required. The economic analysis and transfer efficiency effects of insurances, is a very complex subject; this has been largely studied in the case of agricultural insurances, specifically in the context of the CAP Health check. The conclusion of the assessment was that an EU-wide scheme for protecting farm sector against climatic risks is unfeasible at this stage. Subsidizing insurance premiums would be immensely expensive; questions of "moral hazard" and the efficiency of transfer can be seriously questioned for the subsidy of premiums. The option proposed by the Commission in the CAP Health check has been to give increased flexibility to MS to support the up-take of insurance products. It is therefore proposed to mirror this assessment in the remaining sectors.

– Action 3.1. Within the context of using risk management techniques for addressing the sharing of climate change risks and facilitate better and more acute adaptation, the Commission will examine further the potential for insurance and other financial security products to complement adaptation measures and to function as risk sharing instruments. The Commission will seek to work together with the insurance and financial services industry in order to stimulate and support of the insurance sector in the development of insurance schemes tailored to the needs of specific groups and sectors adaptation efforts to CC. The further work planed on vulnerability indicators for areas and sectors could help to this regard. Furthermore, work on adaptation costs for relevant policy areas, but also costs to be accrued because of inaction or from putting in place non-appropriate solutions can provide input for future financial decisions and adoption of financial security practices.

In any adaptation framework, consideration should be given to the role of specialised Market Based Instruments (MBIs), to develop accompanying specialised MBIs and to encourage, where appropriate, public-private partnerships. This can enable the sharing of investment, the spreading of the risk, reward and responsibilities between the public and private sector in the delivery of adaptation action. Public budgets can be relieved from coping alone with remediation after climate catastrophes and with all the investments needed for adaptation efforts. MBIs can be used in relation to the industry allowing greater flexibility in meeting objectives and thus lower overall compliance costs. MBIs have proven that they can provide firms with an incentive, in the longer term, to pursue technological innovation to further reduce adverse impacts on the environment (“dynamic efficiency”). Furthermore, experience gained with MBIs, suggest that they can support employment when used in the context of environmental tax or fiscal reform. Examples of MBIs include incentive schemes for protecting ecosystem services or for projects that enhance the resilience of ecosystems and economic sectors in the form of Payments for Ecosystem Services (PES).

– Action 3.2. There is a need to strengthen the role of innovative funding mechanisms for adaptation. In the context of the White Paper, it is proposed to **e**stablish EU wide guidelines for designing and implementing schemes for **Payments for Ecosystem Services (PES)** and for stimulating markets for these services (building-up the resilience of ecosystems & ecosystem-dependant economic sectors, financing adaptation measures based on green infrastructure).

12.4. Funding review

The following actions have been identified with regard to financing:

- Action 4.1. Increase the awareness on climate change impacts of the partners dealing with the management of EU funded programmes; Increase uptake of adaptation actions under the current EU financing instruments (2007-2013):

    - The Commission should encourage the MS that when they revise their current Operational Programmes they should mainstream adaptation. The Commission could create a communication initiative to encourage and to create awareness among the managers of the funds.

    - Further promote the use of Rural Development Funds to support agriculture contribution to protection and enhancement of green infrastructure, such as develop connectivity, with a view to facilitating species migration in response to climate change, involving wider land use planning, including trans-boundary collaboration, support crops change to more resilient ones.

- Option 4.2. Review the existing funding instruments to identify and improve their potential to be used for addressing climate change vulnerability; include the climate change adaptation dimension in the Reporting on the use of EU funds.

    - There are opportunities for providing specific guidance for best use of the 2007-13 CP instruments to support CC adaptation. A Commission Communication could substantially help in this direction, by ensuring that adaptation and mitigation of climate change is mainstreamed in the Operational Programmes and by presenting key adaptation actions that provide "no-regret" measures, while proposing ways to incorporate them in current planning processes.

    - Effort should also be made to ensure that the guidelines for the Trans European Energy Networks incorporate an assessment of the impacts of climate change in the production and distribution of energy in Europe and build on an assessment of the vulnerability of critical energy infrastructure to climate change. This can be addressed in a follow up of the Strategic Energy Review and the SET Plan. Also the guidelines for Trans European Transport Networks should look to incorporate an assessment of the impacts of climate change.

    - The revision of the current Funding Guidelines needs to be done in an appropriate way to ensure that adaptation and mitigation of climate change will be mainstreamed in the Operational Programmes. The implications of making a climate impact assessment a mandatory condition for projects which receive significant EU funding should be studied in depth. After the development of methodologies and standards, take climate proofing into account when reviewing the TEN-T, TEN-E guidelines and adopting guidance on investments under Cohesion Policy

    - Making the reduction of fishing capacity (either through decommission of ships or with reduction in fishing gear) an obligatory measure in the European Fisheries Fund (EFF) with specific targets per country. This measure, supported by the EFF, should be done through structural reform measures in the context of the Fisheries policy revision.

- Option 4.3. Climate proofing National and EU public funded investment can be examined as well as the possibility to condition the funding to an assessment of the climate impact on

the proposed investment. Regarding EU funding, for Agriculture, the current RD regulation for 2007-2013 do not give support to new irrigation projects or areas but to improvements in current irrigated areas, water savings technologies and practices. This could be further done for various sectors, where the climate change resilience of projects and measures proposed under EU funding programmes could be assessed, for instance tourism investments should avoid spending under the SF for tourism projects that are unsustainable in the longer term (e.g. ski facilities in low land Alpine areas). Another positive aspect in this direction is the current application of this provision in the field of housing, where the ERDF recently started providing support for climate proofing (i.e. energy efficiency and renewable energies) of housing projects contributing to social cohesion.

– Option 4.4. Prepare Long term funding: The forthcoming budget review could assess further the available options for future adaptation funding in the multi-annual financial framework post 2013 such as the amount of the funds that should be used for adaptation, the need for dedicated adaptation funding mechanisms and the links with funding of mitigation activities and international Adaptation actions in a post 2012 global climate agreement. This action requires quite a lot of prior information and knowledge on relevance of climate change challenge for EU funded measures. Thus preparatory actions for this option should include a dialogue with MS management authorities (or potentially through a dedicated Adaptation Committee), climate experts, exchange of information (maybe through a platform consolidating the information available), training, improved use of existing programme management control and monitoring tools.

12.5. Put in place a process for a better co-ordination of adaptation policies and the assessment of next steps.

The elaboration of an EU Adaptation strategy requires collecting and sharing information for the MS and regions/local authorities as the basis for decisions about further action.

In view of current provisions of Article 4 of the UNFCCC, Member States need to adopt national or regional adaptation strategies and the Commission will them who have not yet done so, to adopt it by 2012 at the latest. On top of this, 4 potential actions have been identified

– Action 5.1. In order to improve the coordination of adaptation strategies in the EU, a new **network of National** Adaptation **Focal Points** could be established or alternatively could be linked to existing networks and instruments, e.g. Eionet. This would involve either supporting the creation of national bodies dealing with CC adaptation or stimulating the take-up of actions by existing national bodies, which will function as focal points for the dissemination of know-how and best practices, plus will contribute to the development of National Strategies.

– Action 5.2. An **Impacts and Adaptation Steering Group (IASG)** could be created composed of representatives from the EU Member States involved in the formulation of national adaptation programmes and measures and from the Commission who will provide the secretariat. The Steering Group would be supported by a number of technical groups, who will deal specifically with developments in key sectors (agriculture, biodiversity, water, energy, etc.). The Steering Group would play a role in developing the EU framework in order to facilitate the ongoing development of the EU strategy and the preparation of national adaptation strategies by the Member States. The Steering Group

would also consider the appropriate level at which actions should be best implemented. In the initial phase the Steering Group would focus on monitoring progress in strengthening the knowledge base, in particular the setting up of the Clearing House Mechanism. The Steering Group would provide a coordinated approach to: building the evidence base on the impacts of climate change, assessing the risks of climate change for the EU, the scope for increasing climate resilience, and costing the risks and opportunities.

– Action 5.3. Some regions or cities have already produced **regional adaptation strategies**. For less advanced regions, however, there could be the need to provide assistance for capacity building and best practice sharing. This would will ensure an increase of institutional and social awareness, and achieve solidarity objectives while allowing a cost-efficient use of public and EU resources. Based on a review of existing regional adaptation strategies, a definition of contents for the strategies and guidelines for implementation will be provided, and the link with potential support at EU level will be assessed.

– Action 5.4. Establish an EU legal framework for Adaptation Strategies, with strict deadlines and procedures and within that a Management Committee with executive powers to evaluate and assess the plans and to make recommendations to the Member States.

It is also proposed to fully exploiting the Global Climate Change Alliance to strengthen dialogue with developing countries and implement concrete pilot adaptation programs.