HABIT-CHANGE

Report on user requirements related to climate change

Output 3.1.5

02/2011

This project is implemented through the CENTRAL EUROPE Programme co-financed by the ERDF

Output Number:	3.1.5	**Date:**	28.02.2011
Title:	Report on user requirements related to climate change		
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Project:	HABIT-CHANGE – Adaptive management of climate-induced changes of habitat diversity in protected areas		
Programme:	CENTRAL EUROPE	**Project Number:**	2CE168P3
Start date:	3/2010	**End date:**	2/2013
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1. Introduction, objective and method

1.1. Introduction

In the proposal for the Habit-Change Project the content of this output is described as follows: "Report on user requirements related to climate change (CC). Based on a literature review and interviews with responsible actors and important stakeholders in the regions the report will highlight existing difficulties to react to CC in an adequate manner as well as in resulting user requirements as seen by the regional actors." This output is one of the two core outputs in work package 3 that focuses on the evaluation and enhancement of existing management strategies and practices in protected areas.

It stands in close relation to the outputs 3.1.2 "Stakeholder Dialogue" which provides a "compilation of most important CC related problems as seen by important stakeholders (e.g. regional administrations, land users, associations)" and output 3.2.1 "Report about existing user difficulties" that will compile the "knowledge about existing user difficulties due to climate change".

During the preparatory works for output 3.1.2 a questionnaire was developed to collect information from the participating investigation areas. Information was requested for relevant stakeholders and land users but also for their awareness of climate change and planned reactions to cope with impacts of climate change. Surprisingly, the awareness of climate change did not yet exist in all protected areas and only a few actors (stakeholders as well as land users) related existing problems to climate change. As a result most actors could not report about difficulties identified to react to climate change in an adequate manner in their respective areas. More detailed information about existing problems and the awareness of climate change is found in the report for output 3.1.2 "Stakeholder Dialogue".

This unexpected lack of information from the protected areas has made it necessary to put more emphasis on the information available in literature. Nevertheless, information from the protected areas about planed adaptations, requirements and options of stakeholders and land users is essential for the adaptation of management plans of protected areas. It is expected that during the development of the Habit-Change Project and the intensification of stakeholder dialogues the awareness of climate change and climate-change related problems will rise and more requirements for local adaptations will be defined in the investigation areas. It is therefore planed to compile an additional report for this output (called output 3.1.5 A) with specified adaptation needs and requirements from stakeholders and land users in Habit-Change investigation areas. This planed report will focus on investigation areas that plan to develop a climate-change adapted management plan (CAMP). This present report 3.1.5 is the basis for an intensified stakeholder dialogue that aims at inquiring planed adaptation measures and strategies of important stakeholders and land users inside the protected areas. The planed additional report 3.1.5 A is scheduled for August 2011.

During the development of the detailed work plan for this output and in discussions at project workshops in Poland (April 2010) and Austria (September 2010) it became obvious that some terms and ideas had to be defined more detailed to avoid misunderstandings. The following definitions are the basis for most outputs in work package 3 and also for some outputs in work packages 4, 5 and 6.

Definitions:

- User: users or land users are defined as persons or groups being present inside the boundaries of protected areas that manage parts of the area and implement measures. They influence the condition of the protected area directly (e.g. management authorities of the protected area, land users like private landowners, farmers or tourists). In the project proposal they are also addressed under the term “responsible actors”. Users are a subunit of stakeholders.

- Stakeholder: stakeholders are defined as persons, groups or institutions who have an influence on the protected area, but are not necessarily present in the area (e.g. regional administrations, associations, NGOs etc.). They may influence the state of the protected area through the development or implementation of policies, programmes, legislation or direct and indirect subsidies. Though users or land users can be considered stakeholders as well they are defined as a separate group because they directly implement measures or influence the protected area by their behaviour and acting.

- User requirements: user requirements due to climate change are understood as explicitly stated needs for adaptation to climate change. Adaptation needs are specified for every sector or land-use in a different way. They are mostly not defined by the land users themselves but by representatives, organisations or by scientists. In some cases the user requirements may also include the needs for mitigation to reduce emissions of greenhouse gases. In this report user requirements include all adaptation needs and options so far formulated by different user groups and researchers.

Following these definitions, this report does not only focus on the needs and requirements of the management authorities of protected areas but also analyses the needs of land users from sectors like agriculture, forestry, tourism, water management, fishery, transportation and settlement that play an important role in maintaining and preserving the protected areas. To find out what important land users in protected areas require and what kind of adaptation measures they plan or ask for is very important for the adaptation of the management plans for the protected areas. This knowledge is needed because nature conservation planning is not only confronted with the impacts of climate change like droughts, heat and flooding but also with the impacts of adaptation measures of important land users. Both developments can put nature conservation aims at risk. Therefore a sound knowledge about the impacts of climate change as well as about the required and planned adaptation measures of important land users and stakeholders is needed.

1.2. Objectives

The objectives of this output have to be seen in relation to the outputs 3.1.2 and 3.2.1 as well as with outputs 3.1.3 and 3.1.8 that provide information from investigation areas in Hungary and in Romania (Bucegi Nature Park), respectively. All these outputs aim to collect information about stakeholders and land users, about existing problems and conflicts inside the protected areas and their reactions, requirements and expectations to climate change. This information is important for the adaptation of the management plans for the protected areas because existing conflicts should be solved as far as possible and new conflicts arising from planned adaptations to climate change should be avoided or mitigated. Therefore, communication and participation with relevant actors and stakeholders is necessary.

This output focuses on the requirements and demands for adaptation to climate change as stated by different groups or sectors of land users and stakeholders. It gathers information from scientific sources and from institutions that represent groups of land users and stakeholders e.g. NGOs. This information will later be completed with information from the Habit-Change Project investigation areas and the responsible project partners to show specific adaptation requirements in participating countries (planed report 3.1.5 A).

Objectives of this output are:

- To compile the adaptation requirements of different land user groups who have influence on the management of protected areas
- To find out if requirements of different land user groups match the objectives and purposes of the protected areas or if they may cause additional conflicts and problems in protected areas
- To find out which land user groups have to be included in the process of adapting the management plans for protected areas because their specific adaptation requirements may have relevant impacts on the protected areas and the conservation goals

1.3. Method

First step for this output was a definition and classification of relevant land user groups to be considered. The basis for this step was the examination of national and international strategies, programmes and policies for adaptation to climate change (for detailed information about analysed sources see report for output 3.1.1 "Literature review": Chapter 5: Legislation and guidelines concerning climate change and nature conservation). This information was aligned with information received through the questionnaires for output 3.1.2 "Stakeholder Dialogue". As a result the following land user groups or sectors were identified to be relevant in most protected areas: agriculture, forestry, nature conservation, water management, fishery, tourism, transportation and settlement. The responsible project partners for this output (PP 6 TUB and PP 2 UniV) agreed to split the necessary contributions: Berlin University of Technology (TUB) donated the sections for agriculture, forestry and nature conservation while the University of Vienna (UniV) donated the sections for water management, fishery, tourism and settlement. The authorship is marked at each chapter.

The next step was a literature review that covered international and European as well as national sources of the countries participating in the Habit-Change Project. It included scientific literature as well as political statements and programmes of different land user groups published by governmental and non-governmental institutions. A research on adaptation options, adaptation needs or requirements and on proposals for adaptation strategies and measures was also conducted. Included were strategic policy options as well as practical measures to be implemented by land users, scientists or institutions.

From the questionnaires that were sent to the investigation areas information about relevant stakeholders, their problems and conflicts with the park management authorities, their awareness of climate change and planned adaptations by different land user groups was selected.

1.4. Categories of adaptation

Adaptation to climate change covers a number of different activities, planned and implemented by different public and private actors. Adaptation includes all responses to climate change that help reducing vulnerability or taking advantage of new opportunities that may arise as a result of climate change (Iglesias et al., 2009, p.33).

Adaptation activities can be classified into three groups based on their scope, perspectives and on their scale. Under implementation, adaptation can be divided into facilitating adaptation and implementing adaptation (Klein, 2004 p. 2). The former includes developing information and raising awareness, mobilising resources for adaptation and enhancing adaptive capacity. The latter includes making the actual changes in operational practices and behaviour, and installing and operating new technologies. The focus of this analysis lies on implementing adaptation because the impacts of these measures on agricultural areas inside and around nature conservation areas are more relevant for the Habit-Change Project and they are easier to estimate.

Adaptation activities can be further classified under different perspectives. They can be divided in autonomous or spontaneous and planned measures. Autonomous adaptation refers mostly to private activities and is predominantly reactive (ex post, after the change). Planned adaptation is anticipatory or proactive (ex ante, before the change) and usually driven by public authorities (Schaller and Weigel, 2007 p. 162).

Adaptation measures and strategies can also be assigned to different temporal or spatial scales. On a temporal scale measures can be differentiated in short-term, mid-term and long-term adjustments. The increasing variability of climate makes short-term adaptations necessary, climate changes like the slow rise of average temperatures demand for long-term adaptations (Kurukulasuriya P., Rosenthal, S. (2003) in (Schaller and Weigel, 2007 p. 162). On a spatial scale there are local, regional and sectoral-level adaptation options.

2. Requirements of different land user groups

2.1. Forestry (TUB)

European forests span over three different bioclimatic zones: from the semiarid Mediterranean region where Mediterranean forests grow over the temperate western and central Europe with Continental and Atlantic forests to the cool northern Europe with Boreal forests. The forests of the investigation areas of the Habit-Change Project belong mostly to the Continental zone and partly to the Mediterranean zone.

"The range of European forests is primarily limited by climate, either through moisture availability or through temperature (both being absolute amounts and seasonal distributions)" (Kellomäki et al., 2000 p. 10). The natural area of distribution of tree species is determined by the site as a result of the specific conditions of climate, soil and water. In most European regions new tree species have been introduced to increase forest productivity and "the current tree species composition is mainly determined by past land use and management activities rather than by natural factors" (Kellomäki et al., 2000 p. 10).

The likely impacts of climate change on forests and forestry in Europe were assessed by Kellomäki et al. (2000) on the basis of expert judgements. Country-specific assessments are available for the following participating Habit-Change Project countries: Austria, the Czech Republic, Germany, Hungary, Italy and Poland. The main findings of this assessment for the Habit-Change Project investigation areas are the following:

- In the continental region expected higher temperatures, reduced precipitation and fewer spring and autumn frosts will lead to an increased drought and fire risk and a higher risk for pest outbreaks. A reduced success of natural regeneration and growth of existing deciduous species is expected. The enhanced decomposition of soil organic matter may lead to an increasing weed competition and soil fertility.

- In the Mediterranean region higher temperatures and a strong seasonality in precipitation with high winter precipitation and extreme summer drought will intensify the severe fire risk in this region. Other expected impacts on Mediterranean forests are: severe drought risk, reduced success of natural regeneration and growth of existing deciduous species, death of some tree species, and increased frequency of damaging fire (Kellomäki et al., 2000 p. 19).

- In both regions increasing droughts and forest fires may cause uncertainties in natural regeneration of domestic tree species. "In these conditions, the preference for a tree provenance of more southern origin and wider spacing in plantations may reduce the impacts of the climate change. Throughout Europe, regular management with shorter rotation enhances the turnover of the current tree populations with a faster introduction of more resistant tree species and provenances into forests. (…) Currently, non-damaging organisms may reach pest level and invading species may be dangerous. (…) Interactions with wildlife generally, and effects on biodiversity, are poorly known" (Kellomäki et al., 2000 p. 9).

The following compilation of adaption requirements and adaptation options is a result of a comprehensive literature review on adaption options for forestry in Europe. Most options are based on studies by Lindner (2008), Kellomäki (2000) and Tubiello (2009). The large number of adaptation strategies and measures that have been suggested in the last years can be classified under different categories that range from stand level over forest management to the policy level. “There are many options to actively adapt to the changing climate conditions in European forests. Because of the long management cycles, forestry must anticipate adaptation to the future much earlier than other sectors” (Lindner et al., 2008 p. 168).

2.1.1. Stand management

The most effective measures and decisions can be taken at stand level, especially in areas where small scale ownerships make adaptations on a landscape level difficult. Where climate variability is limited and only a limited increase of droughts and forest fires is expected, the natural forest regeneration offers “a direct and immediate opportunity to adapt tree species or provenances to the changing climatic conditions” (Lindner et al., 2008 p. 115) that does not require any management activities. Other adaptation strategies require management activities that demand personal and financial resources. To improve the stand structure and their resilience by reducing the susceptibility of stands to disturbances, changes in the frequency and intensity of tending and thinning are proposed. The enhancement of natural regeneration by regulating the stands density and rotation time is also highly recommended. To ensure the success of regeneration an enforced weed-control is advised (Kellomäki et al., 2000).

Harvesting activities should be limited to smaller lots and scales than those currently in place and harvesting schedules should be adapted to climatic conditions (e.g. times with frozen ground in winter). Harvesting activities should be adapted “to the principles of natural regeneration, enhancing structural as well as species and genetic diversity via long regeneration periods” (Lindner 2008; Tubiello 2009). Open stand edges that are vulnerable to prevailing winds and direct sunlight should be avoided. By shortening rotation periods and management cycles regeneration of stands can be influenced.

Where natural regeneration is at risk artificial regeneration offers a couple of opportunities to adapt stands. By increasing the species diversity of planted trees, mixes of hardwood and softwood species, forest managers can cope with the uncertainty in future climates. Another recommended option is to raise the genetic diversity within the seedling generation by using seedlings from different stands of the same or neighbouring provenance regions. When regeneration is manipulated with seeds and seedlings, drought resistant plant and provenances from warmer and dryer regions should be favoured. In the continental region preference should be given to drought tolerance conifers in plantations with wider spacing (Kellomäki et al., 2000). By shifting to more productive species under warmer climatic conditions economic losses can be avoided. The adaptation of tree species and their origin choice would rely on a certain soil-friendly management, producing a reduction of the wild claims costs.

To adapt to higher risks of pests outbreaks and insect damage it is suggested to remove dead timber from the forests, use prescribed burning to reduce forest vulnerability and enhance non-chemical insect control mechanisms and harvest stands and trees vulnerable to insect defoliation preferentially (Tubiello et al., 2008 pp. 39). Another measure suggested for pest-control is to limit the „import of fresh timber from areas with pests potentially damaging forests under the climate change“ (Kellomäki et al., 2000 p. 19).

To reduce sensitivity and to raise resilience of forest ecosystems disturbed forest ecosystems should be restored and pressures coming from overuse, pollutions or interventions in water balance should be reduced to develop forest towards more natural conditions.

Table 1 Summary of adaptive measures at forest stand level

Adaptive measures at stand level	Remarks, required conditions
Natural regeneration	Little increase of droughts and fires
Enhancement of natural regeneration by regulations of density and rotation time	
Support of regeneration through weed control	
Changes in intensity and frequency of tending, thinning and other management activities	Higher costs for management
Limiting harvesting activities	Economic impacts have to be considered
Adjusting harvesting schedules	
Changing of tree species, increasing species diversity	Higher costs for management compared to mono-species stands
Raising the genetic diversity by using seeds from different stands and provenances	
Enforced planting and seeding of drought resistant trees	Soil-friendly management
Increasing the structural diversity, wider spacing	
Shortening rotation periods	
Pest control through controlled burning, removal of dead timber, nonchemical insect control and preferential harvesting	
Increasing forest stability by restoring disturbed forest ecosystems towards more natural conditions	
Reducing pressures and disturbances from pollutions, overuse or interventions in water-balance to raise resilience	

2.1.2. *Forest management*

European forests serve many different purposes which have to be regarded and balanced in management decisions. They reach from nature protection goals to the recreational use and intensive wood production. Forest ecosystems provide a number of ecosystem services reaching for example from water retention, clean and cool air production to carbon sequestration or fibre production. Forest management decisions have to take all these services into account and maintain these functions and services under changing climate conditions. The goal of adaptation on forest level is to protect these functions and services against increasing hazards due to climate change. Specific site and stand characteristics like the species composition and management activities may influence the vulnerability and resilience of a wider region. Therefore a profound knowledge on the complex causalities of impacts on forest ecosystems on a regional scale is needed. Enhanced research activities are necessary to develop adequate adaption strategies to cope with pest outbreaks, diseases, storm damages or temperature changes. The results from research projects have to be incorporated into decision support systems and be transferred to land owners and decision makers.

The challenges of climate change shall be met by new planning and decision support tools that are able to deal with uncertainty and risks in long-term forest planning. These tools still have to be developed and tested. Another option recommended on the forest level is a "flexible adaptive planning, which takes into account all conceivable scenarios and allows to consider multiple options for future development" (Lindner et al., 2008 p. 169). Monitoring and evaluation of processes, objectives and measures are seen as prerequisites for an adaptive management that has to be accompanied by long-term research projects and extended forest inventories. An enforced strategic and operative controlling is expected to support the achievement of management objectives under changing climate conditions.

"Cooperation of scientists, decision makers and stakeholders will lead to a more comprehensive understanding of the complex problems involved in decision making and will provide a more realistic and reliable basis for decision support for management in future forest ecosystems. The increased use of science-based decision support systems in forest management planning could foster such activities" (Lindner et al., 2008 p. 170).

On a forest level adaption strategies should find options for problems like wind or snow damage that may be reduced by avoiding heavy thinning. Integrated forest inventories, pollution control monitoring and adapted and innovative techniques for wood processing (including possible changes in wood quality and tree species) would be required. Increasing drought events require adapted strategies for fire protection with more reserves and special measures for fire fighting. Preventive measures such as forest fire-monitoring and early warning systems and contingency plans for fire fighting will be all required. To explore the different vulnerability of tree species and provenances to storm damage, beetle attacks or drought, adaptive management strategies should be implemented. Stress factors reducing the resilience and the natural regeneration of forests, like e.g. large and feed game populations, must be reduced on a regional level. Concepts for water management have to be developed and implemented in coordination with neighbouring land users and stakeholders and in regard of changing precipitation rates due to climate change (UBA, 2008 p. 2).

Table 2 Summary of adaptive measures at forest management level

Adaptive measures at forest level	Remarks, required conditions

Development and implementation of decision support tools	
Enforced cooperation between scientists, decision-makers and stakeholders	
Enforced research activities	
Coordinated strategies for pest control, snow and wind damage, beetle control	
Adapted and coordinated water management	
Game control	
Reduction of non-climatic stressors	

2.1.3. Planning and policy design

On a national and regional level different actions are required to adapt policies, programmes and research activities. The commission of the European Communities calls the member states and the European institutions to update their forest strategies on climate-related aspects and launch a debate on options for an EU approach on forest protection and forest information systems. Measures of adaptation and water management shall be embedded in national strategies and programmes (European Commission, 2009b p. 9).

Lindner (Lindner et al., 2008 pp. 170) lists the following activities that should be taken on the policy level:

- National and regional institutions have the task to adapt infrastructures for water management and irrigation, and a road network for transport of lumber, management activities and hazard control (forest fires)
- The restoration of a regional groundwater regime can help prevent drought stress in floodplain forests
- The development of monitoring systems is seen as an essential step towards adaptation to climate change
- To facilitate forest regeneration with species varieties adapted to climate change nurseries and tree breeding facilities have to be enabled to provide the requested diversified reproductive material
- Existing forest management guidelines have to be adapted to changing climates in a participative process involving decision-makers, stakeholders, experts and analysts
- New methods and strategies like vulnerability assessment, risk management and the combined implementation of adaptation measures have to be developed and tested in forest management planning at larger geographical scales
- Policy level adaptation strategies have to include the full forest wood chain (wood industries) but also the objectives of climate change mitigation and conservation of biodiversity

The knowledge base related to all aspects concerning adaptive forest management strategies has to be expanded by intensified research activities. This includes the knowledge about the "site suitability of tree species and provenances in the perspective of changing climatic conditions" (Lindner et al., 2008 p. 169).

The German Adaptation Strategy to Climate Change (Bundesministerium für Umwelt, 2008) recommends the enhanced provision of information about climate change, the impacts on forests and the needs for adaptation. It is seen as a task of national and regional institutions to convince forest-owners of necessary adaptation measures and provide the required scientific decision support. Nations and federal states should enhance necessary techniques for monitoring, establish and operate more sample areas to monitor climate change impacts, support the enhancement of breeding of adapted provenances and varieties and adapted harvesting techniques. Also the enhancement of dialogue processes and knowledge transfers between experts and forestry are adaptation activities on the policy level (Bundesministerium für Umwelt, 2008 pp. 32).

Table 3 Summary of adaptive measures at policy level

Adaptive measures at policy level	Remarks, required conditions
Update of national forest strategies and programmes	
Coordination with adaptation of water management strategies	
Enhancement and adaptation of water and road infrastructure	
Restoration of natural groundwater regimes	
Development and enhancement of monitoring systems	
Support of breeding facilities and nurseries	
Adaptation of forest management guidelines in a participatory process	
Development and testing of new strategies: risk management, vulnerability assessment	Including demands of wood chain industries and nature conservation (biodiversity)
Intensified research on all climate change related topics	
Improvement of communication structures and knowledge transfer	Stakeholder dialogues, communication processes

2.1.4. Conclusion

Adaptation options on stand level are seen as the most effective measures in forestry. Many of the suggested and required adaptation actions may have impacts on forest biodiversity and objectives of nature conservation, which are mostly unknown due to the complexity of forest ecosystems. Especially the introduction of new, climate adapted tree species or the removal of dead-wood may conflict the objectives of habitat protection and nature conservation. Some adaptations also have impacts on the social and economic aspects of forestry and may influence existing systems of managing forests. What makes adaptation of forests more difficult than in other sectors is the long time span for the development of a tree from a seedling to a grown tree that can be harvested. Climate change is proceeding faster than forest can adapt to by natural regeneration.

2.2. Agriculture (TUB)

Agricultural systems provide a variety of services for society. They have not only the function to produce food by growing crops and raising animals but they also play a vital role in the conservation of historical landscapes, the preservation of agro-biodiversity, and the provision of high value habitats and many different ecosystem functions. Agriculture is a source of work and social stability in rural areas and plays an increasingly important role in providing renewable energies to help reducing the emission of greenhouse gases and substituting fossil fuels.

Farmers manage the majority of land in the EU and even in some protected areas agriculture is the main land use, thus playing an important role in managing and protecting cultural landscapes and the biodiversity associated to them. Therefore, the Commission of the European Communities encourages the member states to embed climate-change adaptation in the three strands of rural development aimed at improving competitiveness, the environment, and the quality of life in rural areas(European Commission, 2009b p. 9).

Agriculture is strongly depending on weather and climate. Climate changes may have positive or negative effects on the agricultural systems in different EU regions, depending on the regional impacts of climate change and the vulnerability of agricultural systems. "Rising atmospheric CO_2 concentration, higher temperatures, changes in annual and seasonal precipitation patterns and in the frequency of extreme events will affect the volume, quality and stability of food production and the natural environment in which agriculture takes place" (European Commission, 2009a p. 2). The positive effect of higher CO_2 concentrations on plant growth should not be overestimated because productivity will be limited increasingly by the available water resources.

Agricultural systems will have to react and adapt to impacts such as the changes in water availability, new and increasing pests and diseases or the degradation and erosion of soils. Although the projected changes may vary from region to region, it is expected that "intensive farming systems in western Europe will generally have a low sensitivity to climate change because projected changes in temperature or rainfall have only a modest impact and because the farmers can adapt and compensate by changing management practices. (…) On the other hand, low-input farming systems currently located in marginal areas may be severely affected by climate change" (Orlandini et al., 2008 pp. 346).

The EU in its working paper on agriculture (2009) (European Commission, 2009a p. 5) suggests that the vulnerability of farming to climate change varies across the EU "depending on the exposure to adverse climate impacts and on the socio-economic context. Existing agro-ecological conditions and the experience in dealing with changing conditions influence farmers' adaptive capacity." According to this source, socio-economic factors defining resilience include:

- Farm characteristics such as production type, size of the farm, level of intensity
- Diversity of cropping and livestock systems, and the presence of other income sources apart from agriculture
- Access to relevant information, skills and knowledge about climate trends and adaptive solutions; the role played by advisory services in facilitating adaptation

- General socio-economic situation, farmers with limited resources or living in remote rural areas being most vulnerable
- Access to available technology and infrastructure capacity

2.2.1. Objectives of adaptation

The main aim of all adaptation policies is to increase the resilience and to reduce vulnerability of agricultural systems. The review of the common agriculture policy (CAP) for the period after 2013 opens opportunities to integrate adaptation requirements into relevant CAP instruments. The Commission suggestions (European Commission, 2009b p. 10) for adaptation on EU and on member states' level are the following:

- Ensure that measures for adaptation and water management are embedded in rural development national strategies and programmes for 2007-2013
- Consider how adaptation can be integrated into the 3 strands of rural development and give adequate support for sustainable production including how the CAP contributes to the efficient use of water in agriculture
- Examine the capacity of the Farm Advisory System to reinforce training, knowledge and adoption of new technologies that facilitate adaptation

To reduce the possible negative effects and to foster potential positive effects of climate change adaptation strategies need to be introduced (Orlandini et al., 2008 p. 347). Farming systems are suggested to have always adapted to changing weather conditions and it is understood that, to some extent, "adaptation to climate change follow the same principles as adaptation to short-term oscillations" (European Commission, 2009a p. 5). From that point of view, adaptation has already happened in the past as a reaction to temporary changes and is also happening as a reaction to changes induced by climate change. However, it is anticipated that "the magnitude of climatic changes expected in the coming decades may exceed the adaptation capacity of many farmers" (European Commission, 2009a p. 5).

Because of the "large variation across the European continent in climatic conditions, soils, land use, infrastructure, and political and economic conditions" (Orlandini et al., 2008 p. 347) adaptation must consider the regional differences in climate exposure, sensitivity and adaptive capacity and find suitable solutions for different regions with different anticipated climate impacts and different preconditions. The ability to respond and adapt to climate change in an appropriate way largely depends on the availability of resources and knowledge.

Adaptive measures in agriculture should range from technological solutions to political changes such as adaptation plans through adjustments in farm management or structures. Even though autonomous farm level adaptation may be sufficient in the short-term, technological and structural changes will become necessary in the long run. The EU concludes in its working paper for agriculture that this will require planned strategies based on analysis of local and regional conditions (European Commission, 2009a p. 6).

The analysis in sections 2.2.3 and 2.2.4 will differentiate between farm-level and sector-level adaptation and provide, where necessary, additional information on the time horizon for implementation. The chosen categories also allow relating measures to different stakeholders and land users. Suggested and required adaptation measures may have effects on farmland in protected areas and therefore have to be considered in the adaptation process of the management plans for the protected areas.

2.2.2. Guiding principles for adaptation

Guiding principles for adaptation of agriculture to climate change have been outlined by the EU in its working paper for agriculture in 2009. They are intended to support planners and decision makers when dealing with the challenges of adapting to climate change and provide a framework for identifying good practice examples in adaptation.

Prutsch et al. (2010) define adaptation as a "cross-level and cross-sectoral activity which brings together actors from different stakeholders including governments (EU, national, regional, local), businesses, environmental NGOs, scientists and citizens". Guiding principles for adaptation are therefore intended to "support adaptation processes for a wide range of situations and actors. Thus, they are intended to be a common basis for cooperative adaptation activities for all sectors and decision-making levels from local to the European scale" (Prutsch et al., 2010 p. 10).

The following three guiding principles were compiled by the EU after a comprehensive literature review and represent the experience of experts across Europe. They are strongly interlinked and should be understood in an integrated way.

- *Prioritising "no regret" measures*
  Due to the inherent uncertainties, "no regret" options for adaptive action should be prioritised in order to ensure the most cost-effective approach. "No regret" measures are defined as those that would be justified under all plausible future scenarios, including the absence of man-made climate change (Eales et al., 2006 p. 81). They help coping with a broad range of plausible changes and induce socio-economic or environmental co-benefits. No regret measures in the agricultural sector include enhancing resilience of the agricultural ecosystems by more sustainable use of natural resources, in particular water and soils, on which agriculture depends. By doing this, the sector can better build resilience to climatic changes. Such responses will ensure that "management decisions implemented over the next decades do not undermine the ability to cope with potential larger impacts later in the century" (European Commission, 2009a p. 8).

- *Strengthening the role of agriculture as a provider of ecosystem services*
  The maintenance of ecosystems through the management of agricultural land has a central role to play in contributing to overall resilience to climate change. Agriculture can, for example, assist in watershed management and protection of habitats and biodiversity as well as in the maintenance and restoration of multifunctional landscapes. For example, establishing networks of wildlife corridors on agricultural land can facilitate migration of species and the water holding capacity of grazing land can be used to reduce flooding risks. "The potential role of agriculture in providing such "green infrastructure" could be recognized and further enhanced" (European Commission, 2009a p. 9).

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- *Developing synergies between adaptation and mitigation*
  Agricultural activities are an important source of nitrous oxide and methane emissions, which contribute to global warming. In the EU, agriculture can contribute to climate change mitigation by reducing its emissions, by producing renewable energies and bioproducts, and by storing carbon in farmland soils.
  To address the double challenge of reducing greenhouse gases (GHG) emissions while at the same time coping with the changing climate, it will be necessary to ensure synergies between adaptation and mitigation as much as possible. Measures that provide co-benefits in terms of reducing emissions and increasing resilience of farming need to be identified and promoted. Examples include soil and tillage practices that help maintain and increase organic carbon in soils, protection and management of pastures and promotion of organic farming due to its efficient nutrient cycles and soil management as well as due to its potential higher resilience to climate change through diversity enhancement and high level of knowledge of the functioning of the farm ecosystem" (European Commission, 2009a p. 9).

2.2.3. Farm-level adaptation

A constant development of adaptation strategies at farm-level can be observed across Europe. Farmers improve the management and land-use practices and deal with existing climatic conditions in order to increase their productivity. In the COST 734 Action (Impacts of Climate Change and Variability on European Agriculture) Orlandini et al. (2008) found a "surprisingly wide range of adaptation responses to climate change that has already taken place" (Orlandini et al., 2008 pp. 350). The most important changes observed during the last decade include changes in tillage practices and shifts in the sowing dates (e.g., tendency to an earlier sowing of spring crops). Further changes reported include the introduction of new crops to crop rotation, with an increase in the area of silage and grain maize being the most notable changes. In the warmest zones a tendency of farmers to reduce crops that are unsuitable for the changing climatic conditions is observed. The study concludes that, "despite the tendency for new cropping schemes, farmers seem to be more interested in maintaining their present portfolio of crops by introducing new and more suitable cultivars that are able to better cope with drought and other weather extremes of the presently grown crops across all zones" (Orlandini et al., 2008 pp. 350). There have also been widespread efforts to promote techniques that preserve soil water and in introducing cultivation practices that reduce soil erosion. However, improvements in the field drainage systems seem to be least notable. All in all, the level of public awareness on climate-change related impacts seems to be relatively low compared with the urgency of the problem. Therefore, the results of Orlanidini's study show that a "concerted adaptation effort has so far had relatively low priority in almost all countries" (Orlandini et al., 2008 pp. 350).

This already observed farm-level adaptation based on the experience and knowledge of the farmers is deemed to be insufficient to cope with the predicted climate-change impacts on agriculture. Further short and medium-term adaptations are recommended in different published studies [(European Commission, 2009a p. 6), (Tubiello et al., 2008 pp. 36)]. The following adaptations can be implemented now or in the near future, provided the farmers are equipped with the necessary knowledge and guidelines:

- Altering the timing or location of cropping activities

- Implementing technical solutions, such as protecting orchards from frost damage or improving ventilation and cooling systems in animal shelters
- Choosing crops and varieties better adapted to length of the growing season and expected weather conditions and water availability, introduction of heat-tolerant crops
- Improving the effectiveness of pest and disease control through better monitoring, diversified crop rotations, use of varieties and species resistant to pests and diseases or integrated pest management methods
- Using water more efficiently by reducing water losses, improving irrigation practices, and recycling or storing water
- Improving soil management by increasing water retention to conserve soil moisture
- Preventing water logging, erosion, and nutrient and sediment transportation resulting from extreme rainfall events
- Diversifying the livelihood strategy to include income from other farming and non-farming activities
- Improving landscape management by maintaining landscape features providing shelter to livestock, protect soil and improve agricultural ecology
- Matching stocking rates with pasture production, altering the rotation of pastures and modifying the times of grazing
- Using climate forecasting tools to reduce production risk

Some adaptations may require more research and development e. g. the introduction of more heat-tolerant livestock breeds, adapting diet patterns of animals under heat stress conditions or altering the integration within mixed livestock and crop systems including the use of adapted forage crops.

The conversion to organic agriculture is also seen as a way to adapt to climate change as this increases the ability of the farming system to continue functioning when faced with the adverse effects of climate change by increasing resilience within the agro-ecosystem. Organic agriculture is deemed to create "robust and environmentally benign farming systems that are resilient to temperature extremes, drought and which avoid soil erosion" (International Federation of Organic Agriculure Movements (IFOAM), 2009 p. 14). Furthermore, organic farming deals more efficiently with water and soil drainage due to better soil structure and higher levels of humus and other organic matter.

A good overview of farm-level adaptation measures that can be implemented after Iglesias et al. (2009) is shown in Table 4, below:

Table 4 Farm-Level Adaptation Measures

Source: (Iglesias et al., 2009 p . 37)

Measure	Action	Potential result
Choice of crop	Drought of heat resistant	Reduction of risk of yield loss and reduction of irrigation requirements
	Pest resistant	Reduce crop loss when climate conditions are favourable for increased weeds and pests
	Quicker (or slower) maturing varieties	Ensure maturation in growing season shortened by reduced moisture or thermal resources; maximization of yields under longer growing seasons
	Altered mix of crops	Reduction of overall production variability
Tillage and time of operations	Change planting date	Match altered precipitation patterns
	Terracing, ridging	Increase moisture availability to plants
	Land levelling	Spread water and increase infiltration
	Reduced tillage	Reduction of soil organic matter losses, soil erosion, and nutrients
	Deep ploughing	Break up impervious layers or hardpan, to increase infiltration
	Change fallow and mulching practices	Retain moisture and organic matter
	Alter cultivations	Reduce weed infestation
	Switch seasons for cropping	Change from spring to winter crops to avoid increased summer drought
Crop husbandry	Alter row and plant spacing	Increase root extension to soil water
	Intercropping	Reduce yield variability, maximise use of moisture
Irrigation and water harvesting	Introduce new irrigation schemes to dryland areas	Avoid losses due to drought
	Improve irrigation efficiency	Avoid moisture stress
	Water harvesting	Increase moisture availability
Input of agro-chemicals	Vary amounts of fertilizer application	Increase nitrogen to improve yield if more water is available; or decrease to minimise input costs
	Alter time of application	Match applications to (e.g.) altered pattern of precipitation
	Vary amount of chemical control	Avoid pest, weed, and disease damage

2.2.4. Sector-level adaptation

Sector-level adaptation may be needed as climate change impacts gradually become more drastic. This adaptation should be "tailored to the diversity of regional and local agriculture and should be steered by public authorities" (European Commission, 2009a p. 7). A broader range and better coordinated adaptive action should be facilitated, and maladaptation, which could have serious environmental and economic consequences, should be avoided by adopting sector-wide responses.

According to Iglesias (2009), "adaptation is, in part, a political process, and information on options may reflect different views about the long-term future of resources, economies, and society". The perception of environmental and economic damage associated to climate change "is also a driver of the economic component of adaptation" (Iglesias et al., 2009 p. 38).

Public institutions are mostly responsible for adaptations at a sector level. Their support and the establishment of an appropriate framework will be necessary for the planning and implementation of long-term adaptations. National and regional adaptation strategies may help rise awareness for projected changes and encourage farmers and institutions to take early actions and prepare long-term interventions and solutions.

A series of studies and institutions have outlined measures towards a sectoral-level adaptation [(European Commission, 2009a pp. 6-7), (Bundesministerium für Umwelt, 2008 p. 28), (Kronberger et al., 2010), (Iglesias et al., 2009 p. 36), (Deutscher Bauernverband, 2010 pp. 9 - 14)]. These may include:

- Identification of vulnerable areas and sectors and assessment of needs and opportunities
- Support to agricultural research and to experimental production
- Development of alternative farming strategies
- Building adaptive capacity by awareness raising and transfer of knowledge
- Promoting efficient water management and water technology use
- Improvement of irrigation infrastructure and plans as well as water retention
- Development of methods for improving soil natural regulation processes
- Addressing the issue of adjustment of fertilizer management to seasonal weather patterns
- Supporting farmers who develop adapted varieties and innovated methods
- Supporting animal husbandry and management of livestock
- Optimising glass-house culture in terms of energy, water supply and cooling plans
- Mobilizing sufficient resources through the Common Agricultural Policy (CAP)
- Enabling sufficient resources for consulting and research on screening of site suitability for adapted crops
- Evaluating, enhancing and supplementing measures and regulations in subsequent programs
- Monitoring of climate change to improve awareness and understanding of needs
- Developing risk and crisis management instruments to cope with the economic consequences of climate-driven events

Of the measures mentioned above, sector-level adaptation will need to be implemented either at local or regional/national level. An integrated management of water and agriculture sectors will be a key player in the development of adaptation. So, local level adaptation initiatives, according to Iglesias (2009), may combine water reallocation initiatives, engineering and structural improvements to water supply infrastructure, agriculture policies and urban planning/management. At a national/regional level, priorities may include placing greater emphasis on integrated, cross-sectoral water resources management, using river basins as resource management units, and encouraging sound management practices (Iglesias et al., 2009 pp. 38).

To support adaptation measures, effective planning and capacity building for adaptation to climate change is necessary. The IPPC (Easterling et al., 2007 p. 296) has developed guiding principles to facilitate these processes, including the following:

1. Changing enterprising management practices by convincing management that the climate changes are real and are likely to continue (e.g., Parson et al., 2003 in IPPC, 2007). This could be assisted by policies that maintain climate monitoring and communicate this information effectively. There could be a case also for targeted support of the surveillance of pests, diseases and other factors directly affected by climate.

2. Making managers confident that the projected changes will significantly impact their business (Burton and Lim, 2005 in IPPC, 2007). This could be assisted by policies that support the research, systems analysis, extension capacity, and industry and regional networks that provide this information.

3. Making technical and other options available to respond to the projected changes. Investment in new technical or management options (e.g., improved crop, forage, livestock, forest and fisheries germplasm, including via biotechnology) or old technologies revived in response to the new conditions may be required (Bass, 2005 in IPPC, 2007).

4. Supporting role of governments in transitions such as major land use changes, industry location changes and migration. This could be done via direct financial and material support, and by creating alternative livelihood options (reducing dependence on agriculture, supporting community initiatives, building capacity, providing alternative employment sources and developing contingency plans) (e.g., Olesen and Bindi, 2002; Winkels and Adger, 2002; Holling, 2004 in IPPC, 2007). Effective planning for and management of such transitions may also result in less habitat loss, less risk of carbon loss (e.g., Goklany, 1998 in IPPC, 2007) and also lower environmental costs such as soil degradation, siltation and reduced biodiversity (Stoate et al., 2001 in IPPC, 2007).

5. Developing new infrastructure, policies and institutions to support the new management and land use arrangements by addressing climate change in development programs; enhancing investment in irrigation infrastructure and efficient water use technologies; revising land tenure arrangements (FAO, 2003 in IPPC, 2007); and establishing accessible, efficiently functioning markets for products, inputs and for financial services, including insurance (Turvey, 2001 in IPPC, 2007).

6. Implementing efficient targeted monitoring of adaptations to climate change and their costs and effects to make continuing adjustments and improvements in adaptation (Perez and Yohe, 2005 in IPPC, 2007). The 'mainstreaming' of climate change adaptation into policies should be sought in order to intend enhancing broad resilience.

Table 5 Summary of adaptive measures for agriculture at sector level

Adaptive measures at sector level	Remarks, required conditions

Assessment of needs and opportunities	Identification of vulnerable areas
Support to agricultural research and to experimental production	
Development of alternative farming strategies	Supporting farmers who develop adapted varieties and innovated methods
Building adaptive capacity by awareness raising and transfer of knowledge	
Efficient water management	Promote water technology
Improvement of irrigation	Improvement of water retention
Development of methods for improving soil natural regulation processes	
Adjustment of fertilizer management to seasonal weather patterns	
Supporting animal husbandry and management of livestock	
Optimising glass-house culture in terms of energy, water supply and cooling plans	
Mobilizing sufficient resources through the Common Agricultural Policy (CAP)	
Evaluating, enhancing and supplementing measures and regulations in subsequent programs	
Monitoring of climate change to improve awareness and understanding of needs	
Developing risk and crisis management instruments to cope with the economic consequences of climate-driven events	

2.2.5. Conclusion

Adaptation measures in agriculture are already observed all across Europe. However, most actions are taken on farm-level and are short-term adaptations. These measures may have strong influence on the state and objectives of protected areas because they have the potential to impact habitats, species and water balance. Additionally, sector-level adaptation also suggests a shift in some practices, including alternative uses for agricultural land and introduction/adaptation of plant and animal species more resilient to the expected climatic conditions. Agricultural uses taking place in and around protected areas implementing the already observed and the planned adaptation measures may pose a threat to protected habitats and species. Therefore the adaptation process of protected areas has to take planned adaptation measures of important land users and stakeholders into consideration and align them with the objectives and strategies of nature conservation.

Farmers do not only react to changing weather and climate but also to changing conditions on markets. Up to now changes in EU subsidies have stronger impacts on policies, strategies and measures of farmers and agricultural systems than climate change has. Adaptation to climate change therefore has to be seen in relation to changes in legal, technical or institutional conditions. Mobilizing resources to support agricultural uses will have to be done with due regard to the objectives of nature conservation.

2.3. Water management (UniV)

Many of fields can be covered by the catchword “water management”. To mention a few: water availability and demand, drought, water scarcity, floods, waste water treatment, drinking water supply, coastal management, irrigation etc. Therefore a large range of user groups could be defined:

- Agriculture and forestry
- Fishery
- Tourism
- Nature conservation
- Industries and electric power generation
- Marine and freshwater management

As some of the user groups are already covered in other chapters in this report (see chapters 2.1 – 2.8), this chapter will focus on marine and freshwater management.

In 2009 the European Commission presented the White Paper “Adapting to climate change: Towards a European framework for action” (COM, 2009 147 final) as follow up to the Green Paper “Adapting to climate change in Europe – options for EU action” (COM, 2007). This paper underlines the importance of a common adaptation strategy at EU level. The goal is to establish a Clearing House Mechanism (CHM) – a network of stakeholder, NGOs, locals, authorities etc. for exchanging of expertise and knowledge in sight of adaptation strategies. Further requirements are methods, models, data sets, predictions and indicators which should be developed until 2011. Additionally a cost and benefit assessment should be carried out. In the end, adaptation measures should be integrated into EU policies, like into the Water Framework Directive (Directive, 2000/60/EC) or Floods Directive (Directive, 2007/60/EC) or Marine Strategy Directive (Directive, 2008/56/EC).

For all user groups, adaptation is the key to confronting climate change. The urgency of action is accented in several papers. One strong motive for adaptation measures is the financial loss (e.g. Richards and Nicholls 2009) through climate change which far exceeds the costs for adaptation. However uncertainties in prediction models are often used by authorities as an excuse for not taking action.

2.3.1. Freshwater management

(Krysanova et al., 2010) compared adaption strategies for river basins in Europe, Asia and Africa. The most important drivers for the development of climate change adaptation are climate-related disasters and national and international policies. Further but less important drivers are institutional changes, land use change and funding opportunities. In this regard (Huntjens et al., 2010) stated that river basins where one type of extreme (e.g. drought) is dominant, the other potential impacts of other extremes are more or less disregarded. Barriers for adaptation action were found to be spatial and temporal uncertainties in climate scenarios, lack of adequate financial resources and horizontal cooperation. Furthermore different risk perception, lack of human capital, transboundary cooperation, vertical cooperation, regulatory framework and problems in organizational setup to horizontal and vertical integration are found to hinder adaptation strategies Krysanova (2010). Additionally, a Strengths, Weaknesses, Opportunities and Threats (SWOT, Figure 1) – analysis was carried out. This method is seen as an appropriate tool for management.

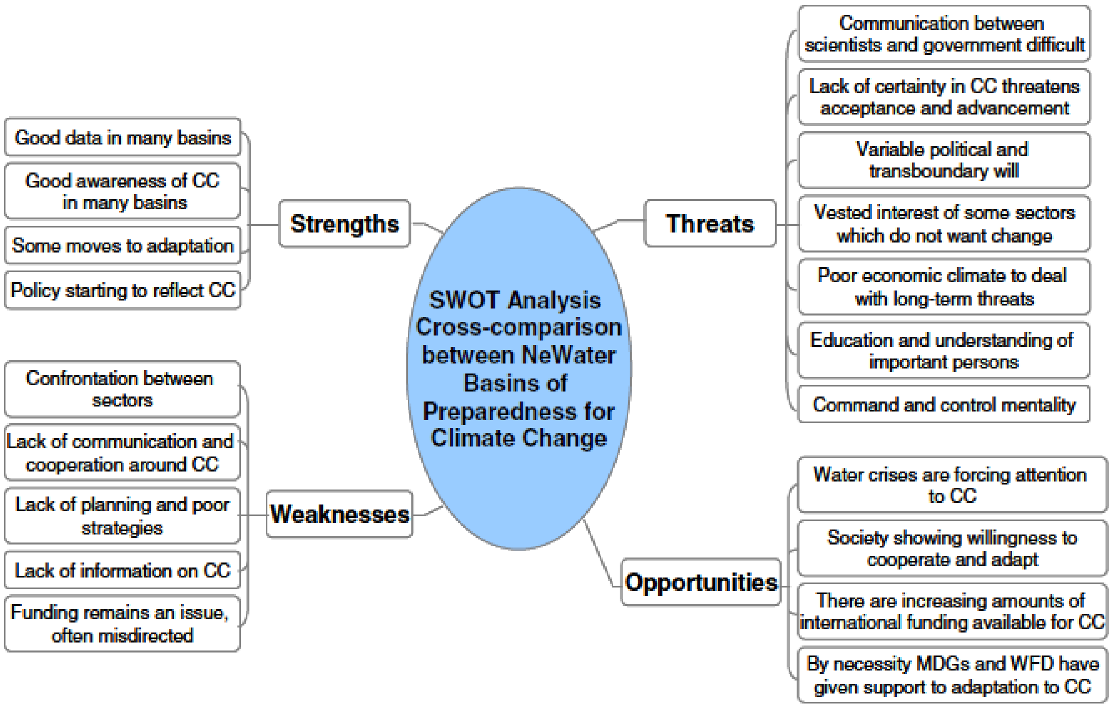

Figure 1: SWOT characteristics in six case study basins in Europe, Asia and Afrika

(Source: Krysanova 2010)

The floodplain restoration along the Lower Danube can be seen as a paradigm for adaptation. In 2005 and 2006, severe flood events killed more than 40 people and caused costs of over Euro 400 M. By establishing the “Lower Danube Green Corridor” - a floodplain restoration of 9.000km^2 - enough retention area could be formed and hence floods are naturally diluted (Huela et al. 2009).

2.3.2. Drought and water scarcity

Climate change is a driving force for water scarcity and droughts – especially but note solely in southern Europe (Fig.2). The impacts are widespread in the fields of human well-being, agriculture and economy. For example, the drought in 2003 affected over 100 million people in one third of the territory of the EU. Beside an increasing number of drought and water scarcity events, the demand of water is still rising.

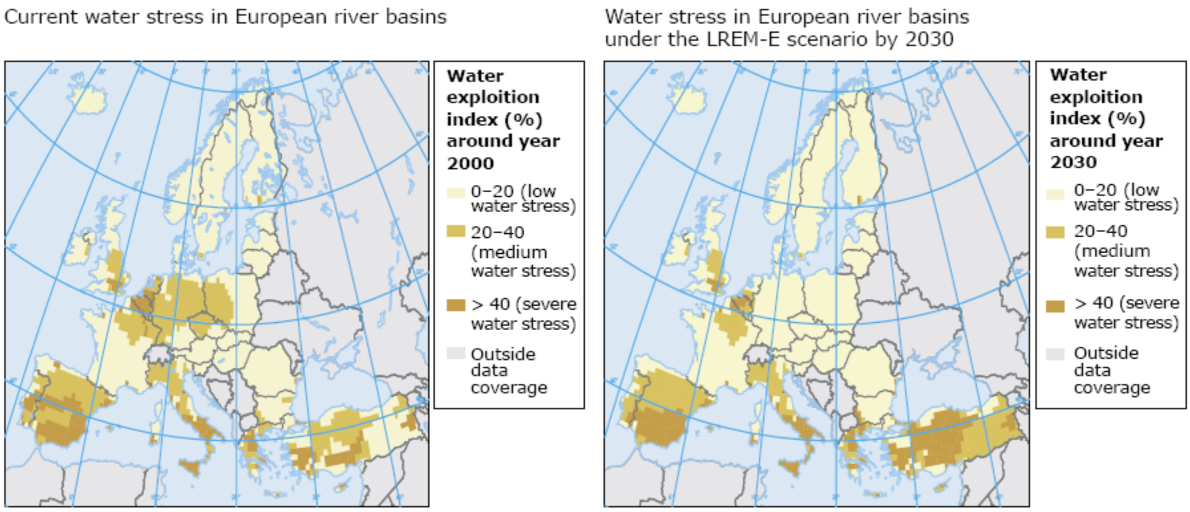

Figure 2: Water stress in European river basins

(Source: EEA 2005)

To combat upcoming problems, the EU presented a Communication addressing the challenge of water scarcity and droughts (COM 2007/0414 final). Seven policy initiatives were identified focusing on the integrated approach of water saving and water efficiency potential:

- Putting the right price tag on water
- Allocating water and water-related funding more efficiently
- Improving drought risk management
- Considering additional water supply infrastructures
- Fostering water efficient technologies and practices
- Fostering the emergence of a water-saving culture in Europe
- Improve knowledge and data collection

Since the publication of this communication paper a number of case studies and projects were launched e.g. for water pricing and water saving in agriculture, to halt desertification or to reduce leakage in water distribution networks. These projects last until 2011 or 2012 and the obtained data will be integrated in a "Blueprint to safeguard European waters" which is going to be finalized in the end of 2012.

2.3.3. Groundwater

Groundwater is the main source of drinking water in Europe and therefore its condition is of vital importance. Pressures for groundwater quality and quantity are nitrate, pesticides, groundwater abstraction, human interventions to the hydrological cycle and climate change. Groundwater exploitation and climate change induced shortage of groundwater have several effects for water suppliers (e.g. restrictions for abstraction volumes or increased abstraction costs), water regulators (e.g. conflicts in water supply between different users or water quality problems in the aquifers) and the environment (e.g. indirect impacts on wetland ecosystems or decreased spring and river flows) (EEA 1999).

The Groundwater Directive (2006/118/EC) specifies the requirements of the Water Framework Directive (COM 2000/60/EC) presenting quality standards for the maximum concentration of pollutants (Nitrates, pesticides etc.) and indicators for pollution (Arsenic, Cadmium, Lead and others). It required groundwater quality standards to be established by the end of 2008, pollution trend studies to be carried out by using existing data and data which is mandatory by the Water Framework Directive (referred to as "baseline level" data obtained in 2007-2008), pollution trends to be reversed so that environmental objectives are achieved by 2015 by using the measures set out in the WFD, measures to prevent or limit inputs of pollutants into groundwater to be operational so that WFD environmental objectives can be achieved by 2015, reviews of technical provisions of the directive to be carried out in 2013 and every six years thereafter and compliance with good chemical status criteria (based on EU standards of nitrates and pesticides and on threshold values established by Member States). The overall aim is to prevent the deterioration of the status of all bodies of groundwater in the European Union. However threats like saltwater intrusion through sea level rise are not yet integrated in this directive.

2.3.4. Drinking water supply

The EU´s Drinking Water Directive (DWD, Council Directive 98/83/EC) aims in protecting the health of the consumers in the European Union and to make sure the water is wholesome and clean. Standards were set for the most common substances (so-called parameters) that can be found in drinking water. In the DWD a total of 48 microbiological and chemical parameters must be monitored and tested regularly. It is not clear how these parameters alter through climate change, therefore research is required.

2.3.5. Marine management

The report “The economics of climate change adaptation in EU coastal areas” by the European Commission (COM 2009) outlined the main threats of climate change to maritime areas:

Baltic Sea:

- Overall vulnerability low, most impact projected for marine species
- Low sea level rise (SLR) expectations, projected land-uplift along major parts of the coastline and many uninhabited areas minimize the vulnerability to coastal flooding;
- Projected increase in sea surface temperature in the semi-enclosed Baltic marine basin threatens marine species as migration is difficult;
- Ice-cover reduction resulting in a different exposure of the coast to winter storms (erosion and sediment transport)

North Sea:

- Mainly vulnerable to coastal flooding

- Significant SLR expectations, storm surges, many low-lying areas (more than 85% in
- BE and NL) and high economic and population concentrations make flood-risk a major concern;
- Significant erosion problems (20% of the coastline).

Atlantic Ocean:

- Coastal flooding is the main climate threat
- Main climate risk is flooding due to SLR and changes in both the direction and the power of waves;
- Southern countries could become more exposed to freshwater shortage in the future due to prolonged and more intense periods of droughts.

Mediterranean Sea:

- Mainly at risk of freshwater shortage
- Medium SLR and few parts of the coastline situated below 5 m elevation result in a
- Modest risk of coastal flooding, with the exception of hot-spot Venice;
- Longest stretch of coastline affected by erosion (30%);
- Large areas affected by saltwater intrusion; dry periods projected to increase in length and frequency putting additional pressure on freshwater availability.

Black Sea:

- Erosion is at present the most significant problem
- Considerable presence of coastal erosion (13% of the coastline);
- Vulnerable to the impact of SLR on intertidal habitats and eco-systems due to low
- intertidal range and limited scope for on-shore migration;
- Dry periods are projected to increase in length and frequency putting pressure on freshwater availability.

Adaptation efforts to combat SLR, flooding and erosion are three part (Tab.1) and further divided into hard and soft measures.

Table 6 Climate change adaptation efforts for combating Sea level rise, flooding and erosion

(Source: COM 2009)

	Protect = effort to continue use of vulnerable areas	**Accommodate** = effort to continue living in vulnerable areas by adjusting living and working habits	**Retreat** = effort to abandon vulnerable areas

Hard	Dikes, seawalls, groins, breakwaters, salt water intrusion barriers	Building on pilings, adapting drainage, emergency flood shelters	Relocating threatened buildings
Soft	Sand nourishments, dune building, wetland restoration or creation	New building codes, growing flood or salt tolerant crops, early warning and evacuation systems, risk-based hazard insurance	Land use restriction, set-back zones

2.3.6. *Flood risk management*

Natural disasters such as floods or droughts have always had severe effects on humankind. In the 20th century, the number of severe flood disasters increased. This calls for pressing ahead with the implementation of integrated flood management, including measures for immediate protection and relief efforts as well as ecologically oriented flood prevention.

Integrated flood management, and the resulting measures, requires clear objectives:

- Protection of human lives
- Protection of natural resources
- Protection of water bodies
- Mitigation of material damage
- Provide for reconstruction and restart
- Sustainability of measures

For future strategies in the field of flood protection, the inclusion of projected climate change is increasingly important. A change in climate could increase the potential hazards of mountain streams and rivers. The propagated creation of flood runoff and retention areas is the goal. Even if the measures for flood control management have proven, you cannot neglect checking the flood runoff and retention areas – against the background of the climatic changes – with regard to a possible future need to keep some areas free from any settlement (Habersack et al., 2004).

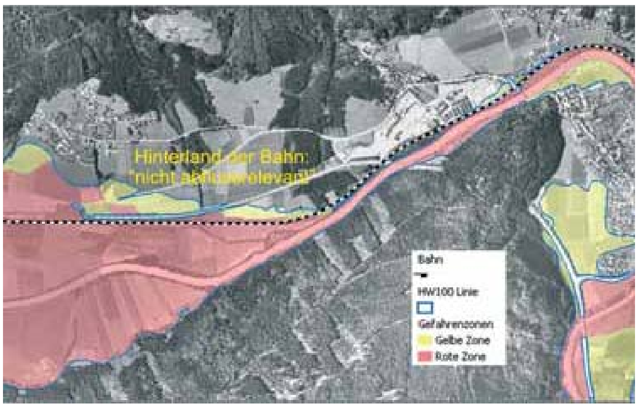

Figure 3: Hazard zone maps and exposition of areas at risk

The above objectives can only be achieved by: Identification of the limits of protection and the responsibility of the parties concerned; awareness promotion; guarantee of adequate land use through spatial planning; promotion of incentives for private precaution; recognition of flood-relevant negative trends; coordination of planning by the public authorities; conducting of necessary measures of protection; emergency planning and preparation of measures for disaster protection - and last but not least provision of funds, insurance and claims settlement (Habersack et al., 2005).

Flood Risk: implementation strategies on climate change

Over the last few centuries in many catchment areas (land-) use changes have occurred, which caused negative effects from view of water protection management and ecology (e.g. soil compaction, concentration of surface water courses, redevelopment and sealing of natural drainage corridors outside the channel, also too little comprehensive or bad conceived regulations). Such changes can, combined with the effects of climate change, increase the potential risk far more. These influences and the general uncertainties have to be included in the measure planning and building dimensions.

The possible actions related to climate change are listed below and can be considered as a basis ("checklist") for future implementation.

- Recognition of flood-relevant negative developments - process-oriented prevention measures: contribution to reducing the causes of climate change, such as measures to achieve the Kyoto targets. Identification of climate consequences, especially for the flood risks (possible change in rainfall pattern) and with that, associated for future risk management.
- Recommendations for research: following research measures to be mentioned: basic research
- Meteorology: Climate Research (forecast of future developments and particularly the impact on precipitation patterns). Furthermore, editing of time series (analysis of fields of atmospheric parameters) would allow an objective, small-scale weather pattern classification. With this data, statements about the climate and its changes in recent years could be calculated, for example, trend analysis of the deductions. From this it would be possible to draw conclusions about development of accumulation and of extreme weather conditions.
- Hydrology and Hydraulics: The impact of climate change on hydrology (downscaling method, coupling of GCMs with small-scale rainfall-runoff models, change of outflow coefficients) (Habersack et al., 2004).

2.3.7. Requirements in Austrian water balance and water management

Analysis of existing data and promotion of further data collection will stimulate better solutions for improved coordination and information on water consumption and water demand. To ensure the future water supply, conscious use of water resources and forcing the management of water resources at low water is required. To achieve the good ecological and chemical status of water bodies (including groundwater), an intensification of water management planning for ground-water occurrences has to be focused.

Adaptive flood management with robust measures will bring an increased determination of design values of floods (in the context of existing processes) with information (combination of flood statistics, regional- and historical information and rainfall-runoff modeling) as extensive as possible. Attention on water temperatures in water management measures will be considered, including an alternative method for cooling, variant tests and the possibility of regulatory approvals except in extreme situations. However, the installation of industrial water management instruments still lacks the budgetary fluxes on its way to the scientific assemblage points. (Kronberger et al. 2010)

2.4. Fishery (UniV)

Millions of people around the world depend on fisheries and aquaculture, directly or indirectly. During the past three decades, the number of people employed in fishery and aquaculture has grown faster than the world's population, and employment in these sectors have grown faster than in traditional agriculture. An expected characteristic of global climate change (CC) is an increase in the variability of environmental conditions. Experience already gained in dealing with long term fluctuations in marine environments, such as those induced by El Niño events, emphasize the need for adaptability in fisheries. The effects of climate change will impact a sector that is already characterized by maximum utilization of resources, large overcapacity and conflicts among fishers, and other stakeholders. Thus, climate change adds a further argument for developing effective and flexible fisheries management system in an ecosystem context (FAO, 2005). Several institutions like Fisheries and Aquaculture Department (http://www.fao.org/fishery/topic/13789/en) and EU projects like RECLAIM (www.climateandfish.eu) studied the impact of climate change on the productivity and distribution of fish and shellfish populations. Although these studies focus on marine systems, also CC effects on freshwater systems are described and are summarized in the following pages

2.4.1. General effects of climate change on fish, fish habitats & fisheries

Climate change impacts are likely to amplify natural variations and to exacerbate existing stresses like fishing pressure, diminishing wetlands and nursery areas, pollution, and UV-B radiation. In marine systems, climate change is expected to result in increases in sea surface temperature, global sea level rise, decreases in sea-ice cover and changes in salinity, wave conditions, and ocean circulation. In terrestrial systems, climate change will affect the availability of water, river flow regimes (particularly in flood plains), size of lakes, etc. and the need of water for other activities competing with fisheries. Changes in climate are predicted to affect fish at all levels of biological organisation: cellular, individual, population, species, community and ecosystem, influencing physiological and ecological processes in a number of direct, indirect and complex ways (FAO 2005, 2009, Ficke et al., 2007).

The general effects of climate change on freshwater systems will likely be: i) increased water temperatures, decreased dissolved oxygen levels, and the increased toxicity of pollutants. ii) in lotic systems, altered hydrologic regimes and increased groundwater temperatures could affect the quality of fish habitat. iii) in lentic systems, eutrophication may be exacerbated or offset, and stratification will likely become more pronounced and stronger, this could alter food webs and change habitat availability and quality (Ficke et al., 2007).

2.4.2. Changes in physical environments

There has so far been no global assessment of warming of inland waters but many lakes have shown moderate to strong warming since the 1960s. There are particular concerns in African lakes, as the atmospheric temperature of the continent is predicted to be higher than the global average and rainfall is projected to decrease. Likewise, wetlands and shallow rivers are susceptible to changes in temperature and precipitation and water levels may drop to the point of drying out more completely in dry seasons. Increased temperature may lead to stronger, earlier and longer stratification of lakes and reservoirs and with limited or no seasonal turnover, greater deoxygenation of bottom layers. River run-off is expected to increase at higher latitudes but decrease in parts of West Africa, southern Europe and southern Latin America. Overall, a global temperature increase of 1°C is associated with a four percent increase in river run-off. Changes in flood areas, timing, and duration are also expected (FAO, 2005).

2.4.3. Changes in biological functions/fish stocks

In general, temperature changes are likely to impact cold-water species negatively, warm-water species positively, and cool-water species positively in their northern ranges and negatively in their southern ranges. There will likely also be a general shift of cool- and warm-water species northward in northern hemisphere rivers. The abundance and species diversity of riverine fishes are predicted to be particularly sensitive to climatic disturbances, since lower dry season water levels may reduce the number of individuals able to spawn successfully. The timing of flood events is critical as a physiological trigger that induces fish to migrate and spawn at the onset of the flood; enabling their eggs and larvae to be transported to nursery areas on floodplains.

2.4.4. Effects of climate change on fisheries

The CC impact on the structure and biological productivity of ecosystems will vary between fisheries and will depend on the specific environmental changes and the particular biological characteristics of each species. In oceans, where species can easily move, climate change will also result in changes of distribution of resources which will most likely move towards the North or South Poles. Consequences for the fishing industry could be significant. Scenarios developed by the Intergovernmental Panel on Climate Change (IPCC) forecast (with indications of "confidence" levels) the following effects (IPCC, 2001):

- Medium Confidence – Globally, saltwater fisheries production is hypothesized to be about the same, or significantly higher, if resource management deficiencies are corrected. Also, globally, freshwater fisheries and aquaculture at mid-to-higher latitudes could benefit from climate change.

- High Confidence – Local shifts in production centres and mixes of species in marine and fresh waters are expected as ecosystems are displaced geographically and changed internally.

- High Confidence – Positive effects such as longer growing seasons, lower natural winter mortality and faster growth rates in higher latitudes may be offset by negative factors such as a changing climate that alters established reproductive patterns, migration routes, and ecosystem relationships.
- High Confidence – Changes in abundance are likely to be more pronounced near major ecosystem boundaries. The rate of climate change may prove a major determinant of the abundance and distribution of new populations. Rapid change due to physical forcing will usually favour production of smaller, low-priced, opportunistic species that discharge large numbers of eggs over long periods.

The sensitivity to global change will vary between fisheries. **The most affected will be fisheries in small rivers and lakes, in regions with larger temperature and precipitation change and on anadromous species**. They will be followed by fisheries within Exclusive Economic Zones, particularly where rigid access regulations reduce the mobility of fishers and their capacity to adjust to fluctuations in stock distribution and abundance, fisheries in large rivers and lakes, fisheries in estuaries (particularly where there are species without migration or spawn dispersal) and in the high seas.

2.4.5. Possible solutions

While the fisheries sector cannot do much to impede or seriously affect global climate change, it could contribute to its stabilization or reduction, and to mitigating its effects. The most important strategies are those needed to promote sustainability and which are useful and practical, even in the absence of climate change. Further, when developing strategies, we need to consider both the problems and the opportunities that are being presented, in the following way (FAO 2005):

- Active participation at global and regional level, to ongoing debate and collaboration, to obtain the best possible information of fisheries-related impacts
- Allocating research funds to analyze local and regional potential changes in resource magnitude and composition and likely socio-economic impacts
- Sharing information obtained with the sector on potential changes, their scale and possible effects on resources and fisheries
- Establishing institutional mechanisms to enable or enhance the capacity of fishing interests (fleets and other infrastructures) to move within and across national boundaries as a consequence of changes in resources distribution. This implies developing bilateral agreements
- Preparing contingency plans for segments of the sector that might not be able to move, particularly for disadvantaged areas and small-scale fishers lacking mobility and alternatives
- Developing effective national and international scale resource management regimes and associated monitoring systems to facilitate adaptation of exploitation regimes in a shifting environment
- Strengthening regional fisheries management organisation and other mechanisms to deal with cross-border stocks

- Integrating fisheries management into coastal areas management to ensure that fisheries needs are taken up when dealing with protection of coastal areas from sea level rise, etc.
- Analyzing aquaculture sustainability in an eco-regional context, forecasting changes in productivity or resistance and in required related changes in culture systems, cultured species or delocalization of productive systems. Particular attention should be given to coastal investments
- Fostering interdisciplinary research, with scientists meeting periodically to exchange information on observations and research results, and meeting with managers to ensure the proper interpretation of results and the relevance of research
- Foreseeing and planning infrastructure adaptations. It could be expected that, in response to shifting populations and species, the industry will respond with faster, longer-range fishing craft, install on-board processing equipment to replace endangered coastal ones or use floating processors when feasible, and find alternative means of transport when coastal roads are flooded and relocation is not possible

Cochrane et al. (FAO, 2009) suggest the following potential adaptation measures in fisheries:

Table 7 Examples of potential adaptation measures in fisheries

(Source: FAO, 2009)

Impact of climate change on fisheries	**Potential adaptation measures**	**Responsibility**	**Reactive/ Anticipatory**
Reduced yield	Access higher value markets/shifting targeted species	Public/private	Either
	Increase effort or fishing power*	Private	Either
	Reduce costs to increase efficiency	Private	Either
	Diversify livelihoods	Private	Either
	Exit the fishery	Private	Either
Increased variability of yield	Diversify livelihood portfolio	Private	Either
	Design insurance schemes	Public	Anticipatory
Change in distribution of fisheries	Migration of fishing effort/strategies and processing/distribution facilities	Private/public	Either
Reduced profitability	Exit the fishery	Private	Either
Vulnerability of infrastructure and communities to flooding, sea level and surges	Add new or improved physical defences	Private/public	Anticipatory
	Managed retreat/accommodation	Private/public	Either
	Rehabilitate infrastructure, design disaster response	Private/public	Reactive
	Integrate coastal management	Public	Anticipatory
	Set up early warning systems, education	Public/private	Anticipatory
Increased dangers of fishing	Set up weather warning system	Public	Anticipatory
	Invest in improved vessel stability/safety/communications	Private	Anticipatory
Influx of new fishers	Support existing local management institutions, diversify livelihoods.	Public	Either

* May risk exacerbating overexploitation.

2.4.6. Information requirements

Brander 2007 states that extreme climate events have significant consequences for fisheries production in both marine and inland systems and our present ability to predict regional and global fish production is poor and requires improvement in a number of areas, including the following:

- Models that relate interannual variability, decadal (regional) variability, and global climate change, to make better use of information on climate change in planning management adaptations.
- Observations and models of regional and global net primary production (NPP). Development of new models for predicting how changes in NPP will pass through the aquatic food chain to fisheries resources.
- Acknowledgment of the consequences of changes in biodiversity for the stability, resilience, and productivity of aquatic systems.
- Greater understanding of the consequences of the trend toward increasing aquaculture for future aquatic production.

2.4.7. Conclusion

Ficke et al. 2007 provide a comprehensive summary of climate change effects on freshwater fisheries. Currently, the magnitude of global climate change is such that most of its effects on freshwater fisheries could be easily masked by or attributed to other anthropogenic influences, such as deforestation, overexploitation and land use change (McDowall 1992; Genta et al. 1998; Nobre et al. 2002). Global climate change appears to represent an additional stressor to the suite that includes pollution, overfishing, water diversion, and widespread introduction of non-native fishes. Large-scale human activities often have dramatic and rapid impacts on fish populations, while the effects presently attributable to climate change exist in the background and may go unnoticed. Temperature increases, decreased dissolved oxygen levels, changes in disease transmission, changes in toxicant stresses, and alterations to hydrographs could all contribute to the decreased productivity of native fish populations. These changes are highly correlated, and fishes will have to cope with some combination of these factors. Furthermore, human response to increased temperatures will lead to secondary effects on fisheries like, increased demand for water and increased waste heat loading that will exacerbate existing environmental challenges (Mulholland et al. 1997; Vörösmarty et al. 2000). Fishes inhabiting regions that receive more precipitation will face new challenges as humans respond by building flood control structures (Abell 2002). Fish are vitally important as a protein source in developing countries. Loss of productivity in the world's fisheries could be exacerbated by rapid human population growth and subsequent high demand for fish protein. Often, freshwater fish stocks in countries with burgeoning populations are already heavily exploited (Thompson 1996; Etim et al. 1999; De Jesus and Kohler 2004). As an alternative to coping with the results of a changing environment, we can actively manage for the inevitable. Possible strategies include removing other anthropogenic stressors so that fishes can better adjust to climate change (Casselman 2002; Magnuson 2002a) and decreasing greenhouse gas emissions to decrease future climate change. It is apparent that a proactive response to managing fisheries in the face of a changing climate will better ensure functional fish communities in the future.

2.5. Tourism (UniV)

Climate is an important resource for many types of tourism. One of several metrics for the suitability of climate for sightseeing is Mieczkowski's "Tourism Climatic Index" (TCI), which summarizes and combines seven climate variables. By means of the TCI, the present climate resources for tourism in Europe and projected changes under future climate change has been analysed by Perch-Nielsen and his colleagues. They used daily data from five regional climate models and compared the reference period 1961-1990 to the A2 scenario in 2071-2100. A comparison of the TCI based on reanalysis data and model simulations for the reference period showed that current regional climate models captured the important climatic patterns. Currently, climate resources are best in Southern Europe and deteriorate with increasing latitude and altitude. With climate change the latitudinal band of favourable climate is projected to shift northward improving climate resources in Northern and Central Europe in most seasons. Southern Europe's suitability for sightseeing tourism drops strikingly in the summer holiday months but is partially compensated by considerable improvements between October and April (Perch-Nielsen 2010).

Climate has also an obvious influence as a location factor for tourist activities. Consequently, the tourist phenomenon in general is heavily controlled by meteorological conditions – in short, by the climate. In “The use of webcam images to determine tourist–climate aptitude” (Ibarra 2010) proposed a set of weather types to establish the climate aptitude for tourism. The use of this (filter) method in climate databases and meteorological forecasts could help determine the tourist season, the suitability of setting up management plans associated with tourism.

2.5.1. National park management adaptations

As ecologists scramble to predict changes, park managers are gearing up for a new management style, which will have to include at least one of two approaches traditionally, anathema to the profession: letting things change, or intervening aggressively to keep them the same. In many cases, choosing between these strategies will be the challenge. If managers choose the former, they will need to create an environment conducive to change. For example, many conservation biologists argue for creating and maintaining corridors that connect parks to other natural areas. The bigger the connected area, the more room plants and animals will have to move and the larger the gene pools available for adaptation.

In 50 years’ time, climate change will have altered some national parks so profoundly that their very names will be anachronisms. Now, park managers around the world are working with researchers to map how the landscapes they care for might change. And they are coming to terms with the idea that the historical remit of most parks systems — to preserve a piece of land in its ‘natural’ state — is untenable. “You can’t fight the climate,” says Ken Aho, an ecologist at Idaho State University in Pocatello. The report “The end of the wild - Climate change means that national parks of the future won’t look like the parks of the past. So what should they look like?” (Marris 2011) hints that climate change may force services of national parks and protection areas to change the way they define their mission. Maintaining a natural state can no longer be the goal, or important tools for adaptation, such as moving species or selective breeding, would be forbidden. And besides, that battle may already be lost (Marris 2011).

The International Commission for the Hydrology of the Rhine basin (CHR) has carried out a research project to assess the impact of climate change on the river flow conditions in the Rhine basin. Along a bottom-up line, different detailed hydrological models with hourly and daily time steps have been developed for representative sub-catchments of the Rhine basin. Along a top-down line, a water balance model for the entire Rhine basin has been developed, which calculates monthly discharges and which was tested on the scale of the major tributaries of the Rhine. Using this set of models, the effects of climate change on the discharge regime in different parts of the Rhine basin were calculated using the results of UKHI and XCCC GCM-experiments. These climate change scenarios are based on two General Circulation Models (GCM), the Hadley centre's high-resolution 11-layer atmospheric GCM (UKHI), and the Canadian CCC model (referred to as XCCC) (Hulme et al., 1994).

All models indicate the same trends in the changes: higher winter discharge as a result of intensified snow-melt and increased winter precipitation, and lower summer discharge due to the reduced winter snow storage and an increase of evapotranspiration. When the results are considered in more detail, however, several differences show up. These can firstly be attributed to different physical characteristics of the studied areas, but different spatial and temporal scales used in the modeling and different representations of several hydrological processes (e.g., evapotranspiration, snow melt) are responsible for the differences found as well. Climate change can affect various socio-economic sectors. Higher temperatures may threaten winter tourism in the lower winter sport areas.

The hydrological changes will increase flood risk during winter, whilst low flows during summer will adversely affect inland navigation, and reduce water availability for agriculture and industry. Balancing the required actions against economic cost and the existing uncertainties in the climate change scenarios, a policy of 'no-regret and flexibility' in water management planning and design is recommended, where anticipatory adaptive measures in response to climate change impacts are undertaken in combination with ongoing activities. (Middlekoop et al. 2001)

2.5.2. Requirements in Austrian tourism (UniV)

The region around the Lake Neusiedl is a popular tourist destination, especially in summer. There are a lot of people coming from the close by city of Vienna for bathing, windsurfing, sailing, biking and culture or just for visiting the national park. Especially in such touristic hot spots climate change should be considered more seriously in tourism strategies. Developing climate-friendly adaptation measures based on tourism strategies will result out of a development-, deployment- and ongoing improvement of regional data as a basis for deciding the direction in tourism and promotion of adaptation measures (Kronberger et al. 2010).

According to the "Fourth Assessment Report" of the IPCC (4AR) the increase of global air temperature over the continents in the 21st century will be strongest in higher northern latitudes and an increase of extremely hot temperatures and heat waves is very probable (probability > 90%). Austria and the Austrian economy are therefore strongly affected by climate change and its consequences. Two thirds of the gross domestic product (GDP) is allotted to the service sector, where Austria particularly profits from tourism. The effect of climate change on winter sports was and is treated in many scientific studies. But summer tourism will also be affected by climate change: a shortening of the winter sports season and an extension of the summer season seems to be a logical development. These changes are regarded as changes of the climatic potential for tourism - only one of many variables, which determine the kind and extent of tourism.

Climate scenarios for the period 2021-50 show the following:

- The number of days with cold stress is reduced by up to 20 days, particularly in the south and southeast of Austria. The period with a potential for cold stress is shortened.

- The number of days with thermal comfort conditions increases by approximately 10 days, but the trends are not clear - urban areas do not show a trend. The period of thermal suitability for recreation and leisure increases and extends into the late autumn.
- The number of days with heat stress increases, but areas above 1000 - 1200 m are not affected. In the southeast, more than 40 days with heat stress may occur; the duration of heat stress periods increases. The number of days with sultriness also increases.
- The number of sunny days increases in the higher areas.
- In general there is a slight upward trend for days with high precipitation. The frequency of days with little or no precipitation as well as days with long precipitation experience an increase in summer.
- The number of days with fog generally decreases.
- No definite statement can be made about the change of strong wind conditions (especially in view of recreation and leisure).
- (The potential for skiing decreases, however it is ensured at higher elevations.)

Overall, the future bioclimatic conditions in Austria are favorable for summer tourism and will lead to an extension of the season with pleasant thermal conditions into late autumn. The accompanying increase of days with sultriness will have positive effects for lake tourism, but might be impair spa/health and wellness tourism. The reduction of summer precipitation described by the climate scenario will affect nearly all sectors of summer tourism favorably. (Kromp-Kolb et al. 2006)

2.6. Nature conservation (TUB)

Nature conservation promotes the protection of species and habitats in order to maintain biological diversity and prevent species' extinction. It is broadly understood that "biodiversity conservation relies predominately on fixed systems of protected areas, and the mandated goals of many conservation agencies and institutions are to protect particular species assemblages and ecosystems within these systems" (Lemieux and Scott, 2005; Scott et al., 2002 in (Heller and Zavaleta, 2009 p. 15).

Recent evidence shows that the impacts of climate change on biodiversity are already visible. For example, the German Adaptation Strategy counts shifted life cycles, shifts in species' distribution, alteration to reproduction success of species, alterations in the composition and structure of species communities, and spreading of invasive species among these impacts. Several authors suggest that with the anticipated magnitude of climate change expected in the current century, "many vegetation types and individual species are expected to lose representation in protected areas" (Araujo et al., 2004; Burns et al., 2003; Lemieux and Scott, 2005; Scott et al., 2002 in (Heller and Zavaleta, 2009 p. 15). Particularly vulnerable are protected areas at "high latitudes and high elevations, on low-elevation islands and the coast, and those with abrupt land use boundaries" (Sala et al., 2000; Shafer, 1999 in (Heller and Zavaleta, 2009 p. 15). Additionally, species dependent on wetlands and on localised habitats are at high risk since these habitats only offer limited alternatives in case of climate-change related impacts.

Although there is no consensus on the relevance of these impacts, the need for adaptation of protected areas, objectives and programmes of nature conservation and the management of natural resources is clear and needs to be addressed at different levels of action.

2.6.1. Objectives of adaptation

The aim of nature protection policies currently includes little consideration of climate change. To efficiently address this issue, the main objectives of nature protection adaptation policies should be to define conservation responses that are anticipatory and systematic. Early adaptation will be required to anticipate the impacts related to climate change. Integrated conservation strategies will need to be defined. A refinement of management practices in existing and future protected areas is therefore essential.

Nature conservation needs to achieve that as many species' habitats as possible are adapted to the changing environmental conditions. This will require developing a macroecology-oriented approach (Badeck et al., 2007 p. 150), i.e. dealing with the study of relationships between organisms subject to nature conservation and their environment at large spatial scales as several authors already suggest (McNeely 1994, Noss 2001 and Ibisch 2006 in (Badeck et al., 2007 p. 151).

To reduce the possible negative effects of climate change, Hannah et al. (2002) suggest building adaptation strategies on ecoregional biodiversity management. The effectiveness of conservation planning will need to be improved by including "insights about the biotic impacts of climate change from biogeography and palaeoecology" (Hannah et al., 2002 p. 485). The developing of Climate Change-Integrated Conservation Strategies able to address the challenges posed by climate change will require "collaboration involving biogeography, ecology and applied conservation" (Hannah et al., 2002 p. 485). Collaboration across disciplines will be the key to plan conservation responses to climate change adequately.

The analysis carried out in sections 2.6.3, 2.6.4, 2.6.5 and 2.6.6 will differentiate geographical extent of the adaptation (species and biotopes/ local level, protected area level, landscape / regional level and policy level) and provide, where necessary, additional information on the time horizon for implementation. Recommended strategies according to international studies will have to be active, adaptive and integrative in the adaptation process of the management plans for the protected areas.

2.6.2. Guiding principles for adaptation

Guiding principles for adaptation of nature conservation to climate change are outlined by different studies giving place to different options but all with the aim of keeping the goals of conservation strategies while facing the challenges posed by climate change. In general, adaptation will need to be an exercise of regional and national co-ordination bringing together actors from different disciplines (stakeholders, conservation managers, environmental NGOs, scientists, etc). Guiding principles are intended to support adaptation processes for a wide range of situations in nature conservation so that they form a common basis for adaptation activities from local to the European scale.

The following guiding principles have been summarised upon a series of studies and they are intended to support conservation managers, planners and decision makers to adapt conservation strategies to climate change.

- *Prioritising "no regret" measures*
  Due to the inherent uncertainties, "no regret" options for adaptive action should be prioritised in order to ensure the most cost-effective approach. According to Welch (2005), “benefits can be obtained by removing or halting maladaptive policies and practices that may increase vulnerability” (Welch, 2005 p. 81).

- *Staying the course*
  A review of literature on biological diversity and climate change assumes that traditional conservation strategies will remain effective (Hunter Jr. et al., 2010 p. 1169). Consideration of climate change may lead to small changes in conservation interventions, but it is understood that “the ability of species to adapt to the novel stresses imposed by climate change will increase if existing stressors can be minimized (e.g., pollution, excessive exploitation, invasive non-native species)”. “Robust populations that are well distributed across a species’ entire geographic range are most likely to persist as climate changes (Schwartz 2006 in (Hunter Jr. et al., 2010 p. 1169). To enhance resilience to degradation, “reserve systems should contain a representative array of environments with enough redundancy to account for unpredictable exigencies”, they should be contiguous “to facilitate species range shifts” and they should maintain or restore “connectivity among populations or processes” (Opdam et al. 2006; Olson et al. 2009 in (Hunter Jr. et al., 2010 p. 1169).

- *Reassessing priorities and strategies*
  Although the traditional approaches to conservation may stay, the challenges of climate change will have “such profound ecological, social, and economic consequences” that conservation strategies will have to “adapt to change and uncertainty” (Hunter Jr. et al., 2010 p. 1169). As an example, “conservation attention may shift toward sedentary species with limited ranges and away from wider-ranging species that are disappearing from a particular nation or state as their range shifts” (Hunter Jr.

et al., 2010 p. 1169). Conservation professionals will have to implement adaptive management and know when to stay the course and when to change in the face of uncertainty (Hunter Jr. et al., 2010 p. 1170).

- *Favour resilience versus resistance*
  „Resistant strategies attempt to bolster a system's defences to rapid environmental change, while resilience strategies attempt to bolster a system's ability to absorb rapid environmental change" (Heller and Zavaleta, 2009 p. 25). Recommendations rather advocate resilience than resistance strategies. However, building resilience strategies may require "radical shifts in perspective for many conservation stakeholders and re-evaluation of conservation goals" (Heller and Zavaleta, 2009 p. 26).

- *Risk management*
  Adaptation will have to anticipate measures, rather than act reactively, particularly if other stressors are mitigated (Welch, 2005 p. 81).

- *Investment*
  "Long-term investment in infrastructure and marketing, by concessionaires and park management agencies alike, must take future climate into account" (Welch, 2005 p. 81).

- *Make use of new opportunities*
  According to Hunter, conservation strategies have generally ignored mitigation as major focus of climate-change policy. Mitigation offers "major new opportunities for conservation professionals to contribute to mitigation efforts and inform climate-change policy". For example, avoiding deforestation has both the potential to reduce global emissions and conserve biological diversity in forest ecosystems. "Curbing deforestation would reduce the input of atmospheric carbon and maintain ecosystems with a high concentration of native species" (Canadell et al. 2007; van der Werf et al. 2009 in (Hunter Jr. et al., 2010 p. 1170). Another example could be preserving watersheds to simultaneously provide water for people and to maintain biological diversity. New opportunities for conservationists will arise to inform the public "about situations in which conserving biological diversity enhances human welfare, especially in the context of climate change" (win–win scenarios) (Hunter Jr. et al., 2010 p. 1170).

2.6.3. Species and habitat level

As the German Adaptation Strategy (Bundesministerium für Umwelt, 2008 pp. 25 - 31) suggests, it will be necessary to take measures to support especially sensitive species and habitats. Suggested measures would include the following:

- Establishment of research and monitoring programmes to analyse expected climate-change related impacts and document potential measures on adaptation. This should be built on the use of indicators and the programmes should be supported by regional and national governments. These programmes should be based as far as possible on existing research and monitoring programmes.

- Incorporate results on climate-change research, including their uncertainties, into programmes and instruments of nature conservation such as protection of species and biotopes. Climate-change related alterations in the endangerment of species and the achievement of objectives should be incorporated as well. Results and analysis should be also taken into consideration when evaluating potential impacts of other stressors and for the consideration of offset measures.

- Reduce additional stressors on biotopes of species who are likely to be especially sensitive to climate-change related impacts. The maintenance of large populations of these species with a genetic diversity is key for their adaptation.

Sensitive habitats and species already form an important part of the management in many protected areas. It is anticipated that climate change will introduce new classes of sensitive biotopes but it may also render changes in range or abundance of once common species so that they become sensitive (Hannah et al., 2002 p. 492). Nature conservation has to achieve that as many species as possible can adapt their areas of distribution to the changing environmental conditions. This will rely on a macroecological-oriented nature protection approach (Badeck et al., 2007 p. 150).

Table 8 Summary of adaptive measures for nature conservation at species and habitat level

Adaptive measures at species and habitat level	Remarks, required conditions
Establishment of research and monitoring programmes to analyse expected climate-change related impacts and document potential measures on adaptation	Use of indicators and suppor of programmes by regional and national governments. Programmes should be based on existing research and monitoring programmes.
Incorporate results on climate-change research, including their uncertainties, into programmes and instruments of nature conservation such as protection of species and biotopes	Results and analysis should be also taken into consideration when evaluating potential impacts of other stressors and for the consideration of offset measures.
Reduce additional stressors on biotopes of species	

2.6.4. Protected area level

For the management of protected areas more detailed requirements are defined by different researchers. Hannah et al. (2002) suggest the development of climate change-integrated conservation strategies (CCS) to respond in an anticipatory and systematic way to the new challenges. CCS consists of five different elements: regional modelling to identify climate change impacts on biodiversity at a regional scale; expanding protected areas management; management of the matrix between protected areas to provide continuity for processes and species range shifts outside of parks; regional coordination to harmonize conservation goals regionally and nationally; and transfer of resources to allow implementation of these elements globally (Hannah et al., 2002 p. 485). To respond to the changing frequency of extreme events an enhanced monitoring for example of invasive species and the implementation of an adaptive management are suggested. To deal with potential invasions of alien species, early alarm systems should be established and biotopes should be linked so that they avoid the widespread of these species (Bundesministerium für Umwelt, 2008 pp. 25 - 31). Existing management practices should be reviewed and revised based on the results of modelling, sensitivity analysis, scenarios, monitoring and survey. “Management planning time horizons will need to be revised in almost all cases” (Hannah et al., 2002 p. 492).

Refinement, review and revision of management practices in existing and future protected areas are, according to Hannah et al. (Hannah et al., 2002 p. 490) necessary to supplemental coverage in a CCS. As a minimum, four elements will be needed for the revision of reserve management:

- Scenario-building
- Enhanced monitoring
- Biological survey
- Review and revision of management practices

Hannah et al. (2002) define scenario-building as an "iterative process in which modelling is used to refine management and management revisions suggest further areas of enquiry for modelling" (Hannah et al., 2002 p. 490). Furthermore, they suggest examples of management practices that will often qualify for review. These are, for example, "management of fire or other disturbance regimes, classification of 'sensitive' areas, and management for 'representative' species" (Hannah et al., 2002 p. 492). They also suggest revising management planning time horizons, since "almost all protected areas management plans have 3–10-year time horizons, which are insufficient to allow for anticipatory management responses to climate change" (Hannah et al., 2002 p. 492). They recommend a minimum of 30–50 years as appropriate planning time horizon for climate change, although a 100-year horizon would be necessary to capture many possible climate change effects (Hannah et al., 2002 p. 492).

Hansen et al. (2003) developed for the World Wildlife Fund a guideline for natural area managers to build resistance and resilience to climate change. They suggest using active adaptive management and strategy testing to find the appropriate reaction to climate change and to deal with the uncertainties. Active management should help reducing the number and/or magnitude of threats faced by an ecosystem. By doing so, the overall resilience of ecosystems can be increased on a local level. They also suggest that protected areas should pursue "threat reduction and sustainable regional ecosystems through conservation partnerships with land management agencies" (Hansen et al., 2003 p. 88, Welch, 2005). Hansen et al. also call for integration of climate change threats into conservation plans and to take disaster mitigation (droughts, floods, avalanches etc.) into account when planning and managing protected areas (Hansen et al., 2003 p. 230). These views are also supported by Baron (2009), who adds that an understanding of reference conditions and an identification of resources and processes at risk for climate change are fundamental before undertaking any other measure (Baron et al., 2009 p. 1033).

Another strategy is suggested by Welch (2005) who compiled adaptation requirements for park managers (Welch, 2005 p. 82): By maintaining as many options as possible for resilience park managers can reduce the vulnerability to the effects of climate change. Welch presents the results of a literature review in which he also refers to Noss (2001) who developed recommendations for forest managers that can be adapted to all types of protected ecosystems. Although Noss targets at forest managers, many of his recommendations can be adapted to other types of protected ecosystems He advises park managers to:

- "Represent vegetation types and diverse gene pools across environmental gradients in reserves
- Protect climatic refugia at all scales
- Avoid fragmentation and provide connectivity

- Provide buffer zones for the adjustment of reserve boundaries

- Maintain natural processes and successional regimes

- Conduct research to identify sensitive biomes

- Conduct long-term monitoring to seek causality between climate and biodiversity responses at several levels of organization" (Noss, 2001) and (Welch, 2005 p. 82).

Further protection strategies suggested by Welch (2005) for parks follow on the recommendations by Wein et al in 1990. Their suggestions include promoting an "international exchanges of ideas between researchers and managers, strengthening the research capacity of parks personnel, Involving local communities, using parks as benchmarks for long-term monitoring and determining the necessity to transplant species, or to control rapidly increasing species" (Welch, 2005 p. 82). Furthermore, they also suggest locating future "parks with climate change in mind, developing contingency plans to expand conservation areas, and protect or establish connecting corridors" (Welch, 2005 p. 82). Welch (2005) builds on this last recommendation suggesting that park boundaries may need to be adjusted for climate change adaptation so that they capture the anticipated movement of critical habitats and species. "Park boundaries could be aligned to accommodate transition zones where large changes of climate, habitat, and species distribution are expected to occur over small distances in relation to park size" (Welch, 2005 p. 82). Badeck (2007) goes further and suggests innovative measures, such as the establishment of "moving protected areas" (Badeck et al., 2007 p. 151). Important to Badeck is that protected areas play a pivotal role in the maintenance of corridors and effective habitat linkages. Regarding the problems with land users and stakeholders in designating new park areas, these options seems very much unrealistic because the park area would have to move together with protected species.

Heller and Zavaleta (2009) compile a series of recommendation for climate change adaptation strategies for biodiversity management assembled from a total of 112 scholarly articles. In addition to the measures suggested by the authors previously mentioned, additional recommendations listed in his study include:

- „Practising intensive management to secure populations

- Protect large areas, and / or increase reserve size

- Create and manage buffer zones around reserves

- Create culturally appropriate adaptation/management options and education programs for public about land use practices and effects on and with climate

- Develop best management practices for climate change scenarios

- Enhance diversity at various scales, since diverse populations tend to be more adaptable

- Capture the full range of bioclimatic variability within preserves and design high species, structural, and landscape diversity into constructed and managed systems. Pockets of outlier vegetation, areas of high endemism, ecotones, and refugia that protected species during climate shifts in the past are anticipated to be important sources for species re-colonization and radiation in the future, as well as provide retreats for migrating or translocated species

- Maintain natural disturbance dynamics of ecosystems and start strategic zoning of land use to minimize climate related impacts

- Anticipate surprises and threshold effects i.e. major extinctions or invasions, design biological preserves for complex changes in time, not just directional change

- Increase wetland protection, for example restoring riparian vegetation what would secure wildlife populations and ecosystem services while also functioning to decrease stream temperatures in the future (Mulholland et al., 1997 in Heller and Zavaleta, 2009), and protect mountains and primary forests" (Heller and Zavaleta, 2009 pp. 18 - 25)

As Baron (2009) summarises based on Parsons (2004), "initiating and maintaining climate change-related management requires prioritizing the resources and processes at risk from climate change, identifying climate change-related risks, establishing reference conditions for protection or restoration, developing monitoring and assessment programs, and developing models of how systems could change" (Baron et al., 2009 p. 1035). These are deemed to be "the fundamentals of applying the scientific method to natural resource management" (Baron et al., 2009 p. 1035).

Table 9 Summary of adaptive measures for nature conservation at protected area level

Adaptive measures at protected area level	Remarks, required conditions
Review of management planning time horizons	
Development of climate change-integrated conservation strategies (CCS)	CCS consist of five different elements: regional modelling; expanding protected areas management; management of the matrix; regional coordination; and transfer of resources
Revision of reserve management practices	Scenario-building, Enhanced monitoring, Biological survey and review and refinement of management practices Conduct research to identify sensitive biomes
Maintaining as many options as possible for resilience	
Represent vegetation types and diverse gene pools across environmental gradients in reserves	
Protect climatic refugia at all scales	
Avoid fragmentation and provide connectivity	Provide buffer zones for the adjustment of reserve boundaries Protect large areas, and / or increase reserve size Increase wetland protection

Adaptive measures at protected area level	Remarks, required conditions
Maintain natural processes and successional regimes	
Maintain natural disturbance dynamics of ecosystems and start strategic zoning of land use to minimize climate related impacts	
Anticipate surprises and threshold effects i.e. major extinctions or invasions, design biological preserves for complex changes in time, not just directional change	

2.6.5. Landscape and regional level

Adaptive management and active ecosystem management will need to be applied at a broader scale than just at single protected areas. As Welch (2005) suggest, landscapes should become porous and parks should be part of “networks of ecological areas within which biodiversity can survive, move, and be appreciated” (Welch, 2005 p. 84). The importance of regional ecosystems characterized by connectivity and porosity for wildlife movement should be promoted. This will require not only defining wildlife corridors, “but removing physical and non-physical impediments to movement across all lands” (Welch, 2005 p. 84). In order to implement regional conservation measures, partnerships should be built. A network of “large protected areas may be wild nature’s best climate change “shock absorber”” (Welch, 2005 p. 84).

Welch (2005) also suggest that, at a regional level, the use of climate change research results should be also sought in order to translate scientific results to regional data sets that place-relevant, user-friendly information into the hands of ecosystem managers (Welch, 2005 p. 88).

At the European level one focus is on the Natura 2000 network, where climate change has to be factored into the management to ensure diversity of and connectivity between natural areas. To enhance the interconnectivity of natural areas, permeable landscape may become necessary. In this context, the European Union and its member states are asked to:

- “Explore the possibilities to improve policies and develop measures which address biodiversity loss and climate change in an integrated manner to fully exploit co-benefits and avoid ecosystem feedbacks that accelerate global warming
- Develop guidelines and a set of tools (guidance and exchange of best practices) to ensure that the River Basin Management Plans (RBMP) are climate-proofed
- Ensure that climate change is taken into account in the implementation of the Floods Directive
- Explore the potential for policies and measures to boost ecosystem storage capacity for water in Europe
- Draft guidelines on dealing with the impact of climate change on the management of Natura 2000 sites.” (European Commission, 2009b p. 12)

In a study on climate change and its impact on Natura 2000 sites Petermann et al. (2007) point out that many species and biotopes are dependent on interactions with their environment and therefore they could not be managed in isolation in protected areas but under efficient management of a network of biotopes. The Natura 2000 network plays a pivotal role in this context, since it enhances the maintenance or increase in genetic diversity of populations which allows species more resilience towards climate change (Petermann et al., 2007 p. 142). The German Adaptation Strategy (Bundesministerium für Umwelt, 2008 pp. 25 - 31) is also in line with these ideas and suggests that an efficient linkage of biotopes has to be built in co-operation with different actors, from the local till the European level. Biotope connection should also be co-ordinated with other programmes, such as agricultural ones. The fragmentation of natural systems has to be minimised.

The German strategy for adaptation also suggests that landscape planning should be used as management approach in order to anticipate changes in nature and landscape. Its goal should be to develop flexible adaptation strategies. The relevance of landscape planning in anticipating climate-change related impacts should be enhanced at regional and local level (Bundesministerium für Umwelt, 2008 pp. 25 - 31).

Badeck (2007) put his focus on an eco-regional biodiversity management following the recommendations in Hannah et al. 2002. The ecosystem approach that is favoured by the Convention on Biological Diversity is one example of these approaches (MILLER et al. 1995, JOPE & DUNSTAN 1996, LISTER & MUNN 1998, OLSON & DINERSTEIN 1999, SCOTT et al. 1999; vgl. NOSS 1998, UNEP 2000, HARTJE et al. 2003 in (Badeck et al., 2007 p. 151).

Other recommendations for climate change adaptation strategies for biodiversity management at a regional level are listed by Heller and Zavaleta (2009) and include integrating climate change into planning exercises (reserve, pest outbreaks, harvest schedules, grazing limits, incentive programs), mitigating other threats (invasive species, fragmentation, pollution), increasing the number of reserves, improving inter-agency and regional co-ordination and creating ecological reserve networks of large reserves connected by small reserves. Planning, modelling, and management should also adopt a long-term and regional perspective (Heller and Zavaleta, 2009 pp. 18 - 25).

Table 10 Summary of adaptive measures for nature conservation at regional level

Adaptive measures at regional level	**Remarks, required conditions**
Explore the possibilities to improve policies and develop measures which address biodiversity loss and climate change in an integrated manner	
Develop guidelines and a set of tools (guidance and exchange of best practices) to ensure that the River Basin Management Plans (RBMP) are climate-proofed	Ensure that climate change is taken into account in the implementation of the Floods Directive
Explore the potential for policies and measures to boost ecosystem storage capacity for water in Europe	
Draft guidelines on dealing with the impact of	

climate change on the management of Natura 2000 sites	
Biotope connection should be co-ordinated with other programmes	The fragmentation of natural systems has to be minimised
Use landscape planning as management approach in order to anticipate changes in nature and landscape.	The relevance of landscape planning in anticipating climate-change related impacts should be enhanced at regional and local level
Integrate climate change into planning exercises (reserve, pest outbreaks, harvest schedules, grazing limits, incentive programs)	
Mitigate other threats (invasive species, fragmentation, pollution)	
Increase the number of reserves	Improve inter-agency and regional co-ordination and create ecological reserve networks of large reserves connected by small reserves

2.6.6. Policy level

At a policy level, nature protection has to be integrated in different plans and policies. For example, the German Adaptation Strategy suggests that nature protection has to be taken into consideration when developing renewable energy projects. Even if renewable energy will contribute to the mitigation of climate change, planning processes should be performed in a sustainable way, i.e. avoiding a negative impact on nature and landscape. Especially important is the protection of sensitive biotopes and key areas for nature protection in the process of selection of sites for, say, biomass crops. Furthermore, the conservation of agro-biodiversity should be aimed through synergies between agriculture, nature conservation, soil and water protection and climate protection (Bundesministerium für Umwelt, 2008 pp. 25 - 31).

Regional and international coordination will be necessary "for conservation goals and management to be coherent on the same scale at which climate change impacts will operate" (Hannah et al., 2002 p. 493). Coordinated management may require formal agreements, for example "when national boundaries are crossed" (Hannah et al., 2002 p. 493). Co-ordination will become increasingly important as climate change progresses and should be prioritised in the short term.

Welch (2005) defines principles and values as a basis for the development of adaptation policies and strategies. He suggests that policies (but also social habits) will require adaptation. He points out that the Intergovernmental Panel on Climate Change "provides a comprehensive summary organized around global-scale ecosystems and societal and governmental responses" (IPCC 2001 in (Welch, 2005 p. 81). He follows on other authors who, for example, indicate that poverty reduction and spreading risk through income diversification could reduce vulnerability to climate change.

Different ways to proceed at the policy level will have to take both scientific evidence and legal, political and operational feasibility into consideration. Badeck (2007) suggests the following options:

- Adaptation and enhancement of the conservation strategies at both operative and political dimensions
- Development of implementation strategies and concepts (policies, barriers to implementation and conflicts, compensation and adaptation strategies, management options)
- Implementation of the results of space-oriented information, i.e. spatial planning and landscape planning (Badeck et al., 2007 p. 156)

Heller and Zavaleta (2009) suggest that “climate change is acting in concert with multiple other drivers of biodiversity loss including habitat degradation, soil loss, nitrogen enrichment, and acidification” (Heller and Zavaleta, 2009 p. 27). Therefore, “strong policies must simultaneously address more than one issue or risk exacerbating environmental problems in the process of trying to combat them” (Watson, 2005 in (Heller and Zavaleta, 2009 p. 27). Although emission reduction programs are part of the agenda for many governments and organizations Heller and Zavaleta suggest that several studies urge that this “reduction programs and the Clean Development Mechanisms (CDMs) in the Kyoto Protocol be implemented in ways that simultaneously address carbon sequestration, biodiversity conservation and human livelihoods, rather than carbon sequestration in isolation” (Heller and Zavaleta, 2009 p. 27).

Policies should also provide support to resource management implemented at individual parks and reserves. As Baron (2009) points out, “a consistent top to bottom vision of how to incorporate climate change considerations into management could promote short- and long-term adaptation practices and a shared culture of trust” (Baron et al., 2009 p. 1040).

Table 11 Summary of adaptive measures for nature conservation at policy level

Adaptive measures at policyl level	Remarks, required conditions
Integrate nature protection in different plans and policies	Regional and international coordination will be necessary
Adaptation and enhancement of the conservation strategies at both operative and political dimensions	Strong policies must simultaneously address more than one issue or risk
Development of implementation strategies and concepts (policies, barriers to implementation and conflicts, compensation and adaptation strategies, management options)	
Implementation of the results of space-oriented information, i.e. spatial planning and landscape planning	

2.6.7. Conclusion

Protected areas contain some of the least human-modified ecosystems. “Their protection becomes increasingly important as these systems become rarer” (Baron 2004 in (Baron et al., 2009 p. 1041). All ecosystems are already responding to climate change and other human-caused pressures. Adaptation will require collaboration of different actors to be efficient, and will require new approaches than in the past about how to manage natural resources. While the range of recommendations for nature conservation in the literature is great, "four consistent, broad themes emerge to apply to climate change planning and adaptation" (Heller and Zavaleta, 2009 p. 28):

1. "The need for regional institutional coordination for reserve planning and management and to improve landscape connectivity
2. The need to broaden spatial and temporal perspective in management activities and practice, and to employ actions that build system resilience
3. The need to incorporate climate change into all conservation planning and actions, which will require increased research and capacity to forecast future conditions and species responses and to deal effectively with unavoidable uncertainty
4. The need to address multiple threats and global change drivers simultaneously and in ways that are responsive to and inclusive of diverse human communities and cultures." (Heller and Zavaleta, 2009 p. 28)

Immediate action to adapt conservation practice to ongoing climate change in order to ensure the persistence of many species and ecosystems is already needed. Protected areas will have to pay ongoing attention to current scientific discoveries on climate change and implement adaptive management strategies.

2.7. Transport (UniV)

"Climate funding needs to be aligned closely with domestic and multilateral development flows of finance in order to make a difference for sustainable transport" (Bakker & Huizenga 2010).

In 2004, the transport sector accounted for six giga-tons CO_2-eq or thirteen percent of global greenhouse emissions (Metz et al., 2007). Taking into account the effect of ozone and aerosols, the transport sector is estimated to have contributed nine percent to the increase in global mean temperature up to the year 2000 since pre-industrial times, with CO2 and ozone being the most significant warming emissions, partly offset by cooling aerosols from shipping (Skeie et al., 2009). Unger et al. (2010) also attribute the largest radiative forcing contribution up to 2020 to road transportation, with an important part of that caused by black carbon. IEA/OECD (2009) projects transport emissions to rise by over 80 % by 2050 in a business-as-usual scenario (Bakker & Huizenga 2010).

In the ASIF framework (Schipper et al. 2000) often used in transport system modeling, emissions are a product of Activity (A), or the demand in person or ton- kilometers; Modal shares (S); Energy intensity (I) of each mode; and the Carbon content of the fuel (F) used in each mode. Substantially changing the rising emissions trend will require the adaption of a range of available and new technologies as well as a change in travel patterns (IEA / OECD 2009; Metz et al. 2007; Wright and Fulton 2005). The "Avoid-Shift-Improve" approach (ADB and CAI-Asia 2010) builds on ASIF and implies that policies to limit GHG emissions in the transport sector will have to consist of a combination of measures aimed at:

(a) Avoiding the need to travel, e.g. by the integration of land use and transport policies;

(b) Shifting travel to the most efficient mode, which in most cases will be either non-motorized or public transport for passenger transport and to rail or water transport for freight; and

(c) Improving existing forms of transport through technological improvements to make engines and fuels less carbon intensive (Bakker & Huizenga 2010).

2.7.1. Impact of aircraft, road traffic and shipping emissions

In 2000, transport emissions have been shown to mainly affect ozone in the Northern Hemisphere. The impact was dominated by road traffic in the middle and upper troposphere, north of 40 °S, and by shipping in the northern lower troposphere, over oceanic regions. A strong reduction of road emissions and a moderate to high increase of the ship and aircraft emissions have been expected by the year 2050. As a consequence, simulations predicted a drastic decrease in the impact of road emissions, whereas aviation would became the major transport perturbation on tropospheric ozone, even in the case of a very optimistic aircraft mitigation scenario.

An A1B emission scenario leaded to an increase of the impact of transport on zonal mean ozone concentrations in 2050 by up to + 30 % and + 50 %, in the Northern and Southern Hemispheres, respectively. Considering climate change, and according to scenario A1B, a decrease of the O_3 tropospheric burden was simulated by 2050 due to climate change (- 1.2 %), whereas an increase of ozone of up to 2 % was calculated in the upper troposphere in the inter-tropical zone, due to enhanced lightning activity. (Koffi et al. 2010)

2.7.2. Nationally appropriate mitigation actions

In the post-2012 climate regime, there may be substantial international financing available in addition to existing credit schemes and international funds, which could be channeled through nationally appropriate mitigation actions (NAMAs). Finally, NAMAs and support need to be measurable, reportable and verifiable (MRV) in order to create transparency and trust between developed and developing countries, to ensure that the support is delivered and used for the purpose it was intended for, and to monitor the progress towards the ultimate objective of the UNFCCC (United Nations Framework Convention on Climate Change), i.e. reducing GHG emissions so that dangerous human interference with the climate is prevented. In addition, MRV can be important for sharing experiences about best practices and creating incentives for action (Bakker et al., 2010b).

Nationally appropriate mitigation actions supported by finance, technology and capacity-building have the potential to generate greater emissions reductions than the existing instruments. In order to achieve this, a special "transport window" in the support for NAMAs would be beneficial, to alleviate the danger that the sector gets crowded out due to competition with other sectors. Second, the scope, design and procedures for transport NAMAs need to:

(a) include finance, capacity-building and technology transfer support to enable mitigation activities which help to avoid future transport emissions;

(b) shift transport activities to the most efficient mode, and improve the vehicle technology and fuel quality;

(c) support national, sub-national and sectoral level actions;

(d) provide for MRV arrangements which enable the transport sector to have unfettered access to NAMA funding. This can mean that MRV frameworks focus less on quantified emissions reductions, calculated through modeling, and that MRV frameworks consisting of indicators focusing on the assessment of implementation and progress of the action are considered. In all cases it is important that MRV frameworks allow for relatively large uncertainty in measuring of GHG impacts;

(e) recognize and reward co-benefits with the aim of increasing replication and scaling-up of NAMAs. This could be part of a general strategy to reward NAMAs with a high scaling up potential or replication capacity.

In light of the relatively limited contribution of climate financing to the overall financing of transport programs and projects, it is important to ensure that the objectives of different climate finance instruments are mutually supportive and that they complement the objectives of other non-climate funding sources. If the specific MRV frameworks for climate finance instruments are compatible with the overall planning and monitoring approach for transport programs and projects, it will increase the opportunities for the effective deployment of climate finance instruments in the transport sector (Bakker & Huizenga 2010).

2.7.3. Inland navigation

An increased frequency of flood periods will stop inland navigation on the Rhine more often. Longer periods of low flow will also increase the average annual number of days during which inland navigation is hampered or stagnates. When the Rhine discharge drops below about 1000 to 1200 m3/s, ships on the major transport route Rotterdam-Germany-Basle cannot be fully loaded, and transporting cost rise. The average annual number of days that the Rhine discharge at Lobith is below 1000 m3 /s may increase from 19 (under present day conditions) to 26 according to the XCCC2050 scenario and 34 according to the UKHI2050 scenario. (see: 2.5. Tourism) Current projects on channel improvements can only partly alleviate these problems (Middlekoop et al. 2001).

In 2004, transport caused some 23 % of the world's energy-related greenhouse gas (GHG) emissions (International Energy Agency, 2006). Transport's GHG emissions have increased at a faster rate than other energy using sectors, with freight transport growing even faster than passenger transport.

The contribution of navigation to global warming is still highly debated. Studies by the Institute of Atmospheric Physics of the German Aerospace Centre, DLR, and by the College of Marine and Earth Studies of the University of Delaware, USA, conclude that emissions from maritime navigation count for 2.7 % of all anthropogenic CO2 emissions. Further studies by DLR reveal the aerosols from ship emissions causing a cooling of the Earth's atmosphere that far outweighs the warming effects of their GHG emissions.

That makes GHG emissions from navigation appear small compared to road transport or other human activities. However, with the world maritime fleet growing steadily and with inland navigation's substantial modal share in some of the growth regions of the world such as China, navigation's share of GHG emissions may increase by as much as 75 % in the next 20 years (Vidal, 2007).

Numerous measures for the reduction of GHG emissions from navigation have been identified – and are already implemented in many cases. The most comprehensive study so far seems to have been undertaken by the International Maritime Organisation (IMO). The study identified significant potential for emission reduction by technical measures, which can be easily implemented, and by operational measures, which are more effective. The reduction of speed is seen as the single most effective measure (Henningsen, 2000).

Interdependencies between mitigation, safety and environmental protection

Navigation accidents often lead to additional GHG emissions, due to salvage operations, waiting times or detours for other vessels. Increasing safety of navigation contributes to GHG reduction. In any case, GHG reduction measures that may have a negative impact on the safety of navigation should be avoided. Even though reducing GHG emissions has become more prominent in navigation, the environmental agenda of maritime and inland navigation is still determined by measures to reduce pollutants, such as NOX and particulate matter. As the burning of fuel is the overriding source of GHG emission from navigation, almost any GHG mitigation measure will also contribute to the reduction of these pollutants and thus create additional benefits (Berk et al., 2006). However, reducing pollutants does not necessarily go hand in hand with a reduction of GHG emissions. For example, producing low sulphur fuel leads to higher CO2 emissions of the oil refineries (PIANC, 2008).

Adaptations in inland navigation

Many GHG mitigation measures have a positive impact on the aquatic environment as generally GHG emission reduction means more (fuel) efficient navigation. This is often achieved by either fewer vessel journeys or journeys of vessels that move with lower engine power and thus less return current, waves or propeller current (PIANC, 2007)

Adaptation should include strategies that adapt our current systems and infrastructure to account for changing climate. Mitigation, on the other hand, refers to activities that directly decrease the contributions to global warming, which is the major driver of climate change. According to IPCC (Adger et al., 2007), many impacts can be avoided, reduced or delayed by mitigation, and while some adaptation is currently underway to address observed and projected climate change, more adaptation is required to reduce vulnerability and consequences associated with climate change. They point out that sustainable development is required to adapt successfully to climate change, but that costs could be prohibitive for some adaptation alternatives. (PIANC, 2008)

2.8. Settlement (UniV)

Current initiatives to deal with climate change no longer focus entirely on mitigation. Adaptation to climate change is now receiving much needed attention. However, many scholars are concerned over possible conflicts between mitigation and adaptation policies, due to the discrepancies in various operational scales of the two approaches. Using the building industry and urban development as the focus area, this is not necessarily the case, as mitigation and adaptation can be practiced over multiple scales and levels. (Kua et al. 2010)

Known adaptation requirements in settlement are:

- Reduction of harmful effects on health in urban heat areas by greening plantation of cities
- Reduction of surface drainage on intense rain days by a decentralized rainwater management
- Energy-saving settlement development, which produces no further motorized private transport
- Protection against extreme events by renunciation of settlement development near waters and in areas of floodplain forests

Identification of appropriate entry points for integrating climate change information into developmental planning is also needed. Considerations of climate change impacts could be included in land use planning, water management planning, redesigning structural standards and Environmental Impact Assessments (EIA).

Another priority that has not received sufficient attention is regional coordination in adaptation planning. Most adaptation plans are at the national level while many impacts cut across national boundaries. Sharing of climate data, from flood control to droughts and best practices at regional level could help countries in the region identify the appropriate mechanism to mainstream climate change adaptation in developmental planning as well as specific adaptation measures that are best suited to their local conditions.

The results of the Regional Workshop on Mainstreaming Climate Change Adaptation into Development Planning held in Tokyo in April 2009 provide some guidance on how future management has to evolve. There was discussion on the relationship between national adaptation plans (NAPs) and national communications (NCs) on climate change, and how both are reflected in national development plans. NCs should provide the foundation for any adaptation planning and be the point of reference for NAPs. NCs and national development plans are often considered in isolation – a weakness that governments must address in order to successfully mainstream adaptation planning and develop effective strategies to cope with climate change.

Overall, the session noted that national efforts on adaptation to date have delivered scientific information, resources, and capacity building, but have yet to facilitate significant on-the ground implementation, technology development, or access or establishment of robust institutions to mainstream adaptation agenda. While some countries have conducted NCs and NAPs, they remain as stand-alone documents and are often given minimal consideration in the bigger and higher-priority policy statements like national development plans.

Requirements in Austrian construction and habitation (settlement) (UniV)

To ensure the thermal comfort in buildings, boosting application of passive cooling and forced use of alternative cooling technologies, implementation of structural measures, as well as reduction of internal loads have to been supported. Improving the microclimate of human settlement-related activities will grow through a climatological bonification of urban areas. The protection of buildings from extreme weather events is implemented with structural measures in buildings and increase of water retention in the area (greening of roofs, sealing up surfaces and creation of retention areas).

There are few tools existing for implementation of adaptation measures in new constructions and inventory. One is the adaptation of construction standards and norms to climate change, but also of the living law, to increase the remediation rate. Moreover, strengthening the rehabilitation support for increase of restoration relies on a change in promotion instruments for adaption of new construction and renovation to climate change (considering micro- and meso- climatical conditions in the city and open land planning).

Public relations and (further) education and employer trainings should bring more awareness on adaptation to the impacts of climate change in settlement. (Kronberger et al. 2010)

3. Resume and conclusions

This report provides an overview on user requirements related to climate change that are likely to be relevant to management of protected areas where different groups of stakeholders and land users actively influence the status of the area. As the reports for output 3.1.2 “Stakeholder dialogue” and 3.2.1 “Existing user difficulties” show all investigation areas of the Habit-Change Project have to deal with several user groups from different sectors (see table 12). The management authorities from the investigation areas reported about problems of users and stakeholders that they experience in attempting to reach their objectives. Some of these problems are caused by climate change. Therefore it is expected that users with problems will change their strategies, objectives and practices in order to adapt to the changing conditions. Those adaptations of users will have impacts on the protected area and the objectives and strategies of nature conservation especially on the conservation of protected habitats.

The compilation of possible and necessary adaptation options of different user groups help the management authorities of the investigation areas to prepare themselves for the climate induced changes in land use that might be initiated by important land users and stakeholders. Together with the information about the projected changes in climate (output 4.5.1) the areas dispose of comprehensive information about drivers and pressures that may affect the conservation status of protected habitats. The user requirements and adaptation options compiled in this report are not yet site specific. The have to be refined by information from the local users in the respective investigation areas to find out what changes the local users are actually planning. This information still has to be collected and will be compiled as soon as possible in the additional report 3.1.5 A.

The results from the literature analysis show that the needs and requirements of some sectors must have a major weight in the future planning processes of protected areas. Major adaptations have to be expected in sectors like agriculture, forestry, water management, tourism and others. Those adaptations will have serious impacts on protected areas and the conservation status of protected habitats and have to be considered in the adaptation process of the management plans.

The presented requirements and adaptation options prove that some land users already respond to changing climate conditions; mainly at a local level and in a largely unplanned manner (agriculture). The results of the literature review reveal difficulties in many sectors to adapt to climate change. Most authors cited in the literature review that was conducted during the preparation of this report suggest that measures will need to be taken in the short-term and mainly at a local level on the basis of adaptive management. However, for achieving medium and long-term adaptation and meeting the adaptation objectives an integrative management that considers the requirements of all users that are of relevance to a single site will have to be taken into consideration. This will require an intensification of stakeholder dialogues to avoid new problems and conflicts between different groups of users.

Beside the adaptation requirements on local scale additional adaptations have to taken at regional, state and international level, i.e. changes in policies, strategies and legislation, where required. This challenge will be addressed in work packages 5 and 6 of the Habit-Change Project when policies recommendations are developed.

The information included in this report will later be completed with information from the Habit-Change Project investigation areas and the responsible project partners to show specific adaptation requirements in participating countries (planed report 3.1.5 A). User requirements will need to be addressed for all sectors at different levels and on different time frames. Adaptation measures should prioritise "no-regret" measures, i.e. those that will lead to an expected result and benefits for as many users as possible no matter how future developments happen. Strategies of adaptation will have to be error-friendly and regularly reviewed as part of a learning process. Monitoring and evaluation of adaptation measures will also be needed for all users. Overall, user requirements will also include the needs for mitigation to reduce emissions of greenhouse gases at all user levels.

Furthermore, research in the investigation areas will be needed for different sectors to identify sensitivity to climate change and to assess the impacts of new measures on land uses and on protected habitats. As outlined in the introduction, existing conflicts in the investigation areas should be addressed in stakeholder dialogues and new potential conflicts arising from planned adaptations to climate change should be avoided or mitigated. Therefore, communication and participation with all relevant actors and stakeholders is necessary.

An overview of expected importance of users' requirements for the different partner investigation sites is provided in table 12 below. This table should be the basis for investigations in the protected areas to find out, which users actually plan adaptations and how adaptation processes of different sectors can be coordinated for the benefit of all users.

The planed report 3.1.5 A will focus on these partner investigation areas and on their plans to develop a climate-change adapted management plan (CAMP). The planned report will use this output 3.1.5 as basis for an intensified stakeholder dialogue aiming at inquiring planed adaptation measures and strategies of important stakeholders and land users inside the protected areas. The planed additional report 3.1.5 A is scheduled for August 2011.

Table 12: Important land users in the Habit-Change investigation areas

(Source: Reports for output 3.1.2 stakeholder dialogue and output 3.2.1 existing user difficulties of the Habit-Change Project)

Investigation area	Forestry	Agriculture	Water Management	Fishery	Tourism	Nature Conservation	Transport	Settlement
Rieserferner-Ahrn Nature Park	x	x			x	x		
Schaalsee Biosphere Reserve	x			x	x	x		x
Flusslandschaft Elbe-Brandenburg Biosphere Reserve	x	x		x (anglers)		x	x (shipping)	
Vessertal - Thuringian Forest Biosphere Reserve	x	x	x		x		x	x
Balaton Uplands National Park	x	x	x	x	x	x		x
Fertö Hansag National Park/ Lake Neusiedl		x	x	x	x	x		
Körös-Maros National Park		x	x		(x)[1]	x		
Biebrza National Park		x	x			x		
Danube Delta Biosphere Reserve[2]			x	x		x		x
Natural Park Bucegi	x				x	x	x	x
Secovlje Salina Nature Park[3]			x			x		
Triglav National Park	x	x			x	x		x
Shatsk National Nature Park	x	x			x	x		

[1] "Visitors of the study trail in Kisvátyon area" (Questionnaire "stakeholder dialogue", completed by Malatinszky, A. and Bánfi, P.)

[2] Questionnaire wasn't filled in completely.

[3] Main economic activity in NP SES is salt production

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