Regional Water Management in Adaptation to Climate Change

A survey-based study among regions in Europe

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1. Executive summary

1.1 FORUM and climate change

At the FORUM 2007 meeting for delegations of European regional assemblies in September 12-13 in Strasbourg, it was decided to conduct a study on regional water management issues in Europe in all its facets, viewed in the light of climate change adaptation. The Institute for Environmental Studies of the VU University Amsterdam was asked to compile a questionnaire, to be sent to chairpersons of European Regions. During a preparatory meeting in The Hague it was decided to organize an international conference in Zwolle (the Netherlands) on climate change adaptation and water management. This report presents the results of the survey, and will provide an important input for the conference. Please keep in mind that this version is not the final version. Regions can still complete the questionnaire and we look forward to your comments.

Eighteen regions from nine countries completed the questionnaire. The results provide a wide range of physical impacts of climate change, adaptation policies and measures implemented, from local scale to national scale. The results and conclusions presented in this report are, however, based on a limited sample. Therefore the statements cannot be seen as representative for certain regions, areas or countries in Europe. However, as one of the first studies in Europe, the results do provide a wide-ranging snapshot of the current status of *regional* issues in water management and climate change. The findings are supplemented by publications of the European Environmental Agency, and the European Commission, notably the Green Paper 'Adapting to climate change in Europe – options for EU action'.

1.2 Provisional conclusions

1.2.1 Present situation

Nature degradation, degrading freshwater quality, floods, and water shortages and droughts are the most important present-day physical problems in the regions that participated in this survey. Most regions expect these problems to deteriorate under anticipated climate change. Furthermore, the regions expect to encounter impacts from increasing heat waves, storms and sea level rise.

Concerning future fresh water availability, the regions expect a reduction in rainfall in the summer, and an increase in water use throughout the year that will be most pressing in the summer season (See Figure 3). Literature support these projections (EEA, 2007; EEA, 2008). Altogether, the regions expect the annual water availability to drop, causing more frequent water shortages and potentially water stress. Most regions expect impacts on the agricultural sector, hydroelectric productivity, ecosystems and biodiversity, and tourism and recreation.

1.2.2 Adaptation policy

Adaptation is a priority in most of the regions. On average, 40% of the effort that regions spend on climate change is spent on adaptation. Most regions have assessed current vulnerabilities, future climate risks, and many have assessed their current and changing

socio-economic conditions. Some regions are already in a state of developing specific adaptation policy. Meanwhile, all regions are already implementing measures using existing (e.g. water) policy frameworks. The measures that the regions are implementing vary greatly in number and characteristics. The general focus is on pre-emptive reduction of vulnerability of people, property and nature to changing climate conditions, for example by regulating water abstractions to prevent water shortages. But of course there are exceptions: Emilia Romagna (Italy) spends 30% of its adaptation budget and time in capitalization on future benefits of climate change, and Lower Silesia and Upper Austria spend 60% of their budget and time on increasing the coping capacity, for example by developing a catastrophe management plan. This category focuses mainly on extreme events and is more technical than the category of reducing vulnerability, which is broader and may include soft response measures, such as early warning, education, etc.

According to the EEA (2007) most water-related adaptation activities taken at the national level focus on flood risk management. Apart from flood risk they also state that water scarcity and drought will become major issues as climate changes, but that adaptation measures have not yet been taken by governments to cope with future droughts. The results from this study, however, show that on a regional level measures are in fact being implemented to adapt to reducing water availability.

1.2.3 Regional perceived constraints

Three types of constraints in regional adaptation efforts in water managements are often cited by the regions:

- It is difficult to find ways to **finance adaptation**, even if the costs are co-financed by other projects. Several regions propose to implement better user-pays mechanisms, to make water use more expensive. This will increase efficiency, lower overall water use and make users more aware of the value and the demand for water.
- **Operating in present policy frameworks:** most regions do not have an adaptation policy, and depend on other policy frameworks. However, the idea of assessing options for adaptation using projections of future changes is not addressed in these existing frameworks. This does not imply the need for stand-alone adaptation policies, but might require adjustment of existing relevant sectoral policies, both at the regional and national level.
- **Cooperation and securing stakeholder support:** future projections are uncertain and measures might be costly or even require changes in individual behaviour or even community displacement. Convincing all parties of the benefits and co-benefits of the proposed measures is therefore often cited as a major difficulty. However, many regions also address the need for participatory approaches during the process of drafting and approving river management plans (for instance). Participation of all stakeholders is often considered as a key success to date. It appears that making all parties cooperate is often difficult, but always very beneficial.

1.2.4 Perceived successes

The type measures that regions consider a success of varies to a great extent: some regions mention purely technical measures. Maramures (Romania) is for example mentions improvement of drinking water supply systems, consolidation of riverbanks, and

the development of a database on water quality. Teleorman (Romania) centralised the waste collection system, and Catalonia (Spain) is proud of developing new unconventional water sources, like recovery of groundwater and desalinisation.

Other regions are successful in the whole process of water services development (Arkhangelsk, Russia), or the development of a public information system on water resources shared between levels of authorities, managers of water services and the regional agency for environmental protection (e.g. Piedmont in Italy).

One explicit aspect of implementation and planning of adaptation measures that many regions consider to be a success is information provision to and cooperation with stakeholders. Cooperation appears crucial to reach agreements, and to eventually benefit by reducing costs and (potentially) save energy and water.

2. Introduction

2.1 Climate change adaptation and water

Even if emissions of greenhouse gasses were stabilized today, increases in temperature and its associated impacts, including water availability and flooding, will continue for many decades to come (EEA, 2007). Climate change requires immediate action in order to safeguard the economy and environment (EEA, 2008), and adaptation is inevitable if we aim to keep risks within acceptable limits. Adaptation aims to reduce impacts and increasing the resilience of natural and human systems to current and future impacts of climate change.

Of the many social, economic and environmental impacts of and vulnerabilities to climate change, the projected effects on both the quality and quantity of European freshwater resources is critical, as freshwater is essential for human health and the economy. Moreover, impacts on the water sector have a cascading effect. Sectors which are projected to be most affected by climate change are agriculture, energy, health, tourism and recreation, fisheries and navigation (EEA, 2007). Moreover, serious impacts on biodiversity and ecosystems become visible.

Adaptation is complex because the severity of impacts will vary over time and from region to region, depending on physical vulnerability, the degree of socio-economic development, natural and human adaptive capacity, health services and disaster surveillance mechanisms. While uncertainties remain about the level and extent of changes in precipitation in specific locations, enough is know for action.

Integrating adaptation into existing policy actions and measures would increase the capacity to deal with climate change. Good practices of adaptation ideally are appropriate, proportionate and cost-effective in the long-term, and mitigation needs to be considered when the adaptation practices are being developed.

The European Union has to take on the challenge of adaptation, working in partnerships with its Member States and globally with partner countries, especially in the developing world. The European Commission has put climate change on the political agenda in June 2007 with the publication of the Green Paper ‘adapting to climate change in Europe – options for EU action’. A white paper will follow at the end of 2008. A European approach is necessary to ensure proper coordination and efficiency of policies that address the impacts of climate change.

The Green Paper recognizes the early action on adaptation already taken within Member States, at national, regional and local level, and also emphasizes the subsidiarity of those actions at different levels. National adaptation strategies have been or are being developed and implemented in many countries, usually on the basis of impact assessments and studies on vulnerability (EEA, 2008). However, while some efforts have been undertaken to survey and study adaptation activities at Member State level (see e.g. EEA 2007; Massey and Bergsma, 2008), relatively little insight is currently available about activities at the regional level. This survey aims to provide some first insights, with particular reference to water management.

2.2 FORUM and regional climate change adaptation

At the FORUM 2007 meeting for delegations of European regional assemblies in September 12-13 in Strasbourg, it was decided to conduct a study on regional climate change adaptation and water problems in Europe. A questionnaire was compiled to gain insight in regional adaptation policies and this report shows the results. It will provide input for the international conference on November 13-14 in Zwolle (the Netherlands). Please keep in mind that this copy is not the final version: regions can still complete the questionnaire and we are happy to receive your comments on the report.

The regional approach of climate change and adaptation is an important one: it is often acknowledged as important for adaptation in terms of, for example, implementation of measures to reduce vulnerability (e.g. Kok *et al*, 2008) and spatial planning (EC, 2007).

Adaptation policies are emerging in nearly all Member States and in some Regions. It is essential to share results from research and experiences from early adaptation actions. The EU Green Paper also stresses the need to share methods, tools and best practices. The capacity to adapt is likely to benefit from experience gained in responding to extreme climate events and from implementation of and collaboration on specific and pro-active climate change risk management plans.

Following approval by the participants of the conference in Zwolle in November, this document will be sent to the presidents of all European regional assemblies and the European Commission.

2.3 Questionnaire

In July, the project team sent out an online questionnaire on regional climate change adaptation and water management. It includes questions on the expected impacts of climate change, the present-day and future problems and the policies adopted to deal with these challenges. The full questionnaire is included in Appendix II. Eighteen regions[1] completed the questionnaire (See Figure 1 and Appendix III). The answers to the survey were analyzed by the Institute for Environmental Studies (IVM) at the VU University in Amsterdam.

2.3.1 Representativeness

Because of the limited number of respondents, the results and conclusions from the survey cannot be regarded as representative for the variety of regions in Europe. It is also important to note that in some countries adaptation to climate change is taken up at the regional level, whereas in other countries, such as Denmark for instance, climate change adaptation is mostly an issue taken up at the local and national level (Peter Fjerring, personal communication). This is reflecting the varying roles of different levels of government in Europe. This diversity shows that there is no single solution or single appropriate level to develop adaptation policy. The diversity can also provide insight in the effectiveness of different levels to take up a pro-active role in the matter.

[1] Upper Austria (AT), Liberec Region (CZ), Andalusia, Catalonia, Madrid (ES), Aosta Valley, Emilia Romagna, Trento, Marche, Piedmont, Tuscany, (IT), Overijssel, South Holland (NL), Lower Silesia (PL), Azores (PT) Maramures, Teleorman (RO), Arkhangelsk (RU).

A large amount of valuable information has been collected, providing an impression of some of the major issues related to climate change and water resources at the regional level in Europe. The regions vary in size (Arkhangelsk is almost 25 times as big as the Azores in terms of land area) and population (with 6.2 million people Catalonia has 60 times more inhabitants than Aosta Valley). Common biogeographical European regions like the Continental and the Mediterranean regions are well represented, but not all zones are included in this study. The Atlantic region is represented by only two regions (both Dutch), and Pannonian region is absent (See Figure 1).

2.4 This report

In the next sections the results from the survey are presented, according to the different topics that were surveyed. These are:

- Climate change projections and impacts
- Regional adaptation policy
- Regional adaptation measures

Section 6 provides some general conclusions. Appendix I provides a glossary. The full questionnaire is included in Appendix II, and Appendix III provides a list of participating regions.

3. Climate change projections and impacts

3.1 Introduction

The eighteen respondent regions are spread over several different European bio-geographical zones, as defined by the EEA, including the Continental, Boreal, Alpine and Mediterranean zones. They also represent both mountainous and low-lying regions, and consequently upstream (or inland) and downstream areas (See Figure 1).

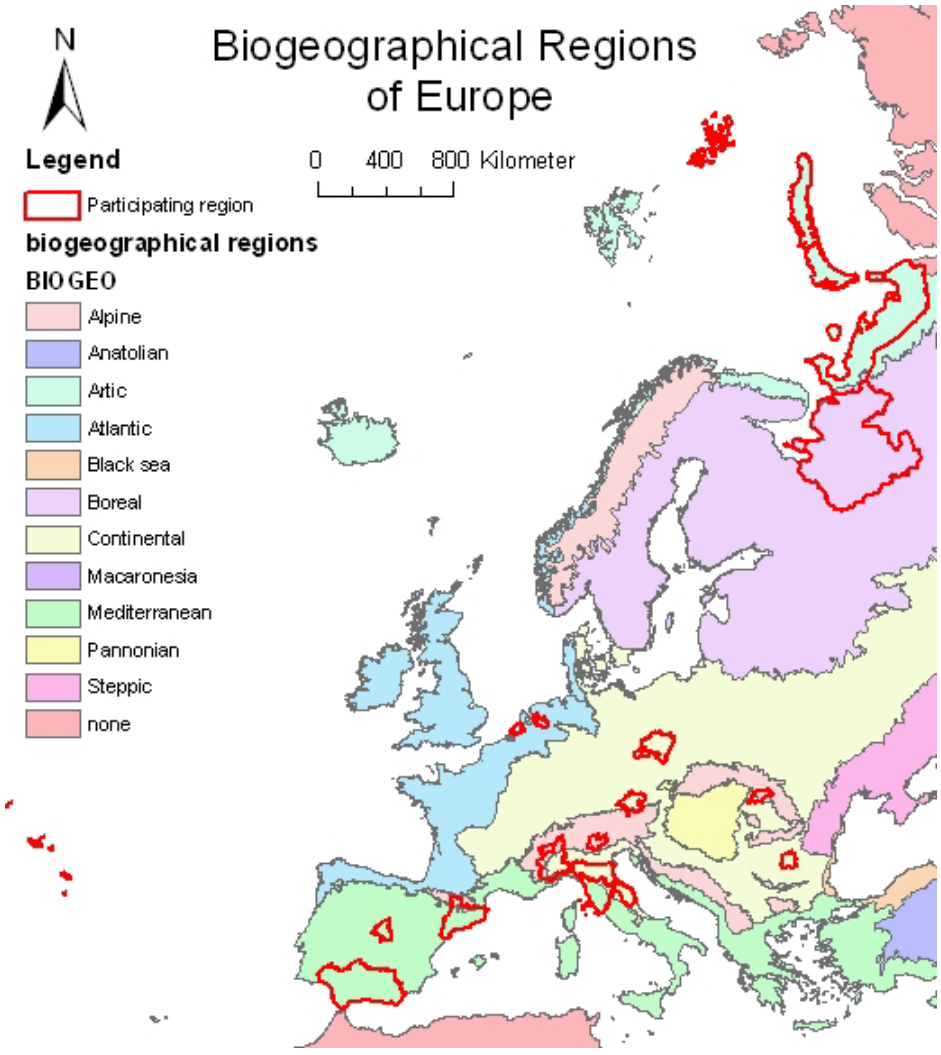

Figure 1 Biogeographical regions of Europe and location of the regions participating in this study.

3.2 Climate change projections

Europe has been warming up more rapidly than the global average (+1.2° vs. +1.0°C, compared to pre-industrial levels), especially in the southwest, the northeast and mountainous areas. Projections suggest further warming in Europe between +1.0 to +5.5°C by the end of the century (see Figure 2). More high temperature extremes and a decreasing number of cold temperatures have occurred the past 5 years and this trend is projected to continue (EEA, 2008).

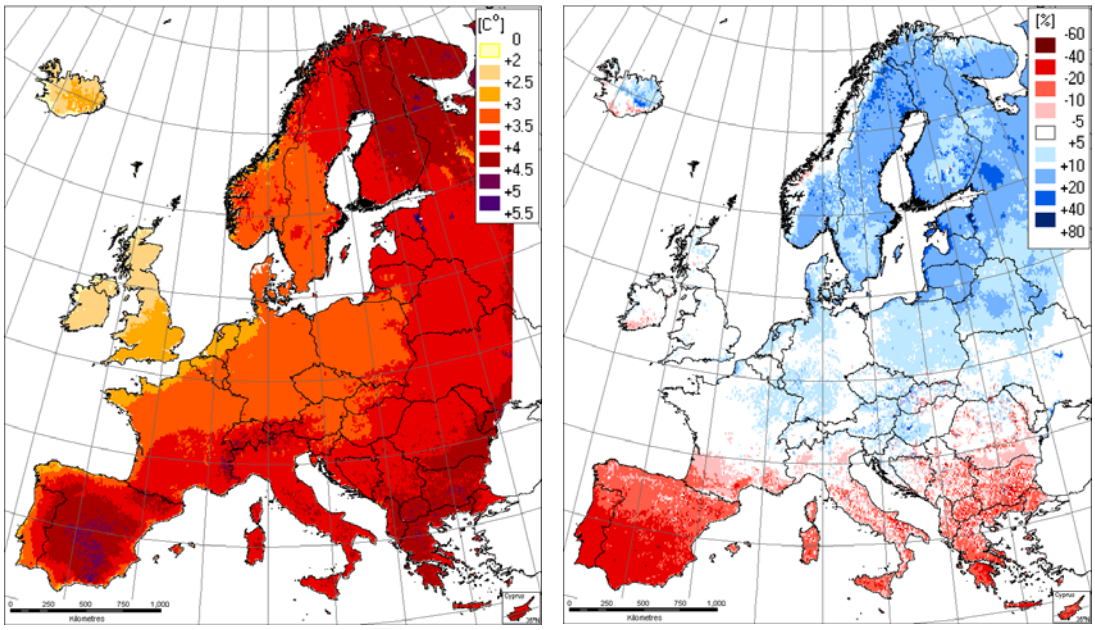

Figure 2 Change in mean annual temperature (left) and change in annual amount of precipitation (right). The figures are based on IPCC SRES scenario A2 and are projected for 2071-2100 relative to 1961-1990 (See EC (2007)).

3.2.1 Precipitation

Changes in precipitation show spatial variability and exacerbate already existing differences between the wet northern part of Europe and the dry south of Europe. The north experienced an increase in precipitation of +10 to +40% during the 20th century, while the south faced a decrease of up to 20%. This trend is projected to continue (See Figure 2). Strong changes in seasonality are projected, with lower flows in rivers in summer and higher flows and risk of flooding in winter. Southern and south-eastern regions, which already suffer most from water stress, will face an increased exposure to water resource reductions and an increase in the frequency and intensity of droughts (EEA, 2008).

In this study, regions generally expect slight changes in precipitation in the spring and autumn (a decrease and an increase, respectively), a strong reduction in precipitation in the summer and a increase in the winter.

3.3 Present day and future physical impacts

3.3.1 A brief overview of impacts according to existing reports

Significant water-related impacts of climate change are expected in Europe, for example because of more intense weather events and increased river flow (except for southern Europe, where the flow decreases). Increased floods are expected, even in regions where mean river flows are expected to drop significantly. Flash and urban floods, triggered by local intense precipitation events, are also likely to be more frequent throughout Europe (EEA, 2008). Climate change can also impact water quality in various ways, such as alterations of the hydrology of water bodies, their physo-chemical and biological characteristics, and changes in anthropogenic pressures. In the past century the temperature in European lakes and streams increased by 1-3°C, a trend that will continue. This will *inter alia* reduce the oxygen content of the water, its thermal stratification, and alter habitats and distribution of aquatic organisms (EEA, 2007).

According to Behrens *et al.* (2008) and the EEA (2007), the most vulnerable areas in Europe are:

- **Southern Europe and the Mediterranean Basin**. Areas already coping with water stress face the joint effect of increasing temperatures and reducing precipitation.
- **Mountain areas**, particularly the Alps. Temperatures increase rapidly, causing snow and ice to melt, and reducing fractions of snow in precipitation. Together this changes the river flow.
- **Coastal zones** in general due to sea level rise and possibly the increased risk for storms.
- **Densely populated floodplains** due to the increase in rainfall, the possible increase in storms and storm surges, and flash floods leading to widespread damages to build-up areas and infrastructure.
- The **arctic region**, which has the highest projected warming on Earth
- **Scandinavia**, where an increase in precipitation is expected, and like in the Alps, a lower fraction of the precipitation will be snow.

3.3.2 Most important effects perceived by the regions

Most regions already consider floods, degradation of the water quality and shortage of freshwater as problematic issues. Nature degradation, heat waves and droughts are major issues as well[2]. A majority of the regions expects these six issues to get worse under climate change. This corresponds with the existing literature on climate change impacts assessments in Europe. It is important to stress that many of the physical impacts are interrelated. Both floods and droughts, for example, have a direct effect on water availability and water quality.

[2] The list of physical impacts (see Table 1) proved not to be complete. During the conference in Zwolle, Aosta Valley also mentioned land slides. Land slides are not necessarily caused by permafrost melt: in Scotland, they cause problems as well (de Roo, personal communication).

Table 1 The crosses indicate present weather-related physical impacts faced by the participating regions. The squares highlighted in green indicate that the regions expect the problems to increase under climate change.

	Sea level rise	nature degradation	shortage of freshwater	degrading water quality	floods	droughts	storms	heat waves	permafrost melting	declining fisheries	Forestry
Aosta Valley			X	X	X				X		
Arkhangelsk		X	X	X	X						
Azores	X			X	X						
Andalusia		X	X	X	X	X		X	X		
Catalunia	X		X	X	X	X	X	X			
Emilia Romagna		X	X	X	X	X	X	X			
Liberec Region*					X						
Lower Silesia		X	X	X	X		X	X			
Madrid		X	X	X	X	X	X	X			
Maramures					X		X				
Marche	X	X	X	X	X	X		X		X	
Overijssel	X	X	X	X	X	X	X	X	X		
Piedmont		X	X	X		X		X			
South Holland	X	X	X	X	X	X		X			
Teleorman					X	X	X	X			
Trento		X	X		X	X	X		X		
Tuscany		X	X	X	X	X		X		X	
Upper Austria		X		X	X	X	X	X			X
Total %	**27,8**	**66,7**	**72,2**	**77,8**	**94,4**	**66,7**	**50,0**	**66,7**	**22,2**	**11,1**	**5,6**
expected to get worse %	35,3	52,9	58,8	58,8	82,4	52,9	58,8	58,8	17,6	5,9	5,9

*Liberec Region did not indicate whether they expect future problems

- All regions mention to suffer from **floods** or the high risk of floods, except for Piedmont[3]. Most of them expect the risk of flooding to increase; Overijssel and Upper Austria expect to encounter difficulties in the protection against floods in the future.
- Many regions cite **degradation of freshwater quality**, and mention the concentration of pollutants due to less dilution (Aosta Valley, Catalonia and Madrid), the inflow of pesticides (Upper Austria), salinisation (the Azores and South Holland), and decreasing oxygen levels (Overijssel).
- Regions express their **shortage of freshwater** for example in terms of the necessity to divide water between different sectors (e.g. Andalusia, Overijssel and Piedmont) or water sources that are subject to drought (e.g. Madrid, Marche and Aosta Valley).

[3] This is interesting because the region suffered from severe floods in November 1994 and October 2000 and apparently implemented successful policies and effective measures.

- **Nature degradation**: This is a broad category, stretching from the effects of glacier retreat on ecosystems (Trento) to desertification (Emilia Romagna), changes in plant cycles, animal migration patterns and an increase in number of parasites (Marche) and changing conditions of water resources (Lower Silesia). Upper Austria mentions conflicts in spatial planning between agriculture and infrastructure projects on the one hand and nature on the other hand, which is however not necessarily climate-related.
- A majority of the regions experience **heat waves**, and many regions expect these to increase in number and in duration. Three regions mention the summer 2003 heat wave and drought as an example and others expect increased water and energy use during future heat waves, and an increasing number of casualties.
- Regions mention an increase in extreme **droughts**, either in frequency, intensity, or both (Catalunia, Marche, Madrid, Trento). Other regions mention the direct effect of reducing water availability on the economy, the agricultural sector and/or ecosystems (Lower Silesia, Teleorman, Tuscany).

Less common Physical problems were sea level rise, permafrost melting and storms**.** Obviously **sea level rise** was only mentioned by the regions bordering seas (and by Overijssel, which borders the IJsselmeer; a lake discharging in the Waddensea). Emilia Romagna indicated not to suffer from sea level rise but expects problems in the future.

Glacier retreat/permafrost melting is only mentioned by the alpine regions. Melting of (mountain) permafrost is already increasing hazards and damage of infrastructure (EEA, 2008). Arkhangelsk does expect melting of permafrost, but does not consider it as a problem at this point because there are no economic activities in the areas where it is happening.

More regions are expecting impacts from **storms**, than there are regions already experiencing the effects. However, according to the EEA (2008), with the exception of temperate maritime regions in Europe, there are neither observed, nor projected trends of increasing storms and storm surges in Europe.

Regions furthermore mentioned climate-related declining fisheries (Marche, Tuscany), and an impact on forestry (Upper Austria).

3.4 Effects of physical impacts

3.4.1 Water availability

According to the IPCC the percentage of land area in Europe under high water stress is likely to increase from 19% today to 35% by 2070. The additional number of affected people between is estimated between 16 and 44 million (Alcamo *et al.,* 2007). Many regions indicate to suffer already from water shortages in mainly agriculture, and tourism and recreation. Water surpluses are less common but are considered as problems for agriculture, the transport sector and to threaten coastal defence structures. Water quality issues are mainly shown for ecosystems and biodiversity, tourism and recreation (e.g. swimming in lakes and streams), industry effluents, and agriculture.

When looking ahead, next to the expected reduction in rainfall in the summer, the regions expect an increase in water use throughout the year that will be most pressing in

the summer (see Figure 3). Indeed literature reveals that water use in summers is likely to increase, for example for irrigation, household consumption, and tourism and recreation (EEA, 2007; EEA, 2008). According to the regions, water availability is expected to drop because of reduced rainfall and increased use[4], causing shortages and potentially water stress. This will directly impact various economic sectors. A large majority of the regions foresee water-quantity related problems for the water sector, which translates itself in distribution problems (and conflicts) mainly for the following sectors:

- **Agricultural sector**: Water shortages and droughts are expected to affect the agricultural sector (Andalucia, Overijssel, Teleorman, Trento); Marche expects a yield reduction and Piedmont thinks that current irrigation systems will malfunction is the future[5]. Salinisation of agricultural lands is also expected (South Holland, Tuscany).
- **Energy supply**: lower hydroelectric productivity (Piedmont, Marche) will result in reduced availability of electricity; possible shortages will be exacerbated by a potential increase in energy use during future heat waves (Tuscany). There will be less cooling-water available (Piedmont, Overijssel). Indeed the EEA (2007) states that hydropower potentials might reduce by 25% in south and south-eastern European countries.
- **Tourism and recreation**: In terms of water quality, regions expect that reduced snow fall amplifies the need for artificial snow (Piedmont, Trento, Upper Austria), and that the reduced quality of fresh water bodies reduces possibilities for practicing of aquatic sports and bathing (Maramures, Marche, Overijssel, South Holland). In terms of quantity, regions expect reduced drinking water availability (Marche, Tuscany) and changing landscapes because of reduction in vegetation (Aosta Valley).
- **Ecosystems and biodiversity**: the effects on ecosystems are take place on the interface of water quantity and quality. Marche and Piedmont mention habitat degradation as an example. Emilia Romagna mentions the change in plant species.

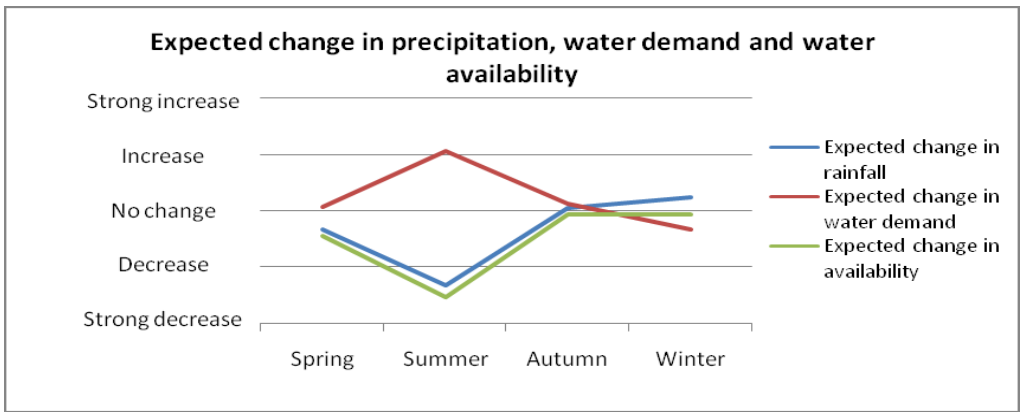

Figure 3 Expected changes in water demand, change in precipitation and availability.

[4] The EEA draws the same conclusions; bud adds two reasons for increasing water stress. First, rising temperatures increase evaporation. Second, in snow-dominated areas, such as the Alps and Scandinavia, a lower fraction of precipitation will fall as snow. This increases river flow in winter, but again reduces summer runoff (EEA, 2008).

[5] No region mentions the variability of future crop-yield, as projected by the EEA (2008).

4. Adaptation policy

4.1 Introduction

According to the EEA (2007), adaptation to climate change in the water sector needs to be incorporated into overall policy framework. They cite an OECD analysis of policy frameworks for water, which shows that *'what should be done, when and by whom depends on the rate of climate change, but also on the existing policy framework in each country. Adaptation occurs mainly at the sub-national and local levels'* (EEA, 2008), but also state that it requires (transboundary) interaction between multiple levels of government. European, national, regional and local levels can strengthen, or weaken, adaptive capacity and action taken at other levels. This chapter provides some information on regional adaptation policies.

4.2 Background information and projections

Except for Arkhangelsk, Liberec Region and Maramures, all regions use climate change projections of the IPCC as a source of information to base their policymaking on. Furthermore, almost 60% of the regions use country projections, and halve of the regions have downscaled regional climate change projections.

4.3 Priority of adaptation

In their Green Paper the European Commission (2007) state that without an early response to climate change, forced, reactive and unplanned adaptation might be necessary at some point. This will prove to be more costly than a proactive response, and also threaten Europe's social and economic systems and its security. For impacts where there is enough confidence in the forecasts, adaptation –and thus also formulating adaptation policy- must therefore start now.

Regions spread their effort over mitigation and adaptation in a diverse way: whilst Piedmont spends 70% of their effort on adaptation, Upper Austria spends only 5%. Catalonia, Maramures and Trento divide their effort equally. The average is 60% mitigation, and 40% adaptation (N=17).

Apart from Lower Silesia all other regions consider adaptation as a priority, either in initial phase, or a region is already developing or implementing an adaptation policy. As can be seen in Figure 1, most regions have already done a current vulnerability assessment. A majority of the regions also made an assessment of future climate risk, and more than halve of the regions has also assessed the present-day and future socio-economic conditions. Many of these activities were however undertaken without the first step of scoping and designing an adaptation project, indicating that the motivation of conducting the activities is not necessarily climate change related. Emilia Romagna, Piedmont, South Holland and Upper Austria are the most advanced in developing their adaptation strategy: they took up the collected information on impacts and vulnerability, formulated an adaptation strategy, and are implementing the strategy.

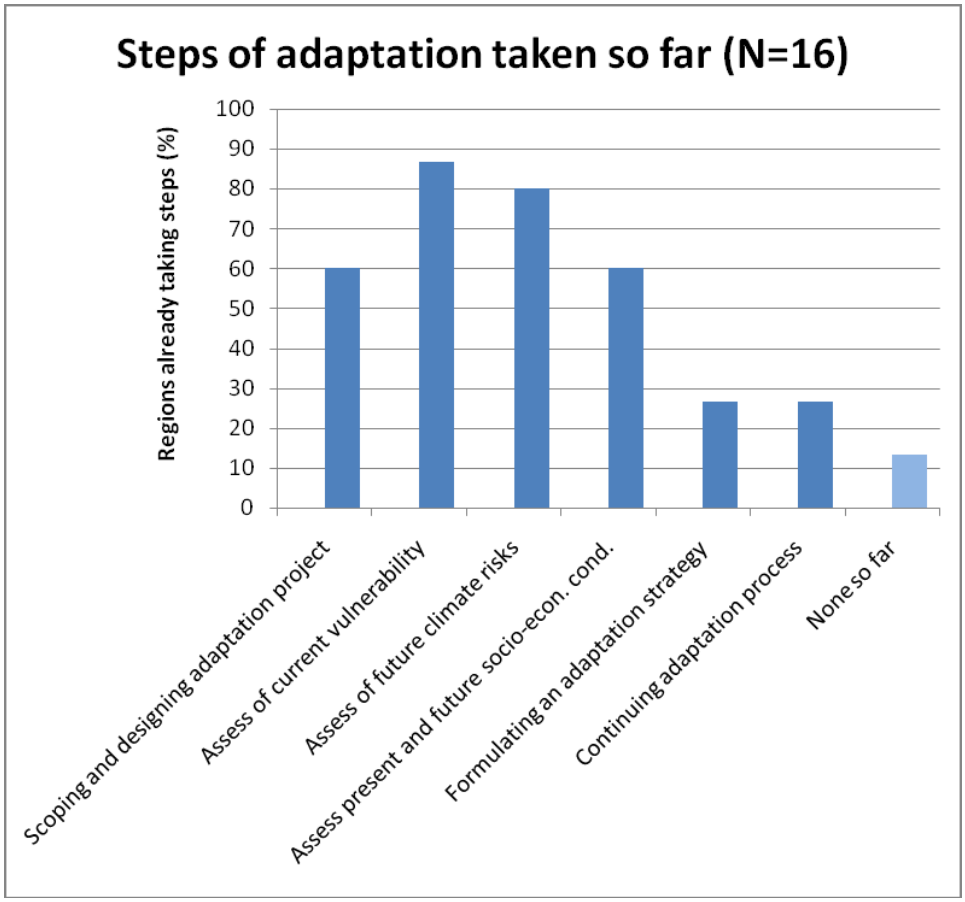

Figure 1 The steps that regions have taken so far on adaptation.

4.4 **Policy agenda**

There are four important administrative levels on which policy can be developed on adaptation: local, regional, national, and at the EU level. The European Commission (2007) states that multilevel governance is emerging on adaptation, involving all actors from the individual citizens and public authorities to the EU level. Action should always be taken at the appropriate level and it should be complementary, based on joint partnerships. The sub-national level is often acknowledged as important for adaptation in terms of, for example, implementation of measures to reduce vulnerability (e.g. Kok *et al*, 2008) and spatial planning (EC, 2007).

Of the fourteen regions answering the question, twelve mention that formulation of an adaptation policy is or would be impacted by the EU and eleven think this way about the national administrative level. At the same time, however, only three out of seventeen regions see the European Union as the optimal scale to develop an adaptation policy, and only six see the national administrative level as such. Except for Lower Silesia, all regions see the regional level as the best level to develop an adaptation strategy.

4.5 Policy implementation

Time and money are spent almost equally over four categories of adaptation (See Figure 2, and Appendix I for an explanation of the four categories). Pre-emptive reduction of risk and vulnerability of people, property and nature to changing climate conditions is clearly the most important category. Good examples of this are preventing water shortages by improving water allocation, and relocating infrastructure out of flood prone areas. Increasing the coping capacity, mainly focussed on extreme events, is the second-largest category. Regions for example develop catastrophe management plans, or draw flood risk maps. The category is followed by building adaptation capacity, which consists mostly of soft measures like research on regional effects of climate change and information campaigns on for example flood risks. It is often overlooked, but some benefit might arise from changing climate conditions. South Holland for example expects a positive effect on tourism and recreation, and according to the IPCC crop productivity is likely to increase in northern Europe (Alcamo *et al*, 2007). However, regions spend only little money and effort on capitalizing on changing climate conditions.

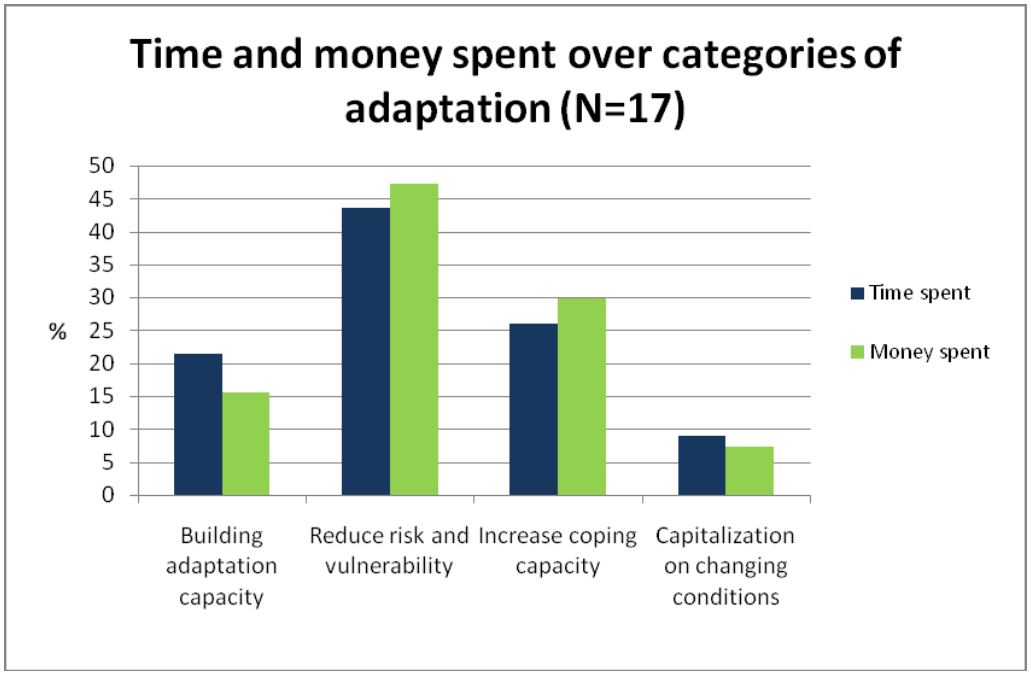

Figure 2 Time and money spend over different categories of adaptation.

5. Adaptation measures

5.1 Introduction

Even though most regions do not have a separate adaptation policy, many measures are already being taken or planned to improve water management by incorporating climate change. In the absence of an adaptation policy these measures are mainstreamed in water management policy. There is a great variation in the extent to which regions have proceeded with taking measures. During implementation of measures, regions face constraints and successes, which will both be summarized in this chapter.

5.2 Measures

The extent to which regions have proceeded with taking measures, vary greatly: from collection of information, scoping and defining strategies, to actual implementation of measures.

Catalonia is in the stage of studying the envisaged impact of climate change, for example by identifying flood prone areas and developing protocols for comprehensive management of resources and drought conditions, for instance by incorporating unconventional sources such as desalinisation, reuse, and recovery of groundwater. Catalonia is in a process of identifying impacts, with the final goal of including an adaption policy in the Water Plan.

Teleorman focuses on water quality issues, and has drilled deep wells to avoid nitrate pollution, and has installed new water purification plants.

Arkhangelsk, Liberec Region and Lower Silesia so far have strategies to cope with extreme events only. The Russian region has regulations for emergency cases are in place, including actions plans and appointment of responsible institutions and companies. Liberec Region is developing crisis and flood plans and provides environmental education, and Lower Silesia initiated a Centre of Crisis Management.

The Azores are one step further and is elaborating the regional water plan, which covers all islands and focuses on both inland areas and coastal areas, where salinisation of aquifers is a problem. Madrid also has a hydrological plan, which comprises several dam breach scenarios, flood damage estimations and droughts mitigation measures. The region takes climate change into account in its planning scenarios for water use.

Andalusia has implemented a River Basin Drought Management Plan and installed Drought Management Commissions; including for example water forums and water management participatory bodies; Water rights exchange centres; Flood Prevention Plan and Inventory and Mapping of flood-prone areas.

Piedmont has a Regional Water Management Plan to measure quantitative and qualitative remediation and protection of water resources at river basin level, to achieve a good environmental status for all waters. Water quantity is for example regulated by maintaining a minimum flow at all times, releasing water abstraction permits according to water availability, and re-balancing water abstraction for agricultural purposes. Water quality is maintained for instance by regulation the use of pesticide and fertilizers. Moreover, an

information system for water is being developed, and to cover the institutional aspects a steering group is established for coping with drought periods.

Emilia Romagna and South Holland have implemented a Regional Water Protection Plan as well. Emilia Romagna formulated a plan in cooperation with Provinces and major stakeholders. Now they are planning the implementation of *inter alia* minimal flow in rivers, streamlining of surface water and groundwater abstractions, water reuse for irrigation and other uses, and increasing water use efficiency. South Holland incorporated climate change in the general water policy, which focuses on the prevention of severe flooding by improving 'weak links' and river dikes, implement peak storage facilities, and development of a policy to cope with drought, salinisation and shortage.

Tuscany and Overijssel include sustainable development in their planning. While Overijssel focuses mainly sustainable spatial planning, Tuscany is working on a legislation based on sustainable development in planning of resource use, strategic planning of infrastructure, and actions aimed at saving and conservation.

Generally, most of the planned measures are on protection against floods and droughts, improving water quality and the river environment, and reducing and reconsidering water usage. In order to achieve the latter, several regions have plans to improve water pricing policies by making users pay. Arkhangelsk for example wants to attract financial resources from water-intensive industries, and Marche is also planning to implement a pricing policy.

5.3 Perceived successes

The type of measures that regions are proud of varies to a great extent: some regions are proud of truly technical measures. Maramures is for example proud of improving drinking water supply systems, consolidation of riverbanks, the development of a database on water quality, and construction of treatment plants. Teleorman considers the centralization of the waste collection system as a success, and Catalonia is proud of developing new unconventional water sources. South Holland was a partner in the development of the so called 'sand engine'; usage of a natural process to strengthen the coastal defence. Tuscany and Madrid are proud of a public awareness campaign on water as a limited resource. Other regions consider to be successful in the whole process of water services development (Andalusia, Arkhangelsk), or the implementation of an information system on water resources shared between levels of authorities, managers of water services and regional Agency for Environmental protection (Piedmont).

One specific aspect of implementation and planning of measures that many regions consider to be a success is information provision to and co-operation with stakeholders. The IJsseldelta-project (Overijssel) aims to obtain an integrated and potentially conflicting spatial development, in which stakeholder support is crucial. Trento mentions to be particularly proud of the way information on climate change is provided to the citizens, and Upper Austria also brings up the co-operation of municipalities in special associations on flood prevention. Benefits of involving stakeholders and wider public are obvious: it reduces costs (Upper Austria), and it will save energy and water (Trento).

5.4 Perceived constraints

Apart from some administrative and technical problems[6], and problems that have to do with uncertainty of climate change scenarios, three types of constraints in regional adaptation efforts in water managements are often cited: financing adaptation, operating in the present policy framework, cooperation and securing stakeholder support.

First, there is an issue of **financing adaptation**. The Azores, Overijssel, Emilia Romagna, Madrid, Piedmont, South Holland and Trento all state explicitly that it is difficult to finance planned adaptation measures. Maramures adds that it is difficult, even if the costs represent only co-financing of other projects. Aosta Valley and the Azores mention that their costs are relatively high in comparison to other regions because of a scattered population over a mountainous area and several islands, respectively. Piedmont also point out that in order to reduce the impact of climate change, some stakeholders should limit their water abstraction and face the economic consequences of this. Andalusia, Arkhangelsk, Marche and Tuscany are also in favour of increasing costs for users and/or polluters. Upper Austria wants the national Austrian catastrophe fund to open up for financing adaptation measures. The European Commission writes that in particular, economic instruments and the user pays principle should be applied across all sectors, including households, transport, energy, agriculture, and tourism. This will provide strong incentives to increase water-use efficiency and reduces water consumption (EC, 2007). Moreover, people become aware of the value and importance of water.

The second constraint is **operating in present policy frameworks**. According to Upper Austria there is freedom of implementation as long as the adaptation measure either provides extra benefits or is in line with other strategies. This implicitly means that the present policy framework is not optional for implementing adaptation measures. Catalonia's legal framework for water brings about substantial restrictions when implementing environmental flows or possible limits of water use that are not regarded as present-day priorities in drought management. One of the issues here is that the application of measures has a different scope than the present-day water framework: implementing adaptation measures is a cross-disciplinary process among several policies regarding water, e.g. urban planning, agriculture, industry, and energy. This does not necessarily imply the need for stand-alone adaptation policies, but calls for adjustment of relevant sectoral policies, both at the regional and national level. Arkhangelsk and Emilia Romagna simply state that laws and regulations for planned activities to reduce the impact of climate change do not work well.

Third, some regions name difficulties with **cooperation and securing stakeholder support** for adaptation measures (Andalusia, Overijssel, Piedmont, Trento, Tuscany). First, climate change projections can be uncertain, whilst implementation costs of adaptation measures can be high, and the results of the measures contested. Second, there is a difference in time horizon between the effects of climate change and normal planning activities. Third, in some cases climate change adaptation requires changes in personal behaviour of different actors, or (community) displacement. Piedmont for example points

[6] Administrative: lack of processing capacity of executing units, prolonged administrative procedures, etc. Technical: ensuring downstream flow of rivers, improving local water quality, improving wastewater management, etc.

out that in order to reduce the impact of climate change some stakeholders should limit their water abstraction and face the economic consequences of this. Securing stakeholder support can thus be very difficult.

6. Conclusion

6.1 Sample size

The results and conclusions presented in this report are based on a limited sample size. Therefore the statements cannot be seen as representative for certain regions, areas or countries in Europe. However, they do provide a wide-ranging snapshot of the current status of major issues in water management and climate change, and current preparation and adaptation responses. The findings are supplemented by publications of the European Environmental Agency, and the European Commission, notably the Green Paper 'Adapting to climate change in Europe – options for EU action'.

6.2 Present situation

Floods, degrading freshwater quality, water shortages, nature degradation, droughts and heat waves are the most important present-day physical problems in the regions that participated in this survey. Most regions expect these problems to deteriorate under anticipated climate change. Furthermore, the regions expect to encounter impacts from storms, and, if applicable, sea level rise and permafrost melting.

6.3 Climate change

Europe has been warming up more rapidly than the global average (+1.2° C, compared to pre-industrial levels), especially in the dry south-west, the arctic and boreal north-east and mountainous areas. Projections suggest further warming in Europe between +1.0-5.5°C by the end of the century. Changes in precipitation show spatial variability and exacerbate already existing differences between the wet northern part of Europe (+ 10 to 40% during the 20th century) and the dry south of Europe (a decrease up to 20%). Strong changes in seasonality are projected, with lower flows in rivers in summer and higher flows and risk of flooding in winter. Southern and south-eastern regions, which already suffer most from water stress, will face an increased exposure to water resource reductions and an increase in the frequency and intensity of droughts (EEA, 2008).

Regions expect a reduction in rainfall in the summer, and an increase in water use throughout the year that will be most pressing in the summer season. Literature supports these projections (EEA, 2007; EEA, 2008). Regions expect the water availability to drop, causing more frequent water shortages and potentially water stress. Most regions expect impacts on the agricultural sector, tourism and recreation, hydroelectric productivity, and ecosystems and biodiversity.

6.4 Adaptation policy

Adaptation is a priority in most regions. On average, 60% of the effort that regions spend on climate change is spent on mitigation and 40% on adaptation. Most regions have assessed current vulnerabilities, future climate risks, and many have also assessed current and changing socio-economic conditions. A couple of regions are developing a specific adaptation policy. Meanwhile, all regions are already implementing measures using existing (e.g. water) policy frameworks. The measures that the regions are implementing vary greatly in number and characteristics. The general focus of these measures is on re-

ducing vulnerability of people, property and nature to changing climate conditions, for example by preventing water shortages by improving water allocation, and implement peak storage facilities. But of course there are exceptions: Emilia Romagna spends 30% of its budget and time in capitalization on climate change, and Lower Silesia and Upper Austria spend 60% of their budget and time on increasing their coping capacity towards extreme events.

According to the EEA (2007) most water-related adaptation activities taken at the national level focus on flood risk management, while water scarcity and drought are recognized as problems, but measures have not yet been taken. The results from this study show that on a regional level measures are in fact being taken to adapt to reducing water availability.

6.5 Regional constraints and successes

Three types of constraints in regional adaptation efforts in water managements are often cited by the regions:

- **Financing adaptation** is difficult, even if the costs represent only co-financing of other projects. Several regions propose to implement better user-pays mechanisms. This will increase efficiency, lower overall water use and make users more aware of the value and the demand for water. The European Commission (2007) indeed states that inadequate water pricing, inconsistent land-use planning and bad water allocation automatically lead to overuse.
- **Operating in present policy frameworks:** most regions do not have an adaptation policy, and depend on other policy frameworks. Long-term adaptation measures based on projections of future changes do not always fit in existing frameworks. This does not imply the need for stand-alone adaptation policies, but might require adjustment of relevant sectoral policies on national and regional level.
- **Cooperation and securing stakeholder support:** future projections are uncertain and measures might be costly, require changes in individual behaviour, or even community displacement. Convincing all parties of the benefits and co-benefits of the proposed measures is therefore often cited as a major difficulty.

The type of successful measures that regions are proud of vary to a great extent: some regions are proud of truly technical measures, like improving drinking water supply systems, consolidation of riverbanks, the development of a database on water quality, or developing new unconventional water sources. Other regions find the whole process of water services development successful.

One explicit aspect of implementation and planning of measures that many regions consider to be a success is information provision to and cooperation with stakeholders. Many regions cite the participatory approaches used during the process of drafting and approving for example river or drought management plans as key successes to date. It appears that making all parties cooperate is often difficult, but always very beneficial, for even in terms of reducing costs and save energy and water.

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Appendix I. Glossary

Adaptation	Adapt to the adverse effects of climate change (e.g. build dikes to cope with a rising sea level)
Agriculture	Includes forestry, cattle farming, and growing crops. Climate change will affect crop yields, livestock management and location of production with important risks for farm income and land abandonment in certain areas of Europe.
Building adaptative capacity	These measures impart information so as to promote action at a later stage. These are mostly government reports, information campaigns or research studies that assess inter alia risks and sensitivities as well as inform about particular vulnerabilities to climate change. A publication of a flood risk map is a good example.
Capitalization on changed climatic conditions	It is often overlooked, but some benefit might arise from changing climate conditions. In this case a measure might be applied to capitalize the changing conditions.
Ecosystems and biodiversity	The impacts of climate change on man are largely mediated by natural capital, biodiversity and the flow of ecosystem services in terrestrial, freshwater and marine ecosystems. Climate change will thus significantly affect economies and societies through its impacts on ecosystems and biodiversity. Approximately 20-30% of plant and animal species assessed so far are likely to be at increased risk of extinction if increases in global average temperatures exceed 1.5-2.5°C.
Energy	'Energy' is twofold: Please focus on the adaptation-side of energy, whilst considering both production and consumption. Changes in mainly precipitation patterns can have both negative and positive effects on the production of especially hydro energy. A water-related example of energy consumption is for example desalinization of water.
Fisheries	Includes both fisheries and outdoor aquaculture. Climate change can affect the distribution patterns and abundance of species from plankton to top predators, which may result in major changes in ecosystem functions and geographical ranges in stocks. Temperature differences might even have an effect on aquatic animal farming
Health	Climate Change will have direct and indirect effect on human and animal health. The effects of extreme weather and infectious (waterborne) diseases are among the most important risks.
Increased coping capacity to extreme or damaging events	While closely related to reduction of risks this measure focuses on extreme events and their effects on people, property and nature, not simply overall climatic change effects. In the temporal aspect it is concerned primarily during and after something happened. Measures for example include installing extra hospital beds in anticipation of a heat wave, or insurance companies or governments increasing capital outlays to help pay for the after effects of an extreme event.
Mitigation	Try to prevent climate change (e.g. by reducing greenhouse gas emissions)

Policy concern	First level of adaptation action, characterized by general statements on specific issue areas without offering a concrete plan of action. For example: "In the next ten years we foresee an increase in the incidence of heat waves, action must be taken". There is a focus on heat waves but no specification on what to do about it.
Policy measure	An actual implemented policy measure (note: out of climate concerns, or at least that acknowledge this concern), such as the construction of a sea wall or the implementation of an early warning system to detect heat waves.
Policy recommendation	Specific recommendations are put forward to address specific problems, for example: "It is recommended that in the next five years we allocate 20 million Euros to develop an early warning system for a high sea level.
Reduction of risk and vulnerability	Measures that can be undertaken to reduce the risk and sensitivity of people, property and nature to changing climate conditions. These include actions such as building a sea wall.
Spatial planning (measures)	Structures like houses, industry, roads etc. and activities like recreation and fishing can be induced to relocate because of climate change. Some areas will become more practical for certain functions than others, and some activities might even become impossible to proceed at certain areas.
Technical measures	Construction of special drainage systems, dikes, infrastructure, etc.
Tourism and Recreation	High-seasons of tourism might change as an effect of climate change, especially for beach and snow related tourism
Transport	Includes for example shipping over navigable rivers that need a sufficient water level. For the construction of new road networks it needs to be taken into account that the sea level is rising.

Appendix II. Survey Questions

What is the name of your Regional Assembly
Country
What is the centre of competence of the Regional Assembly?

Policy

What is the priority of adaptation of your regional government?

(Please mark the correct option)

No priority	Low priority	Priority, but in initial phase	Priority: adaptation strategy is being developed	Priority: adaptation strategy is being implemented

Which steps have you taken so far?

(Please mark the correct option(s))

Stage	activity	mark
1	Scoping and designing adaptation project	
2	Assessment of current vulnerability	
2	Assessment of future climate risks	
2	Assessment current and changing socio-economic conditions	
3	Formulating an adaptation strategy	
4	Continuing adaptation process	

What is the relation adaptation-mitigation in regional policymaking?

(Please add a percentage; mitigation and adaptation together need to add up to hundred)

	Adaptation (%)	Mitigation (%)	Total
Climate practices			100%

Is your regional adaptation policy impacted by local, national or EU adaptation policies?

(Please mark the correct option(s))

Local	National	EU

What would be the optimal scale to develop an adaptation policy for your region?

(Please mark the correct option(s))

Local	Regional	National	EU

What physical circumstances are regionally considered to be major issues at the present?

Issues (examples)	Yes/No	Please indicate why	Will climate change make it worse in the future (y/n)?
Sea level rise			
Nature degradation			
Shortage freshwater			
Degradation of freshwater quality			
Floods			
Droughts			
Storms			
Heat waves			
Permafrost/ glacier melting			
Other:...			

What is the regional policy of WATER-RELATED adaptation on technical measures?

(Please mark the correct option(s))

Measure (examples)	Policy concern	Policy recommendation	Policy measure
Adapt sewer system			
Flood prevention			
Drought prevention			
Water quality maintenance			
Other:...			

What is the regional policy of WATER-RELATED adaptation in the regional spatial planning?

(Please mark the correct option(s))

Measure (examples)	Policy concern	Policy recommendation	Policy measure
Housing			
Industry			
Agriculture			
Transport			
Tourism and recreation			
Ecosystems & biodiversity			
Fisheries			
Other:...			

What is the regional policy of WATER-RELATED adaptation on soft measures?

(Please mark the correct option(s))

Measures (examples)	Policy concern	Policy recommendation	Policy measure
Disaster preparedness; evacuation			
Create awareness			
Healthcare			
Insurance			
Other:.....			

Measures

Please shortly describe measures taken in your region.

Please describe shortly the measures that are planned for the next 5-10 years.

Which project are you most proud of? Why?

Please estimate the way time is spend over the following categories:

(Explanation of the options are given in the glossary. Answers need to add up to 100%)

	=100%
Building adaptation capacity	
Reduce risk and vulnerability	
Increase coping capacity to extreme or damaging events	
Capitalization on changed climatic conditions	

Please estimate the way money is spend over the following categories

(Explanation of the options are given in the glossary. Answers need to add up to 100%)

	=100%
Building adaptation capacity	
Reduce risk and vulnerability	
Increase coping capacity to extreme or damaging events	
Capitalization on changed climatic conditions	

What are the major constraints when implementing measures?

Estimate the percentage of your total regional budget that is spend on water-related policy

Adaptation requires financial support. Where do you get funding from at the present?

Adaptation requires financial support. From which policy level SHOULD the larger part of the funding come from?

(Please mark 1 or 2 options)

Local administrations	Regional	National	EU

Is there cooperation on adaptation or are there plans to start cooperating with other regions or at a national/EU scale?

(Please mark whether there is cooperation on the following sectors, and add more sectors if applicable)

	Other regions	National	EU
Agriculture			
Industry			
Tourism and recreation			
Ecosystems and biodiversity			
Energy			
Coastal defence			
Health			
Transport			
Water management			
Other:.....			

Background information of the region

What is the size (in km2) of your region?

	Land	Water bodies	Total
Size (km^2)			

Present problems in water-related sectors

(Please mark the correct option(s))

	Shortage	Surplus	Bad quality
Agriculture			
Industry			
Tourism & recreation			
Ecosystems & biodiversity			
Energy			
Coastal defence			
Transport			
Other:			
Housing			

Expected effects of climate change

Which of the following climate change projections does your region use as a source of information for policymaking?

(Please mark the correct option(s))

Climate change projection	Use
IPCC	
European projection	
National projection	
Regional projection	
Other:	

What general changes in rainfall are expected for your region in comparison to the present situation?

(Please mark the correct option for each season (*1 mark per season please*))

	Much less	Less	Same	More	Much more
Spring					
Summer					
Autumn					
Winter					

What are the expected changes in annual water demand compared to the present situation?

(Please mark the correct option for each season (1 *mark per season please*))

	Far less	Less	Same	More	Far more
Spring					
Summer					
Autumn					
Winter					

Any remarks?

What are the expected changes in available water quantity?

If applicable, please add the first character of the sector for which it will be problematic. Type 'no problem' if no problems are expected. You can add as many characters as you like for each season. If you would like to add a sector that is absent in the list given, please write the full name.

A = Agriculture	I = Industry	T = Tourism	F = Flood protection
N = Nature (ecosystems and biodiversity)	E = Energy production	H = Household consumption	No problem = no problems expected

(Please mark the right option, and add a letter if applicable)

	Great shortage	Small shortage	No shortage	Small surplus	Great surplus
Spring					
Summer					
Autumn					
Winter					

Do you have any ideas about the impact of climate change on the water quality in your region?

Will climate change induced changes on water resources impact the following sectors?

(please mark the correct option(s))

	Water Quality	Water Quantity	Why? (optional)
Agriculture			
Industry			
Tourism and recreation			
Ecosystems and biodiversity			
Energy			
Coastal defence			
Health			
Transport			
Water management			
Other:			
…			

Appendix III. Participating regions

Region	Country	Size of land area (km^2)	Population (x 1000)
Andalusia	Spain	84563	7995
Aosta Valley	Italy	3200	119
Arkhangelsk	Russia	587400	1265
Azores	Portugal	2352	243
Catalonia	Spain	31895	7246
Emilia Romagna	Italy	22117	4275
Liberec Region	Czech Republic	3163	428
Lower Silesia	Poland	19569	2879
Madrid	Spain	8030	6082
Maramures	Romania	6304	513
Marche	Italy	9694	1542
Overijssel	Netherlands	3326	1116
Piedmont	Italy	25256	4350
South Holland	Netherlands	3403	3469
Teleorman	Romania	5634	422
Trento	Italy	6107	513
Tuscany	Italy	22760	3500
Upper Austria	Austria	11718	1408