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Climate change and water adaptation issues

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Contents

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Executive summary

The impact of climate change on Europe's water resources is a critical issue for people's lives and the economy. Even if emissions of greenhouse gases were stabilised today, increases in temperature and the associated impacts, including water availability and flooding, will continue for many decades to come. This report aims to evaluate the implications of the need to adapt to climate change for water resource policy and regulation across Europe, assess the strengths and weaknesses of current policies and regulations, and describe progress and activities in European countries.

Too much water and too little: In recent decades more intense rainfall events have occurred and parts of Europe have experienced extreme weather events in the form of severe floods, droughts and heat waves. Analyses from climate change models project an exacerbation in the frequency and intensity of these events. Changes in precipitation, combined with rising temperatures and reduced snow cover, will have impacts on water quality and quantity, requiring water managers to incorporate climate change in their planning and investment decisions. While uncertainties remain about the level and extent of changes in precipitation in specific locations, enough is known for action.

Sectoral and regional aspects: Water is a critical core sector so that impacts here have a cascading effect. Economic sectors which are projected to be most affected are agriculture (increased demand for irrigation), energy (reduced hydropower potential and cooling water availability), health (worsened water quality), recreation (water-linked tourism), fisheries and navigation. Serious impacts on biodiversity loom. The dominant impacts are flooding in central Europe, hydropower, health and ecosystem concerns in the northern countries, and water scarcity in the southern countries.

Embedding adaptation: Climate change is an important driver but there are other factors that affect European water management. Climate change concerns need to be integrated with other issues. For example increased water demand for agriculture, and tourism, and land-use development in flood-prone areas, can increase vulnerability to climate change. Strategies for adaptation need to be embedded within existing national policy and institutional frameworks.

Overall adaptation seems to be facilitated if it coincides with other objectives, and if win-win solutions can be implemented that also have other benefits. A range of strategies and actions are possible, including 'no regrets' measures, so there are often difficult policy choices to be made, for example, between additional capital investments or campaigns to promote behavioural change. The aim should thus be to achieve cost-effective and flexible frameworks which can be modified as scientific understanding improves.

Sustainability aspects: From the sustainable development perspective, the top priority for adaptation in the water sector should be to reduce the vulnerabilities of people and societies to shifts in hydro-meteorological trends, increased climate variability, and extreme events. A second priority should be to protect and restore ecosystems that provide critical land and water resources and services. A third should be to close the gap between water supply and demand by enhancing actions which reduce demand. A wide range of strategies are available to address these priorities, including sharing the losses, preventing the effects, research and education. Climate change impacts can also be limited by structural and technological change, and/or regulatory and institutional change.

Time and multi-stakeholder dynamics: Implementation of any of these strategies takes considerable time, particularly if substantial step changes are needed. Successful adaptation will also require interactions between multiple levels of government: European, national, sub-national, and local, as adaptation at one level can strengthen, or weaken, adaptive capacity and action at other levels. A range of civil society and business sector organisations should also be involved. These governance and engagement issues enhance the need for action now.

National practices: The responses to the questionnaires on which much of this report is based show that awareness of climate change impacts is generally high, that European countries expect significant changes in water resources and hydrology as a consequence of climate change, and that policy-makers are generally well-informed about the results of up-to-date scientific research. In many countries adaptation research is taking

place and adaptation policies are being planned and developed, but much remains to be done. So far only a few countries have overall national policy frameworks in place on climate change adaptation. In the water sector, initiatives include long-term planning and policy-oriented research, institutional development, technical investments, spatial planning and regulatory measures, flood defence and management in response to observed trends, coastal defence, and management of water scarcity. Many adaptation activities currently seem to be focused on flood management and defence, while measures related to the management of water scarcity and drought, although recognised in the vulnerability assessment as also damaging, do not yet seem to be widespread. Uncertainties with respect to future climate change impacts are a major obstacle to the development of adaptation actions.

Many countries highlight the subsidiarity principle and the need for Member States to react flexibly to the specific challenges in their countries. However, many see a role for the EU in the coordination of trans-boundary issues, sectoral policies — including funding, supporting monitoring and information exchange, research funding, awareness-raising and education.

European policies: There are several tools and emerging frameworks at the European level which can provide the necessary coherent European leadership and vehicles for coordination, guidance and awareness-raising. The Green Paper on Climate Change Adaptation, to be published in 2007, is expected to create an EU-wide legal framework, such as support for adaptation within the EU's direct funding programmes, in particular the Structural, Cohesion and Solidarity funds, the Agriculture and Rural Development funds, and the LIFE+ instrument. These funds are already being be accessed for activities relevant to climate change adaptation which will create new challenges on resource allocation. The funds should increasingly be used to support EU climate change policy objectives. There are also existing and new directives and initiatives which can be mobilised.

While the main text of the Water Framework Directive (WFD) does not explicitly address climate change, it is well-suited to handle the long-term implications of climate change with its step-wise and cyclical approach. Its effectiveness to deliver climate change adaptation will depend on the extent to which the long-term perspective is included in river basin management plans. Implementing the directive requires assessment of the impacts of climate change on the reference conditions of water bodies and on the cost-effectiveness of water management strategies. Adaptation could be explicitly incorporated into the implementation of the WFD in various ways, for example through a climate change impact assessment for each river basin district and inclusion of associated catchment-wide actions in the programmes of measures. Inclusion of climate change impacts and adaptation indicators in WFD monitoring activities could also be considered.

There are other relevant EU policy instruments. The proposed directive on the Assessment and Management of Floods complements the WFD by specifically addressing flood risks which are affected by climate change. Similarly, the proposed Marine Strategy Directive also provides an overall framework for developing marine strategies that could take into account and enable adaptation to the impacts of climate change. The Maritime Policy Green Paper recognises climate change as a major threat, and discusses adaptation to changing coastal risks in Europe. The common fisheries policy has a key role in managing fish populations and, to the extent that climate change affects fish stocks, it could take climate change into account. There is also an EU initiative on drought and water scarcity underway with a communication due in 2007.

Mitigation of greenhouse gas emissions and adaptation: Providing additional supplies of water to alleviate droughts can often involve more investment in energy, for example desalination plants and pumped water transfer schemes. Improvements in water quality, which may be needed to combat existing pollution, also often require increased use of energy. Land management schemes for river basin protection, for example the use of land for water storage to alleviate flooding, may have implications for emissions of greenhouse gases. This report does not cover greenhouse gas mitigation but it is evident that efforts should be made to link the two areas of climate change policy which currently operate in separately at all governance levels.

Research and policy support: There is general agreement within countries about the need for enhanced regional and local climate change scenarios. The greatest demand is for climate information for the next 20–50 years, and even the next 5–10 years. Uncertainties need to be reduced and more knowledge is needed to distinguish the consequences of climate change and of natural climate variability. Countries want regional and local data to be merged with hydrological

models, and for improvements in the accuracy of hydrological and hydraulic models, including groundwater. There is also a need to improve the coupling of climate and hydrological models.

Countries see the need to maintain observation networks to identify climate change trends, and suggested including remote-sensing techniques in hydrological monitoring.

Basic gaps still exist: The need for research on the vulnerability of society and ecosystems to climate change impacts is felt by many of countries, particularly for the water sector. Better databases on frequency, intensity and effects of extreme events and on national adaptation practises, including responses to these extremes, would facilitate the development of effective adaptation strategies.

Sources: One of the purposes of this report is to support the symposium organised under Germany's EU presidency *Time to Adapt — Climate Change and European Water Dimension* in 2007. This report draws on a specific survey of country actions and perspectives. A larger annexed, compilation of information by country (see Annex 1), could be developed further in the future.

1 Introduction

1.1 Background and objectives

1.1.1 Background

The latest Assessment Report of the Intergovernmental Panel on Climate Change (IPCC, 2007a) projects that global average temperatures in 2100 will be between 1.8–4.0 °C higher than the 1980–2000 average (best estimate, likely range 1.1–6.4 °C). Sea levels are projected to rise 0.18–0.59 m by 2100 (based on observed rates of ice flow from Greenland and Antarctica). More frequent and intense extreme weather events (including drought and flooding) are also expected.

The need to mitigate climate change and prevent dangerous impacts has resulted in a strong policy focus on the reduction of greenhouse gas (GHG) emissions. The European Council and the European Parliament have both confirmed the EU's objective to limit global temperature increase to a maximum of 2 °C above pre-industrial levels, to limit climate change to a manageable level and to reduce the likelihood of massive and irreversible disruptions to the global ecosystem. Achieving this target will require global GHG emissions to peak before 2025 and then fall by up to 50 % by 2050 compared with 1990 levels. Realistic and effective measures have been identified for the EU and globally that will allow the 2 °C target to be met (EC, 2007a).

However, there is a growing awareness that, even if GHG emissions were stabilised today, increases in temperature and associated impacts will continue for many decades to come. Even if the EU targets are achieved, the already incurred and embedded warming will lead to various climate change impacts to which Europe will need to adapt. Significant impacts have been identified with temperature increases below 2 °C (Warren *et al.*, 2006). There has been recognition of the need to tackle adaptation at the EU level, resulting in the Commission's work on a Green Paper on Climate Change and Adaptation (due in 2007). Increased emphasis has also been placed on adaptation under the UN Framework Convention on Climate Change (UNFCCC), for example through a five-year work programme on 'impacts, vulnerability and adaptation to climate change' agreed at the UN climate change conference in Nairobi, November 2006.

1.1.2 Climate change and water resources

Of the many social, economic and environmental impacts and vulnerabilities to climate change, the projected effects on the qualitative and quantitative status of European water resources is a critical area for people's lives and the economy. Water resource issues interact with a wide range of socio-economic and environmental sectors including health, agriculture, biodiversity, public safety, industry and navigation. Indeed, there are few activities that do not in some way depend on or interact with water resources.

The main climate change consequences related to water resources are increases in temperature, shifts in precipitation patterns and snow cover, an increase in the frequency of flooding and droughts, and the possible large impact of future sea-level rises (e.g. IPCC, 2007b; EEA, 2004; EEA, 2005a; JRC, 2005). There is also a growing body of knowledge on the nature and scale of future impacts. This has led to an increasing urgency to adapt water resource management to meet the future challenges.

Apart from the forthcoming Green Paper on Adaptation, there are substantial developments in the overarching EU policy regulatory frameworks, for example with the ongoing implementation of the Water Framework Directive (Directive 2000/60/EC), and proposals for new regulation on floods ([1]).

This report has been prepared in support of the symposium organised with Germany's presidency of the EU *Time to Adapt — Climate Change and the European Water Dimension* in 2007. Other reports will be prepared for the Symposium by Ecologic in cooperation with the Potsdam Institute for Climate Impact Research (PIK), and by the Commission's Directorate General for Research and the Joint Research Centre, (EC, 2007b). The Intergovernmental Panel on Climate Change (IPCC) 4th Assessment, to be published in 2007, will cover observed and projected climate changes, and include specific chapters on water and Europe. This

([1]) A proposal for a directive of the European Parliament and of the Council on the assessment and management of floods (COM(2006)15 final of 18.01.2006.

report has a focus on two issues: the identification of critical climate change issues within the Water Framework Directive, and a review of policies on water issues in Member States related to adaptation to climate change ([2]).

The underlying objectives of the report are:

- to evaluate the implications for water resource policy and regulation across Europe of the need to adapt to climate change;
- to assess the strengths and weaknesses of current policies and regulations;
- to describe progress and activities in European countries.

The report also seeks to identify areas where there are information gaps and uncertainties and where future challenges and priorities may lie.

1.1.3 Structure of the report

The remainder of this section provides a brief overview of the scientific knowledge on the impacts of climate change on water resources in Europe, providing background on the need for adaptation. The volume of literature and evidence in this area is huge, growing and cannot all be covered here. It also introduces the challenges that these changes present and the types of adaptation strategies that can be adopted.

Chapter 2 considers the regulatory and policy framework at the EU level. Drawing on a review of the regulatory instruments, principally the guidance and documentation for the Water Framework Directive (WFD), the section discusses how the interaction of climate change with the regulatory framework can be handled.

Chapter 3 draws on a review of information from European countries about the diversity of activities and challenges across Europe. More details are covered in Annex 1. Finally, in Chapter 4 the key issues are discussed and conclusions drawn.

The information sources for the report were: questionnaires sent to EEA member countries by the EEA and the German Federal Ministry for the Environment (BMU); national communications under UNFCCC; documents prepared under the Water Framework Directive; a survey undertaken as part of the European action on water scarcity and drought (ENV 372, 21 June 2006); and the scientific literature.

1.2 Climate change and impacts on water

1.2.1 Observed and projected effects

A number of studies have reported significant changes in climate and associated effects all over the world. Examples of observed and projected changes in Europe are provided in Table 1.1.

Climate change can affect the quantitative and qualitative status of water resources by altering hydrological cycles and systems which, in turn, affect variables including:

- intensity and frequency of floods and droughts;
- water availability and demand;
- water quality, including temperature and nutrient content.

Changes in these variables lead to impacts on all the socio-economic and environmental goods and services that depend on these variables directly or indirectly.

There is a wide range of issues and vulnerabilities across Europe. These reflect the diverse hydrological situation, such as long and dry summers in the south, less variation in the west, and high river-flow periods in the north due to snow melt. In addition there are considerable differences in climate change projections across Europe. Furthermore, the impacts vary in time and space: some impacts are on daily/local scale (e.g. lower oxygen content), others are at longer/larger scales (e.g. changes in algal blooms over weeks or months, changes in species composition over many years, groundwater level variations and alterations to groundwater flow directions).

1.2.2 Climate change and river flow

The variations in the hydrological cycles of many rivers in Europe are determined mainly by the seasonality of the precipitation and the temperature,

([2]) For the purposes of this report, the term adaptation refers to any policies, practices and projects (or aspects of these) that can either moderate damage and/or realise opportunities associated with climate change (see also EEA, 2005a). In this respect the definitions differ slightly from those used in the IPCC context and in the field of hazard prevention.

which governs the ratio between snow and rainfall. Studies have observed changes in annual river run-off in many European catchments over the past few decades. Annual river run-off has changed over recent decades across Europe (EEA, 2004). In some regions, including eastern Europe, it has increased, while in others, including southern Europe, it has fallen. Projections show an enhancement of these changes for annual run-off (Arnell, 1999; Schröter *et al.*, 2006). Most climate change models show that northern and eastern Europe may experience an increase in annual average run-off and water availability (Figure 1.1). The average run-off in southern European rivers, in contrast, is projected to decrease due to increasing temperature and decreasing precipitation. In particular, some river basins in the Mediterranean, which already face water stress, may see marked decreases of water availability. Figure 1.1 also illustrates that the different climate change models predicts different changes in run-off.

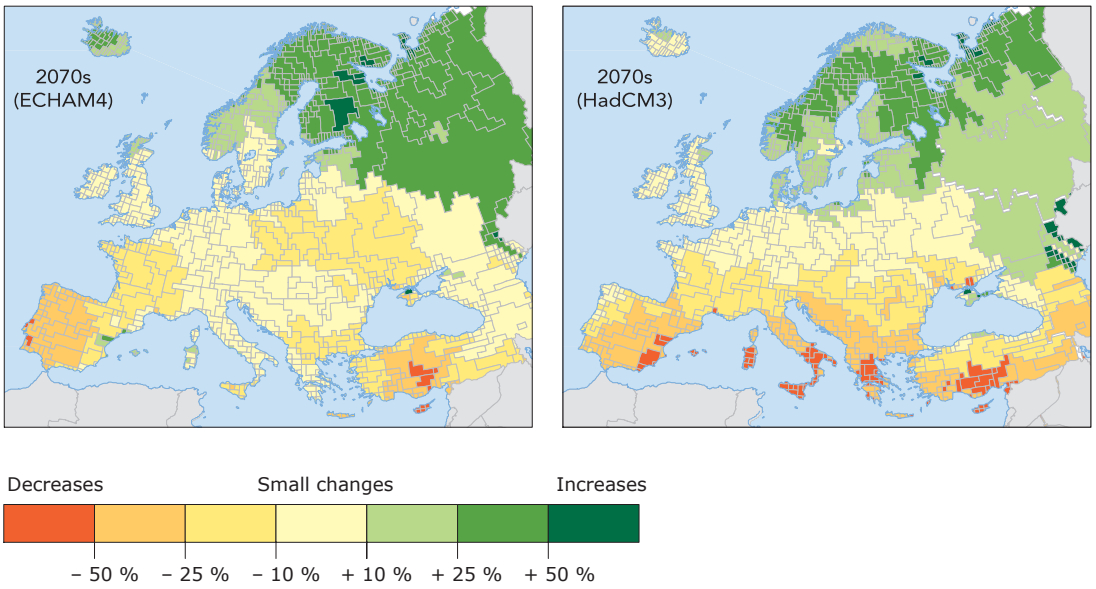
In addition to the annual changes discussed above, seasonal changes in river flows are also projected to result from climate change. For example, higher temperatures push the snow limit in northern Europe and in mountainous regions upwards and reduce the fraction of total precipitation falling as snow (Barnett *et al.*, 2005). This results in a marked drop in winter retention and higher winter run-off

Table 1.1 Observed and projected changes in climatic conditions

Climate variable	Observed change	Projected change (without mitigation)	References
Temperature	Global: increase 0.76 °C in last 100 years 1990s warmest decade for 150 years; 1998 and 2005 warmer than any individual year since 1850 Europe: increase 1.1 °C, winters increase more than summer, largest increase over Iberian Peninsula, south-east Europe and Baltic States	Global: best estimated increase 1.8–4.0 °C during this century (range 1.1–6.4 °C) Europe: mean increase 2.1–4.4 °C by 2080 (range 2.0–6.2 °C) with larger increases in eastern and southern Europe.	IPCCa,b, 2007; EEA, 2006; Schröter, 2005.
Precipitation	Global: trends highly variable in space and time have been observed during the last century Northern Europe: 10–40 % more precipitation South and east Europe: 20 % less precipitation	Northern Europe: annual precipitation increase 1–2 % per decade. Decrease in summer precipitation Southern Europe: Overall decrease in annual precipitation. 5 % decrease in summers.	IPCCa,b, 2007; JRC, 2005; Klein Tank *et al.*, 2002.
Extremes	Temperature extremes are more intense and more frequent than some decades ago Globally, more intense and longer dry periods Significantly more wet days in mid and northern Europe, fewer wet days in southern Europe More heavy rain events in most parts of Europe, strongly linked to the North Atlantic Oscillation Increasing trend in consecutive dry days	Heat waves are expected to increase in frequency and severity in a warmer world More frequent extreme precipitation events in entire Europe. Northern Europe: more frequent summer droughts, despite more intense precipitation events during these periods. Southern Europe: more droughts in all seasons.	Klein Tank, 2004; Meehl and Tebaldi; 2004, Moberg and Jones, 2005; Stott *et al.*, 2004. Alexander *et al.*, 2006; Frei *et al.*, 2006; Haylock and Goodess, 2004.
Sea level	Sea levels rose by 0.17 m during 20th century 1.8 mm year^{-1} 1961–2003 3.3 mm year^{-1} 1993–2003	0.2–0.6 m by 2100. Increased Greenland-Antartic melt may add 0.1–0.2 m to this Larger values can not be excluded (due to factors not yet sufficiently understood)	IPCCa,b, 2007.

rates of northern European (Andréasson *et al.*, 2004; Graham, 2004) and Alpine rivers such as the Rhine, Rhône and Danube (Middelkoop *et al.*, 2001; Redaud *et al.*, 2002; GLOWA-Danube). This increase in winter run-off will be aggravated by the increasing winter precipitation Moreover, earlier spring melts will lead to a shift in peak flow levels. As a result of the declining snow reservoir, the earlier snow melt and the general decrease in summer precipitation, longer periods with low river-flow rates may be observed in summer in many parts of Europe.

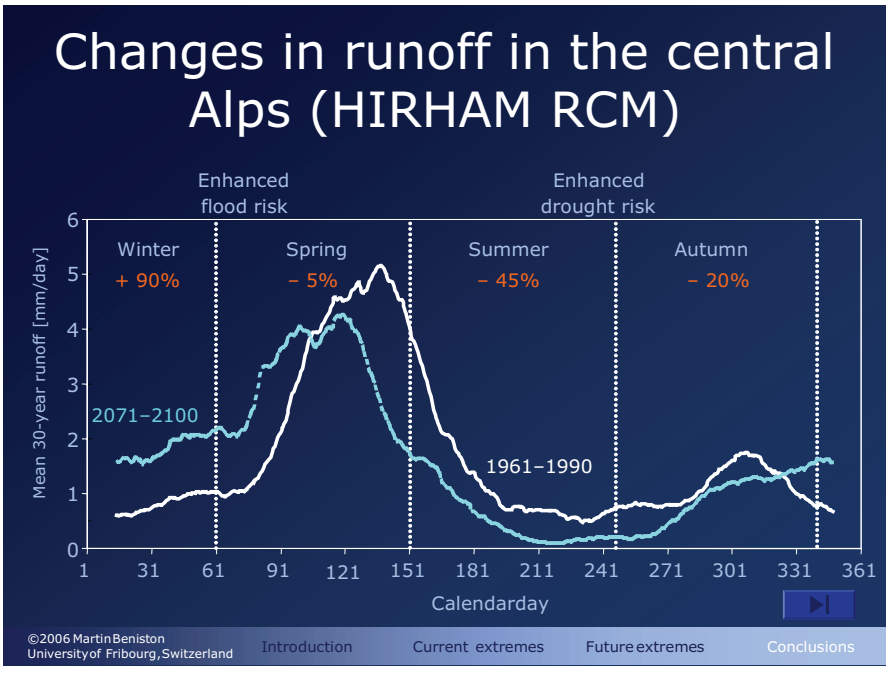
Figure 1.1 Change in average annual river run-off in Europe 2070 versus 2000



Note: Note that larger changes in seasonal averages are expected in some regions.

Source: Lehner *et al.*, 2001; EEA, 2004.

Figure 1.2 Change in seasonal run-off in the central Alps in 2071–2100 compared with 1961–1990



Source: Beniston, 2006.

Changes in the seasonal flow regime may change the periods with enhanced flood risk and periods with enhanced drought risk. Beniston 2006, for example predicts a 90 % increase in winter run-off and a 45 % decrease in summer run-off in the central Alps, which may result in periods of enhanced flood risks and droughts risks, respectively (Figure 1.2).

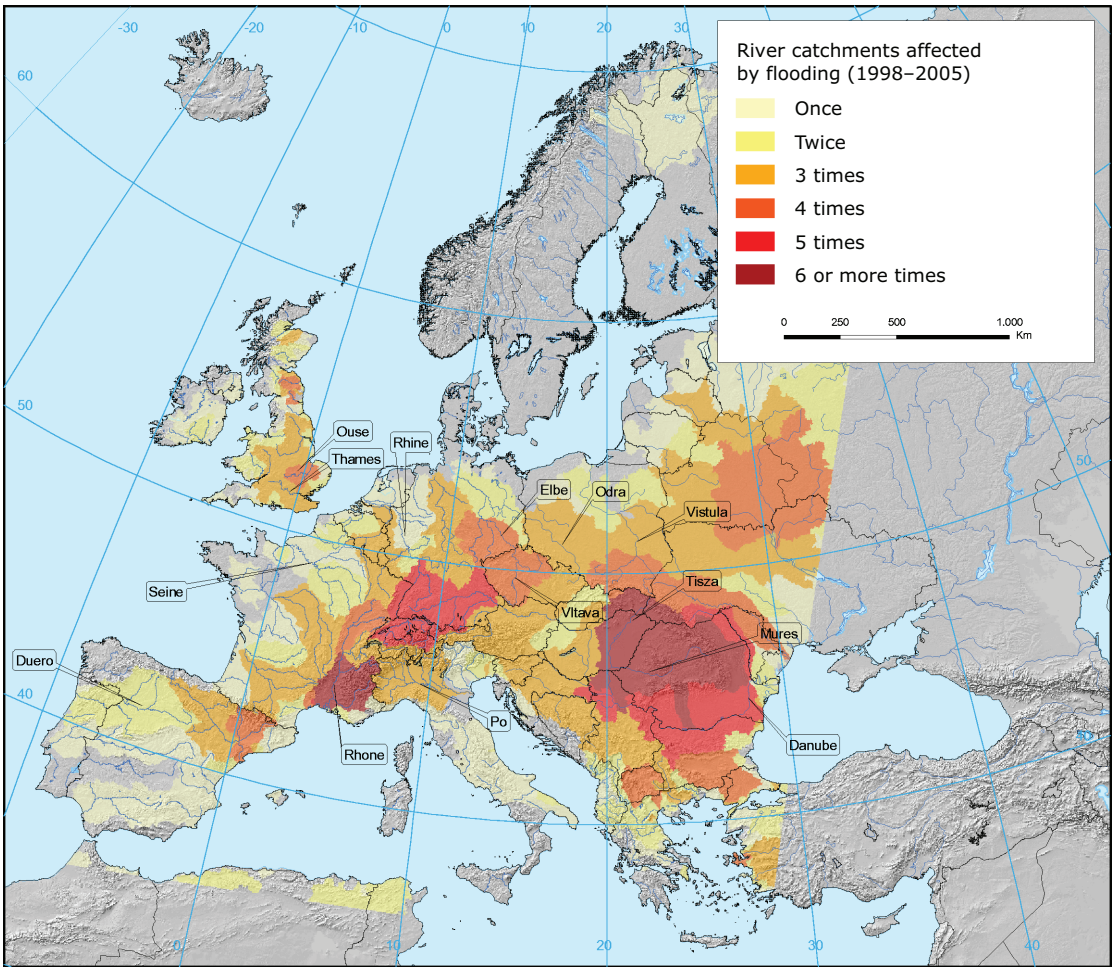
1.2.3 Flooding and flood frequency

In the last five years Europe has suffered over 100 major damaging floods (Dartmouth Flood Observatory). Figure 1.3 provides data on the recurrence of flood events in Europe between 1998 and 2005. A study (Huntington, 2006) suggests that on a regional scale there have been increases in both floods and droughts during the second half of the 20th century. Consequences include significant damage to people, property, infrastructure, agriculture and nature.

These major floods cannot be attributed to global climate change alone. In fact, analyses of long-term frequency patterns of historical floods across Europe since the 14th century show considerable variation over decades to centuries (Brázdil, 2006). Changes in river management (e.g. deepening and straightening of rivers) and the increased urbanisation of former floodplains also affect flood generation. Deforestation of upstream mountainous areas can further enhance local rainfall run-off. Nevertheless, notable recent events, such as the widespread winter flooding of the United Kingdom in 2000/2001 (Marsh, 2001) and the disastrous summer central European flooding in 2002 (Ulbrich *et al.*, 2003) are considered examples of what is expected under climate change (Milly *et al.*, 2002).

An increasing risk of flooding in Europe is expected under climate change. Climate models generally predicts increases in the frequency and intensity

Figure 1.3 Recurrence of flood events in Europe between 1998 and 2005



Source: EEA, based on data from Dartmouth Flood Observatory.

of extreme rainfall events (Christensen and Christensen, 2003). It is likely that even in summer there will be an increase in the occurrence of flooding due to heavy rainfall events (JRC, 2005).

Many coastal areas in Europe may be threatened by climate change. One third of the EU population lives within 50 km of the coast. Sea-level rise and potential increases in the frequency and/or intensity of extreme weather events, such as storms and associated surges, are additional pressures. Impacts of climate change and sea-level rise include inundation and displacement of wetlands, coastal erosion, increased salinity, and impeded drainage. Between 1896 and 1996, sea level along the European coasts increased by between 80 and 300 mm (Liebisch *et al.*, 2002). This increase was probably the result of thermal expansion of the sea water (due to higher temperatures) and additional fresh water due to the melting of glaciers and the Antarctic and Greenland ice sheets (Church, 2001; Thomas, 2004; Raper and Braithewaite, 2006).

The sea level is projected to rise by 0.2 to 0.6 m during the 21st century (IPCC, 2007a). Relatively large sea-level rises are projected for the Arctic region (up to 0.5 m by 2100 (ACIA, 2004)). None of these projections incorporate the possible contribution of tidal surges (Woth, 2005) or accelerated melting of the West Antarctic Ice Sheet (WAIS) and the Greenland ice sheet. These ice sheets contain enough water for a potential sea level rise up to 13 m (the Greenland ice sheet alone is about 7 m), possibly released within 1 000 years. Recent observations indicate a fast melt of especially the Greenland ice sheet (CIRES, 2005). However, there remains high uncertainty on the probability of such a (full) melting of the Greenland ice sheet (Ridley *et al.*, 2005).

1.2.4 Climate change and the marine environment

Climate change will have profound impacts on the status, sustainability, productivity, and biodiversity of the coastal zone and marine ecosystems of Europe. The capacity of the oceans to act as a sink for CO_2 in the atmosphere and help mitigate climate change may be impaired by increased sea temperatures caused by climate change itself in a 'positive' feedback loop. Further, experimental evidence suggests that increased CO_2 concentrations in the sea can turn it more acid, which could cause difficulties for marine organisms that build carbonate shells and external skeletons.

Global climate change will affect the physical, biological, and bio-geochemical characteristics of the oceans and coasts, modifying their ecological structure, their functions, and the goods and services they provide. Large-scale impacts of global warming on the oceans will include:

- increases in sea-surface temperature and sea level;
- decreases in sea-ice cover;
- changes in salinity, alkalinity, wave climate, and possibly ocean circulation;
- (possibly) changes in ocean mixing, deep water production, and coastal upwelling;
- increased freshwater and land-based pollutant run-off;
- ecosystem modifications with distinct shifts northward of warm-water species associated — to a decrease in the mean number of cold water species;
- phenological changes leading to a mismatch between trophic levels and functional groups.

Since these issues were highlighted in the Dangerous Climate Change Conference (Exeter January, 2005, Turley *et al.*, 2006), it has commanded more attention recently in other assessment reports, for example by the German Advisory Council on Climate Change, (WBGU, 2006), the European Science Foundation (ESF, 2006) and the JRC (JRC, 2006).

The marine and coastal environment is considerably affected by other non-climatic pressures (e.g. eutrophication, over-fishing, pollution, urbanisation, agriculture practices, dredging, damming), which increase its vulnerability to climate change.

1.2.5 Droughts and water scarcity

Over the past thirty years, Europe has been affected by several major drought episodes, most notably in 1976, 1989–1991, 2003 and 2005 (UNEP, 2004; EurAqua 2004; EC, 2006). Opinion is, however, divided (Hisdal *et al.*, 2001) as to whether these events represent a significant trend or simply reflect natural climate variability (see Section 1.2.7). Although there is also a direct human component causing these droughts, the primary cause is a deficiency in rainfall, and the shift in timing of flows (Schröter *et al.*, 2005). Climate-change models project more frequent and intense summer droughts across many parts of Europe, particularly in the southern part (Goodess *et al.*, 2007). This may be further

exacerbated because of an increasing demand for water as a result of elevated temperatures. Figure 1.4 shows 'water stress' — the predicted ratio of water withdrawals to availability by 2030.

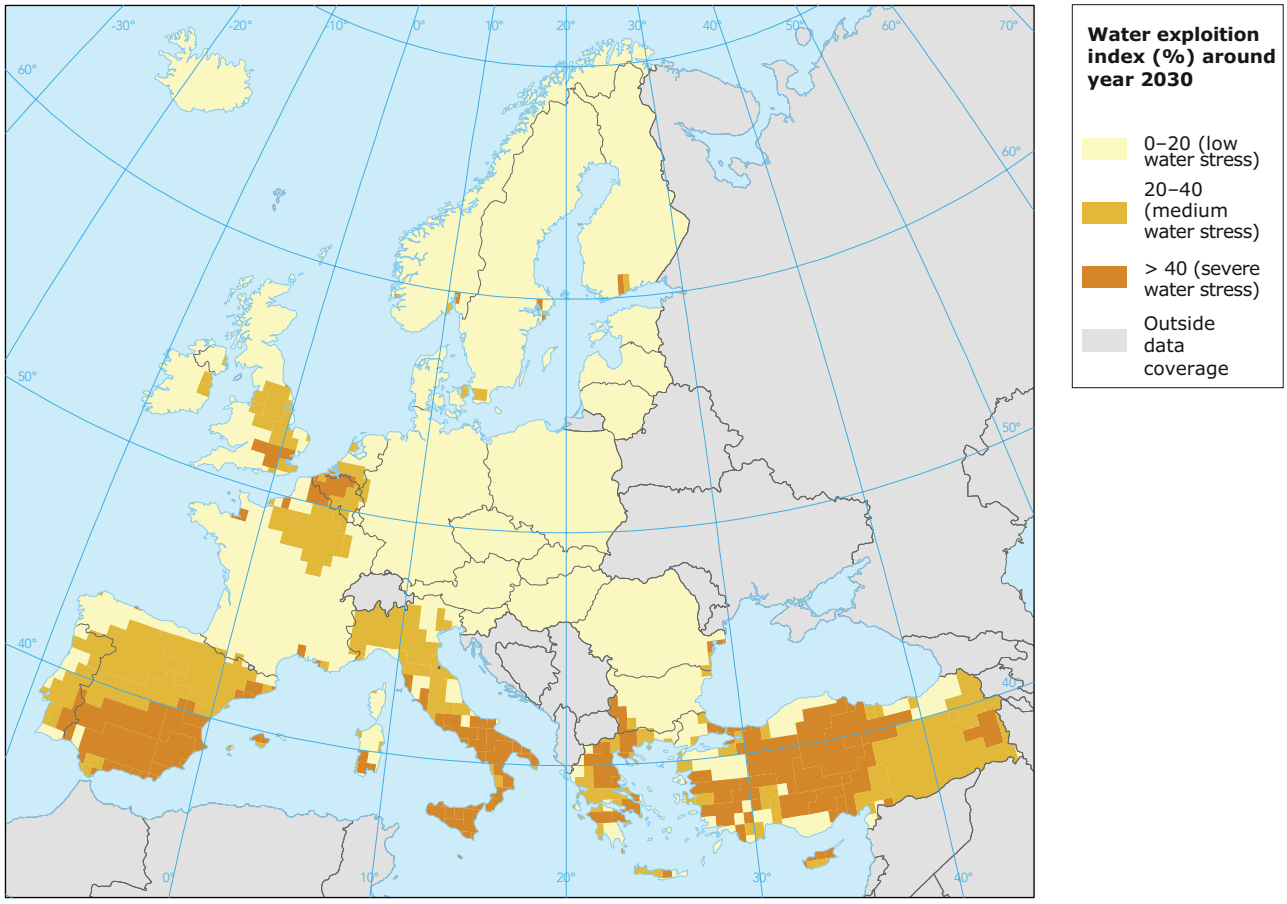
Groundwater is an important element of the hydrological cycle. It is a crucial source of water for nature — especially wetlands and coastal ecosystems, and for water supply, especially for drinking water. The recharge of groundwater depends on a number of variables, most significantly precipitation, especially in the winter season. Observations indicate a lower recharge of groundwater, partly because of climate variations (Eckhardt and Ulbrich, 2003) as well as higher abstractions.

Further decreases in groundwater levels are projected because the lower recharge is (partly) caused by a shorter length of the recharge season and the drop in water retention as snow. While an increase in winter rainfall could in principle increase groundwater recharge, saturated soil conditions could mean more immediate surface run-off of water instead of infiltration into the ground. UKWIR (2003), for example, indicates a 5–15 % lower recharge of the groundwater layers throughout the United Kingdom mainly due to a shorter recharge period in winter.

In the coastal areas, especially in southern Europe, where the pressure on water demand is already very high due to agriculture and tourism, the reduced availability of surface water during dry periods and the reduced groundwater recharge will increase the pressure on groundwater considerably. Many of the groundwater bodies are already heavily abstracted and over-exploited, and some will not be suitable as drinking water because of saline intrusion due to rising sea levels.

Even groundwater bodies that are currently managed in a sustainable manner might need a considerable reduction in water abstraction if their recharge is reduced as a result of climate change.

Figure 1.4 Water stress in European river basins under a base-line scenario by 2030



Note: The water exploitation index is the percentage of available water resource abstracted each year.

Source: EEA, 2005b.

1.2.6 Impacts on water quality

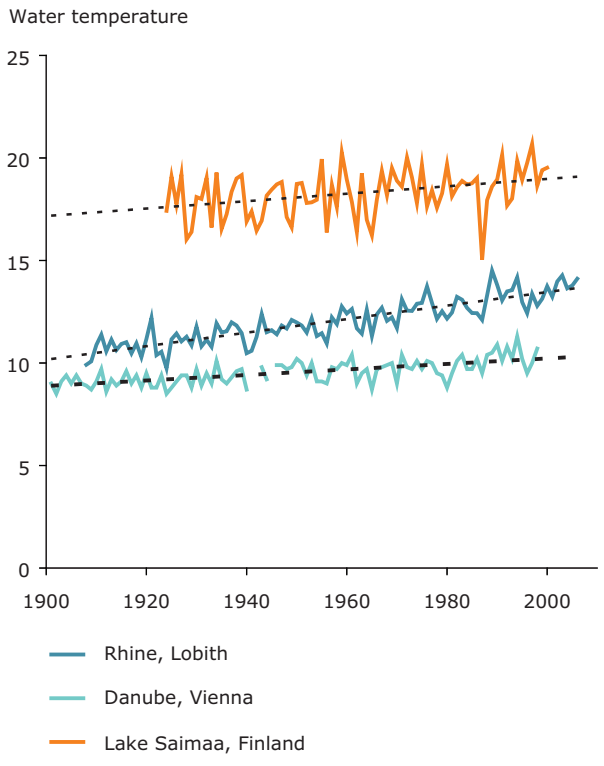
Climate change could also result in significant changes in the variables that affect the quality of water. These impacts come from a variety of alterations to the hydrology of water bodies, their physico-chemical and biological attributes, and changes in anthropogenic pressures. Climate change impacts are not limited to changes in precipitation but also include other factors.

Higher air temperatures lead to higher water temperatures. During last century the water temperature of European rivers and lakes increased by 1–3 °C (Figure 1.5).

The temperature changes that are projected to result from climate change could result in:

- reduced oxygen content. Increases in water temperature in streams and rivers reduce oxygen content and increase biological respiration rates and thus may result in lower dissolved oxygen concentrations, particularly in summer low-flow periods;
- alterations to habitats and distribution of aquatic organisms. For example, a number of aquatic organisms conform to temperature preferences which determine their spatial distribution. Higher water temperatures lead to changes in distribution (more northwards in Europe) and may even lead to extinction of some aquatic species;
- bacteriological conditions and incidence of pathogens including botulism but improved performance of water treatment works;
- alterations to thermal stratification and mixing of water in lakes (Dokulil *et al.*, 2006);
- less ice formation. For example, studies have shown that ice break-up in rivers is occurring 15–20 days earlier than in the 1950s, and a shift towards a longer annual ice-free period and earlier ice break-up has been observed in many Nordic lakes in recent decades (Korhonen 2005; Magnusson *et al.*, 2000). The timing of lake ice break-up is of ecological importance because the disappearance of ice cover affects the production and biodiversity of phytoplankton and the occurrence of winter fish kills (Weyhenmeyer, 2006);
- changed nutrient cycling in aquatic systems and algal blooms. For example, spring phytoplankton blooms in large Swedish lakes have been observed one month earlier in the 1990s than in the 1970s (Weyhenmeyer, 2001);
- as temperatures increase, bacterial populations that control nitrogen mineralisation and nitrification processes in the soils also increase (Whitehead *et al.*, 2002; 2006).

Figure 1.5 Trend in annual water temperature in river Rhine (1909–2006), Danube (1901–1990) and average water temperature in August in Lake Saimaa, Finland (1924–2000)



Source: River Rhine: Rijkswaterstaat; River Danube: Hohensinner, 2006; and Lake Saimaa: Korhonen J., 2002.

1.2.7 Impacts of climate variability

While the temperature signal of climate change is clear, the impacts of climate change on precipitation are likely to be dominated by natural climate variability until the 2030s, particularly on the scale of individual river basins. Despite the immediate wide range of possible future greenhouse gas emissions shown in the IPCC Special Report on Emission Scenarios (SRES), uncertainty in future emissions has very little influence on uncertainty in climate change until the second half of the 21st century. Rather, the climate of the next few decades will be dominated by natural variations

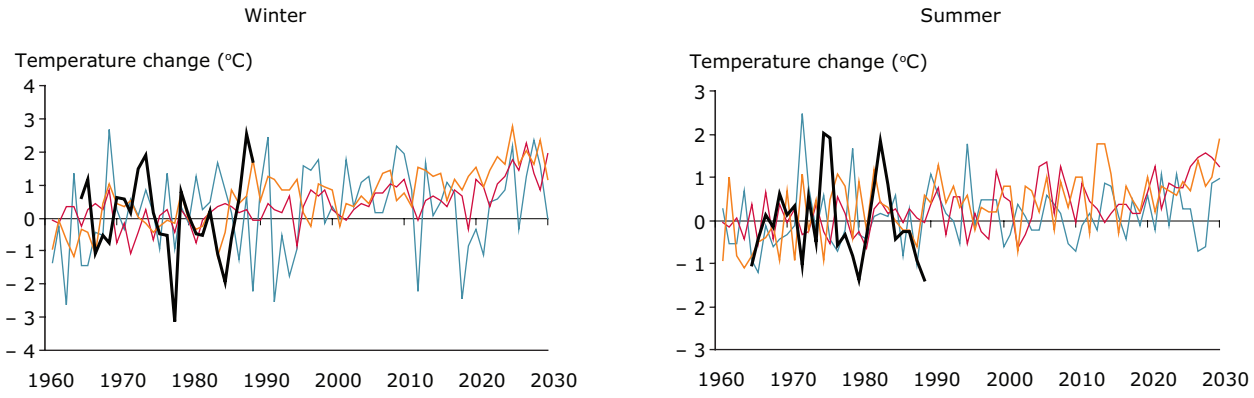
from year-to-year and decade-to-decade arising from the chaotic nature of ocean-atmosphere interactions, changes in the output of the sun, and the amounts of aerosol injected into the stratosphere by explosive volcanic eruptions. Having sufficiently long and representative environmental records is a prerequisite to quantifying the full range of natural variability and associated societal impacts before climate change is added.

These points are illustrated by climate change scenarios (Wilby *et al.*, 2006a) developed for an appraisal of options for reducing nitrate concentrations in a lowland river of southern England (Whitehead *et al.*, 2006). Although the scenarios point to winter temperature increases of 2.5–4.5 °C by the 2080s, the warming by the 2020s is only 0.5–1.6 °C depending on the choice of climate model (see Figure 1.6). For comparison, the standard deviations of observed winter and summer temperatures are 1.2 °C and 0.9 °C respectively. In other words, projected temperature changes by the 2020s lie within the range of natural variability (with 95 % confidence). Climate change signals are even less pronounced for seasonal precipitation, and do not emerge from natural variability until after the 2050s.

The small 'signal' and large 'noise' in hydro-climatic scenarios projected to the 2030s has important implications for policy and responses in the near term such as the Water Framework Directive. First, claims that trends already found in observational records (typically less than 30 years) can be attributed to climate change should be treated with extreme caution. Although some regional studies have reported increases since the 1970s in autumn and winter river flows (Hannaford and Marsh, 2006), pan-European assessments of extreme weather (Moberg and Jones, 2005) and droughts (Hisdal *et al.*, 2001) show no such changes in summer. Trends found in winter rainfall and river flow records could simply be an outcome of the positive phase of the North Atlantic Oscillation that has persisted over the same period. Other research has suggested that trends in river flows are unlikely to be statistically detectable in most basins for many more decades (Wilby, 2006). However, there is greater confidence in the detection and attribution of increased risk of European heat waves (Stott *et al.*, 2004).

Second, the earliest evidence of anthropogenic climate change will be found in records that have relatively low year-to-year variability and/or are located in sites that experience most rapid climate change. Sensitive variables include air and water temperatures, or river flows from groundwater-dominated basins. Some of the most potentially climate-sensitive environments include the coastal zone (due to rising sea levels and ocean temperatures) and uplands (due to reduced snow/ice storage, amplification of extreme rainfall events, and loss of bioclimatic space) (Beniston *et al.*, 1997). There is already evidence that water temperature changes have affected invertebrate assemblages and richness in some UK uplands (Durance and Ormerod, 2006) and that other species such as salmonids may be

Figure 1.6 Winter and summer mean temperature anomalies downscaled for the river Kennet, United Kingdom ([3])



Source: Whitehead *et al.*, 2006.

([3]) Using output from three climate models (HadCM3 — blue line; CGCM2 — red line; CSIRO — orange line) under the A2 SRES emissions scenario. All changes are expressed with respect to the 1961–1990 baseline. The thick black line shows observations.

particularly temperature-sensitive (Davidson and Hazelwood, 2005).

1.2.8 Socio-economic impacts — overview

Changes in the hydrological, biological and chemical characteristics of the European water resource will have consequences for several economic sectors. This has been identified by independent researchers and countries themselves in their responses to the questionnaire underpinning this report ([4]). Their perceptions are outlined in Tables 1.2 and 1.3.

Low water and droughts have severe consequences on most sectors, particularly agriculture, forestry, energy, and drinking water providers. Activities that depend on high water abstraction and use, such as irrigated agriculture, hydropower generation and use of cooling water, will be affected by changed flow regimes and reduced annual water availability. Moreover, wetlands and aquatic ecosystems are threatened which will affect the sectors that depend on the goods and services they provide. Reduced raw water quality will affect drinking water supplies and sectors that depend on high water quality such as water-related recreation activities and may in the worst case affect the health of the population.

Overall economic impacts of drought events in the last 30 years have been estimated to be EUR 85 billion in the EU, with an average of EUR 5.3 billion/year in the 1991–2006 period with an exceptional costs of EUR 7.5 billion in 2003. (EC, 2006).

Although the current understanding of the relationship between climate change and water demand is not perfect, some potential sectoral changes are highlighted here.

Climate change will certainly have an effect on agriculture and in many regions there may be an increase in irrigated area and water abstraction for irrigation. Agro-climatic zones are likely to move northwards as a result of climate change. In the southern areas, current crop areas may be abandoned due to low availability of water. Ayala-Carcedo (2000) estimated an increase of between 5 % and 10 % in water demand for the current crops in the Spanish part of the Douro, Tajo and Guadiana river basins by 2060. Downing *et al.* (2003) modelled increases in irrigation use in England of around 20 % by the 2020s and around 30 % by the 2050s due to climate change. Increases in precipitation projected for some countries are likely to be beneficial for agriculture.

- In the absence of water-saving campaigns, *household demand* is likely to increase, with more water used for garden watering and personal hygiene. Hot summers such as 2003 may provide an indication of future climate impacts on peak water demand. In the Netherlands in 2003 there was a 15 % increase in public water supply in August compared with previous years. Downing *et al*. (2003) concluded that per capita domestic demand in England could rise by an extra 2 to 5 % during the coming 20 to 50 years as a result of climate change.

- *Recreation demand*. The general increase in wealth and the generally hotter and longer summers may also increase the number of golf courses, swimming pools and aqua parks, further increasing water demand. Problems of water supply in tourist resorts are becoming increasingly common and may be further increased by climate change and increasing demand from other sectors. Some countries have indicated that they expect negative impacts, in particular from impaired water quality and sea level rise on tourism. Decreased precipitation is seen as beneficial by some countries and damaging by other, mainly southern, countries. Island countries (Cyprus, Malta, Ireland) foresee a link between sea level rise and disrupted beach tourism.

- *Impact on drinking water provision and recreation.* High water temperature, low water flows and therefore less dilution of pollutants may have severe consequences for the quality of drinking water and recreation activities related to water. Saline intrusion in coastal aquifers, making the water unsuitable for drinking, may be exacerbated by future sea level rise.

- *Electricity generation — hydropower*. Hydropower systems may get some positive benefits but are affected by the volume and timing of river flows. Less storage of water as snow during winter may affect the hydropower potential. Dam safety may be affected under changed climatic conditions with more frequent extreme flows. Studies (Veijalainen and Vehviläinen, 2006; Andréasson *et al.*, 2006 and Lehner *et al.*,

([4]) Questionnaires sent to EEA member countries by the EEA and the German Federal Ministry for the Environment (BMU).

2005) indicate that, following moderate climate and global change scenario assumptions, severe future alterations in discharge regimes can be expected, affecting hydropower potentials with reductions of 25 % or more for southern and south-eastern European countries. The Nordic countries have analysed impacts and suggest that generally there will be an increase in hydropower potential (Bergström *et al.*, 2006).

- *Electricity generation — cooling systems.* Decreased precipitation is expected to have a negative impact on the electricity generation sector where rivers provide the cooling water. Power stations have to be shut down when water temperatures exceed certain thresholds. Electricity production has already had to be reduced in various locations in Europe during very warm summers (e.g. 2003, 2005 and 2006) (BMU, 2007; Lehner *et al.*, 2005).

- Climate change could affect *navigation* by changing water levels in rivers, reservoirs, and lakes, and by increasing the frequency of floods and droughts (EA, 2007). In particular, the probability of low water-levels is projected to increase in summers, forcing inland ships to only use a fraction of their normal loading capacity. Navigation on inland waterways plays an essential role in only some European countries so this will affect relatively few countries, in which the impacts are expected to be almost all negative.

There are also some emerging economic and environmental interactions between the impacts and causes of climate change. Some solutions for increased water scarcity involve additional energy use, such as desalinisation (the United Kingdom and Spain) and pumped water transfers. One UK water company has already changed water treatment methods on the grounds of saving energy (The Times, 18.01.2006).

1.2.9 Socio-economic impacts — country perspectives on key impacts

In the survey undertaken by the EEA and Germany, countries were asked about the key impacts of changes in water resources, see Table 1.2. There is a broad awareness of changes in water systems as a result of climate change and their wider implications for adaptation strategies.

1.2.10 Socio-economic impacts — country perspectives on socio-economic sectors

In the questionnaire, countries were also asked to describe the impacts of climate change-driven changes in water resources on society. The responses provide an overview of the economic and social consequences that European countries expect from physical changes in climate. The main responses are presented in Table 1.3, grouped by the climate impacts from which they result. In summary, while a number of different impacts for society are mentioned by respondents, most countries' focus seems to be on the relatively tangible social and economic impacts of flooding and extreme events, as opposed to longer term, progressive impacts brought about by climate change.

1.3 Adaptation policy issues

1.3.1 Recent developments

The United Nations Framework Convention on Climate Change (UNFCCC), adopted in 1992, includes the issue of adaptation in various of its articles. For example, it places obligations on Member States to develop programmes to facilitate adaptation and to cooperate in preparing for adaptation, and called upon developed parties to provide financial assistance to enable the adaptation of developing countries ([5]). Within the UNFCCC process, increasing attention is given to actions regarding climate change adaptation in developing countries, with new funding mechanisms in place. The Five-Year Work Programme on 'impacts, vulnerability and adaptation to climate change' (Nairobi Declaration, November 2006) ([6]) has started. Within this programme, nine different activities have been identified that focus on information collection and suitable methodologies and practices for assessing impact, vulnerability and adaptation.

One chapter of the Stern Review (Stern Review, 2006) examined adaptation in the developed world. Its main messages are that adaptation will be required to reduce the costs and disruption caused by climate change, particularly from extreme weather events like storms, floods and heat waves. The additional costs of making new infrastructures resilient to climate change in OECD countries could range from USD 15–150 billion each year (0.05–0.5 % of GDP) with higher costs possible with the prospect of higher

([5]) Articles 4(1)(b), 4(1)(e), and 4(4) respectively.
([6]) www.unfccc.int/meetings/cop_12/items/3754.php.

Table 1.2 Country views of key impacts

Issue	Climate change	Expected impacts
	Biodiversity (Habitats)	
Water bodies (general)	Increases in temperature and changes in precipitation	**Romania**: biodiversity loss, altered species composition, eutrophication and contamination, habitat loss, alterations in sediment and salinisation
		Slovenia: endangered water ecosystems and endemic species in Karst, decline of biodiversity
		Malta: loss of habitats and species and alteration of species composition in wetlands, riparian woodlands and watercourses
	Adaptation measures — construction of flood defences, drainage systems, etc.	**Sweden**: society's attempts to adapt water systems to new conditions threatens to disrupt natural hydrological systems (such as natural flood plains, wetlands), which might impact a range of habitats
Estuarine/marine	**Freshwater discharge** — caused by increased precipitation and run-off	**Netherlands**: lost shellfish stocks
		Belgium: decreased water residence time alters nutrient fluxes
Wetlands	**Reduced groundwater** — caused by decreased precipitation	**Netherlands**: loss of dune stacks, pools and small rivers
		Lithuania: loss of biodiversity
	Increased temperatures	**Belgium**: increased biomass productivity and summer drought
		Finland: loss of wetlands through changing conditions
Salt-dependent ecosystems	**Sea level rise**	**United Kingdom**: rare saltmarsh habitats disappear
	Changes in hydrological cycle	**Malta**: adverse impacts on littoral species and communities
		Austria: low-resilience ecosystems in Pannonian areas threatened
Peatlands and montane heaths	**Increased temperatures** (summer drying)	**Ireland**: already vulnerable habitats further squeezed by drier conditions
Streams and lakes	**Increased temperatures**	**Austria**: streams and lakes fed by glacial melt water disappear along with glaciers
	Reduced run-off	**Spain**: rivers become seasonal (and seasonal rivers become irregular) affecting dependent biodiversity
Forests	**Fire damage** — caused by increased temperatures and drought	**Lithuania**: drier forests more susceptible to fire, causing loss of biodiversity and habitat destruction
		Switzerland: forests impacted by extreme events
	Drought — caused by higher temperatures and reduced precipitation	**United Kingdom**: beech woodlands not suited to summer drought conditions
		Malta: woodland, maquis and garigue more susceptible to fire and less productive under drought conditions
		Luxembourg: certain tree species would be subject to water and temperature stress and thus more prone to be affected by diseases
Alien species	**Changing temperatures, seasonal shift**	**United Kingdom**: introduction of new diseases, pests and species that thrive in new climate threaten native species
	Human health	
Water quality	**Increased temperatures, increased run-off, decreased recharge, increased evapo-transpiration** (concentrating pollutants)	**The Netherlands, Austria and Spain**: human health is dependent on clean water
		Luxembourg: higher temperatures in summer more likely to affect public health, especially in urban areas
	Increased precipitation and storm run-off	**Belgium**: higher volumes of water pass through storm overflow without being treated by wastewater works
	Increased flood hazards	**United Kingdom**: overflow of sewage during extreme floods, potential for spread of water-borne disease
		Sweden: flood run-off leaches nutrients from soil and transports pollutants, potentially affecting water quality and therefore human health
	Sea-level rise	**Malta**: change in amenity value due to changes in landscape and potential loss of recreational spaces (e.g. beaches, coastal areas)
Disease	**Northward migration of ticks** — caused by increased (water) temperatures	**Slovakia and Finland**: diseases transmitted by ticks will be introduced into new areas with changing conditions

Source: EEA and German survey — analysed by Benzie *et al.*, 2006.

Table 1.3 Country views of key socio-economic impacts

Climate change impact	Social/economic impact
Extreme events: floods	**Economic loss:** Austria, France, the Netherlands, Spain, Sweden, the United Kingdom, Estonia, Hungary, Malta, Slovenia, Romania
	Infrastructure and property: Austria, Belgium, Finland, Ireland, Lithuania, the Netherlands, Norway, Slovakia, Sweden, the United Kingdom, Estonia, Malta
	Loss of life Belgium, Romania
	Adverse effects on human health: Hungary
Extreme events: drought/heat waves	**Economic loss:** Austria, the United Kingdom, Ireland, Hungary, Slovenia)
	Loss of life: France, Italy
	Impacts on agriculture: France, Switzerland, Norway, the United Kingdom, Ireland, Malta
Dry conditions	**Limited water supply, competition between users:** Belgium, Cyprus, Finland, Ireland, Norway, Spain, Sweden, the United Kingdom, Malta, Slovenia
	Lost hydropower and nuclear output: Spain, Switzerland
	Heightened water conflict, water use restrictions: Slovakia, Spain, Switzerland, Ireland, Luxembourg, Hungary
High flows	**Hydropower benefit:** Finland, Norway, Sweden
	Dam safety risk: Norway
Increased temperatures	**Disease:** Spain
	Lost winter tourism: Switzerland

Source: EEA and German survey — analysed by Benzie *et al.*, 2006.

temperatures in the future (Stern Review, 2006, page 416). The report recognised that adaptation in developed countries is still at an early stage even though market structures are well-developed and the capacity to adapt is relatively high, and suggested that governments had a role in providing a clear policy framework to guide effective adaptation by individuals and firms in the medium and longer term. Four key areas were identified for action:

- high quality climate information will help drive efficient markets and improved regional predictions will be critical, particularly for rainfall and storm patterns;
- land-use planning and performance standards to encourage investment in buildings, and long-lived infrastructure to take account of climate change;
- long-term policies for climate-sensitive public goods such as protection of natural resources, coastal protection and emergency preparedness;
- a financial safety net to help the poorest in society.

1.3.2 Developing policy frameworks

Adaptation to climate change in the water sector needs to be incorporated into overall policy frameworks. A recent OECD analysis of policy frameworks for water has shown that what should be done, when and by whom depends on the rate of climate change, but also on the existing policy frameworks in each country (Levina and Adams, 2005). These policy frameworks generally contain the following elements:

- a system of legal frameworks that stipulate rights and responsibilities (e.g. water rights and abstraction permits);
- institutions: national, regional, local;
- policies that guide national, regional/state, local laws;
- clearly defined role for players (Governments, Ministries, departments, regulators and other authorities);
- physical water infrastructure: dams, levees reservoirs and sewerage systems;

- a set of water management plans with the flexibility to anticipate and respond to climate change;
- a system for sharing current and projected climate information.

Interactions at different scales of governance are recognised as critical. Multi-level governance operates vertically across multiple levels of government (local to national) and horizontally across government departments as well as non-government actors (Corfee-Morlot, 2006). Successful adaptation requires interactions between different levels of government since adaptation at one level can strengthen or weaken adaptive capacity and action at other levels; local institutions can block or support as higher-level organisations shape the operating environment (Pelling, 2006).

1.3.3 Typology of adaptation strategies

The survey undertaken for this report examined current practise in different countries. A useful framework for all types of actions is shown in Table 1.4.

However this typology of all possible types of action does not provide guidance on what should be done to achieve certain types of objectives, for example sustainability. Some of the actions are more resource-intensive than others.

There are also differences between incremental adaptation and adaptation that requires major step-changes. The preparatory work for upgrading the Thames Barrier in the United Kingdom is one example of such a major development: mega-scale infrastructure needs to be planned now to provide protection against a 1 in 2000-year-event until 2100.

1.3.4 Adaptation policy priorities

How should we choose what adaptation actions to pursue? Three priorities can be set in relation to adaptation in the water sector (Bergkamp *et al.*, 2003). There are two main strands:

- reduce vulnerability so as to increase protection of people and ecosystems;
- reduce demand for natural resources such as water.

The first priority for adaptation should be to reduce the vulnerability of people and societies to shifts in hydro-meteorological trends, increased variability and extreme events.

An increase in the occurrence of floods, droughts and other extreme weather events due to climate change poses a considerable threat to national economies and sustainable development. Current and future risks and uncertainties associated with such climate-related problems need to be addressed to safeguard people and societies from increased loss of life, property and assets.

The second priority should be to protect and restore ecosystems that provide critical land and water resources and services.

Degradation of water and land resources threatens the production of goods and services from river-basin ecosystems. Protection and restoration of such ecosystems is urgently needed to maintain and restore natural capacities that help to protect people and assets from the impacts of increased climate variability and extreme events.

The third priority should be to close the gap between water supply and demand.

In many regions, water demand now exceeds or threatens to outstrip sustainable levels of supply. Conventional strategies to increase water supply can no longer meet growing needs, and are unable to cope with the uncertainty arising from increased climate variability and climate change. Sustained efforts are therefore needed to reduce water demand. This could have ancillary benefits of reduced energy consumption for water treatment and distribution.

1.4 Summary

The potential direct impacts of climate change on overall water resources in Europe are well understood, but critical uncertainties remain about the extent of changes in precipitation at specific locations. The temperature signal is much clearer and where extreme temperatures coincide with drought periods, consequences for water quality can be acute, with eutrophication and algal blooms. Natural temperature variability is likely to dominate until the 2030s (and to 2050s for precipitation) so it will be important to quantify the full range of natural variations before climate change is added and responses devised. Specific extreme flood and drought events of course require action, whatever their cause, and there is a need to reduce

Table 1.4 Typology of possible adaptation strategies

Adaptation type	Description/examples of application
Share loss	Insurance-type strategies Use other new financial products that lay-off the risk Diversify
Bear loss	Where losses cannot be avoided: • Certain species of montane fauna and flora (e.g. some arctic alpine flora may disappear) • Loss of coastal areas to sea level rise and/or increased rates of coastal erosion
Prevent the effects: structural and technological (usually dependent on further investment)	Hard engineering solutions and implementation of improved design standards: • Increase reservoir capacity • Increase transfers of water • Implement water efficiency schemes • Scale-up programmes of coastal protection • Upgrade wastewater and storm-water systems • Build resilient housing • Modify transport infrastructures • Install or adopt crop irrigation measures • Make room for rivers • Create wildlife corridors
Prevent the effects: legislative, regulatory and institutional	Find new ways of planning that cut across individual sectors and areas of responsibility (integration) Change traditional land-use planning practices to give greater weight to new factors such as flood risk and maintaining water supply-demand balance and security of supply Adopt new methods of dealing with uncertainty Provide more resources for estuarine and coastal flood defence Revise guidance notes for planners Factor climate change into criteria for site designation for biodiversity protection Amend design standards (e.g. building regulations) and enforce compliance
Avoid or exploit changes in risk: change location or other avoidance strategy	Migration of people away from high-risk areas Grow new agricultural crops Change location of new housing, water-intensive industry, tourism Improve forecasting systems to give advance warning of climate hazards and impacts Contingency and disaster plans
Research	Use research to: • Provide better knowledge of relationships between past and present variations in climate and the performance of environmental, social and economic systems (e.g. fluvial and coastal hydrology, drought tolerance and distribution of flora and fauna, economic impacts on key industrial sectors and regional economies), i.e. reduce uncertainty about the consequences of climate change for receptors and decision-makers • Improve short-term climate forecasting and hazard characterisation • Produce higher-resolution spatial and temporal data on future climate variability from model-based climate scenarios • Provide more information on the frequency and magnitude of extreme events under climate change • Find better regional indicators of climate change • Develop more risk-based integrated climate-change impact assessments
Education, behavioural	Lengthen planning time-frames (need to consider not just the next two to five years, but 2020s, 2050s and beyond) Reduce uneven stakeholder awareness of climate change Increase public awareness of the need to take individual action to deal with climate change (e.g. on health, home protection, flood awareness) and accept change to public policies (e.g. on coastal protection, landscape protection, biodiversity conservation)

Source: Willows and Connell, 2003, modified from Burton 1996.

vulnerabilities to these as a first step to providing resilience to climate change.

Indirectly, climate change will impact on key economic activities such as agriculture, hydropower and other forms of energy production, and tourism. Serious impacts on biodiversity are envisaged.

These challenges will require major changes. For example, agricultural production will have to face increasing shortages of water. Irrigation plans may help to ensure regular, competitive production, but it will also be necessary to increase efficiency in water use and reduce water losses, and be based on careful planning and assessment.

Policy and regulation is needed at all levels with clear frameworks and roles for all players at European, national regional and local levels. Progress even in the most developed countries is still at an early stage. Public policy will need to generate high-quality climate information with improved regional predictions, and to develop regulatory standards to encourage better-targeted investment. Long-term policies for public goods such as natural resources, coastal protection and emergency preparedness are needed.

However, there is a wide range of possible responses to tackle the impacts of climate change on water resources. Different levels of investment are required and there is a range of outcomes for social and economic structures. It is possible to envisage approaches which may be sustainable though this has not yet been tackled at the European level. The Water Framework Directive is a possible building block for such an approach.

2 Climate change and EU water policy

2.1 Background

2.1.1 Introduction

As outlined in Chapter 1, climate change is projected to affect water resources across Europe in many different ways because of the diversity of hydrological regimes, water uses and land uses.

In addition there are issues unrelated to climate change, such as unsustainable use of water for agriculture and industry, nutrient and other emissions that may affect water quality, and changing land-use patterns and other influences on river flows that may result in increases in peak discharges. Actions to address these issues and events are generally established in national policies and measures (and are outlined in Chapter 3 and Annex 1). But climate change is expected to increase the frequency and intensity of events and present a new scale of challenges. This understanding, coupled with recent experience of heat waves, severe floods and droughts, has provided the stimulus for the development of policies and measures at the national and European level. There is a need to ensure cooperation between Member States, particularly in respect of catchments across territorial boundaries. National actions, both current and envisaged, are considered in more detail in Chapter 3. This section focuses on critical issues at the European level.

2.1.2 Development of EU adaptation policy

Adaptation is a new area within European climate change policy. An impacts and adaptation work programme was set up as part of the European Climate Change Programme (ECCP II) in 2006. Its main objective was to explore options to improve Europe's resilience to climate change impacts, to encourage the integration of climate change adaptation into other policy areas at the European, national and regional level, and to define the role of EU-wide policies that complement action by Member States.

The aim in the first phase of the work was to identify good practice in the development of adaptation policies, foster learning from different sectoral experiences and explore a possible EU role in adaptation policies. The Commission led a series of ten sectoral meetings looking at adaptation issues for different sectors, one of which examined the impacts on the water cycle and water resource management, and the prediction of extreme events. The overall outcomes will be presented in a Green Paper to be published in 2007 which will launch a period of consultation.

The ECCP II meeting on water identified where existing mechanisms and approaches could be used, particularly the Water Framework Directive (EC, 2000), Directive 2000/60/EC Establishing a Framework for Community Action in the Field of Water Policy, discussed in detail below. It also identified a number of gaps which need to be addressed at the local, national, regional or EU level. Possible approaches include:

- improving information and knowledge, for example higher-resolution climate modelling, better information on sectoral impacts;
- economic instruments, including water pricing and the use of CAP subsidies to avoid mal-adaptation;
- improved risk and disaster management through the WFD and the European Flood Action Programme.

Two other areas are under active development. Water scarcity and drought is an emerging policy issue, and the ad hoc work in this area is covered in Section 2.5.1 The Maritime Policy Green Paper, for which the Marine Strategy will develop the environmental pillar, recognises climate change as a major threat, and discusses adaptation to changing coastal risks in Europe.

2.1.3 Water Framework Directive (WFD)

The WFD, which entered into force on 22 December 2000, introduced a significant shift in regulatory approach from one of multiple instruments with separate (but overlapping) objectives to one providing an integrated framework covering all variables affecting the status of water bodies (qualitative and quantitative) and the water needs of terrestrial ecosystems and wetlands that depend directly on aquatic ecosystems. It aims to establish good surface and ground water status in the EU

Member States, including coastal and transitional waters.

In 2001, the Common Implementation Strategy (CIS) was set up by the Member States, Norway and the Commission, with accession countries, other stakeholders and non-governmental organisations. It is led by EU water directors and provides guidance and an agreed strategy for implementing the WFD covering a wide range of issues. Goals have been set for 2009, after which a six-year period for review and renewal will follow. Projected work includes more consideration of how to integrate climate change into water management (under the WFD and elsewhere).

The ECCP II water meeting recognised that the WFD is a key instrument in climate adaptation policies in the water sector. The way it addresses the water sector can be seen as a possible example for other adaptation policy areas because it requires Member States to:

- undertake a comprehensive stocktaking of environmental pressures including additional climate change pressures;
- apply a river basin (catchment area) approach (across administrative boundaries);
- aim for long-term ecosystem management;
- monitor relevant environmental (climate change related and other) impacts;
- define clear (environmental quality) targets;
- devise and implement management plans with concrete measures to achieve these targets;
- review management plans regularly to take account of recent data and information.

Using this approach, the directive defines six-year management cycles, starting with the first management plans in 2009 (including objectives for 2015) and the first review and update in 2015

2.1.4 European flood action programme

The European flood action programme has three components, which include exchange of knowledge and experience and support for research efforts, and best use of EU funding instruments for flood risk management. The third component is a proposal for a directive on the Assessment and Management of Floods (COM(2006)15 final), published by the Commission on 18 January 2006 with the aim of further complementing the objectives in the WFD to address the effects of floods (including a changed pattern of flooding, i.e. frequency and duration due to climate change).

The proposed directive contains a requirement for Member States to perform a preliminary flood risk assessment, which includes assessing climate change impacts, prepare detailed flood maps and finally develop flood risk management plans.

The following knowledge and experience exchange activities have been developed under the action programme:

- The Exchange Circle on Flood Forecasting and Early Warning (EXCIFF) was piloted jointly by JRC and the French Ministry of the Environment. It was launched in December 2004 and has 22 Member State or agencies and 31 operational hydrological and meteorological centres or organisations as members.
- The Exchange Circle on Flood Mapping (EXCIMAP) consists of 33 participants, including 15 European countries, international hydrological commissions, EU-funded projects, European organisations, and other interested stakeholders. A first draft guide of good practices in flood mapping will be presented in 2007.
- An Exchange Circle on land-use planning may be set up on an initiative of Norway and the Netherlands.

The EU Solidarity Fund ([7]) helps the EU respond to requests for aid in the event of major natural disasters. It may therefore create important links to the management of weather-related risks, such as floods and droughts, within the EU.

2.2 Climate change and the Water Framework Directive

2.2.1 Introduction

The main text of the WFD, Common Implementation Strategy (CIS) guidance and associated policy documents have been reviewed to assess the way

([7]) Council Regulation (EC) No 2012/2002 of 11 November 2002.

in which the issue of climate change is being (or is likely to be) treated.

One of the key lessons from the review is that while 'climate change' is not included in the main text of the directive, the directive can encompass the longer term implications of climate change. The issues and interactions are complex because of the timeframes and cycles of the directive and uncertainties in future climate change, and particularly need to be considered in relation to economic appraisal. However, if sufficient account of climate change implications is taken, the WFD can provide a powerful adaptive management tool.

2.2.2 Key issues

Climatic variables are the root of many of the parameters that influence water resources and the ecological status of water bodies. In this way, using the terminology of the WFD, not only does climate change represent an 'anthropogenic pressure' in its own right (with the potential to alter factors such as the quantitative status of water bodies, flow regimes, morphology, and temperature and light conditions), it also has the potential to aggravate other anthropogenic pressures. For example, changes in precipitation and hotter/drier summer periods alter both the availability of water and the demand for water for uses such as agriculture.

This means that climate change has the potential to alter a number of the biological, chemical, hydrological and quantitative parameters used by the WFD to assess ecological status. A study, Wilby *et al.*, 2006b provide a summary of impacts on some of these parameters (see Table 2.1).

To summarise, the key questions and concerns relating to the interaction between the policy framework introduced by the WFD and climate change are that:

- climate change will alter the hydro-morphological, and physico-chemical quantitative parameters underpinning the biological status of water bodies;
- climate change will increase the frequency of extreme flooding events;
- climate change will increase the frequency of drought conditions and water scarcity.

Issues of floods, water scarcity and droughts are covered in subsequent sections. The next section analyses how the basic principles and tools of the WFD relate to climate change in more detail.

2.3 Climate change and the basic principles and tools of the WFD

2.3.1 Climate implications for reference conditions and status definitions

The legal text of the WFD acknowledges the need to consider longer-term influences on water bodies.

Table 2.1 Potential climate change impacts on ecological status

Parameters	Examples of impacts
Physico-chemical	Changes in water temperature and dissolved oxygen Decreased dilution capacity of receiving waters Increased erosion and diffuse pollution More frequent flushing of combined sewer outflows Photoactivation of toxicants Exceedence of water quality standards
Biological	Changing metabolic rates of organisms Changing ecosystem productivity and biodiversity Climate space of plant and animal distributions Fish migration patterns and dispersal corridors Increased eutrophication and prevalence of algal blooms Changes in aquatic fauna and flora at reference sites Changes in species assemblages in designated areas
Hydro-morphological	Changing river flows and sea levels lead to coastal erosion Indirect impacts from land-use practices and agriculture Hydrological connectivity of slopes, channels, and coastal zones Diffuse and point sources of sediment Long-term bed-load and channel change Geomorphological processes creating dynamic/diverse habitats

Source: Wilby *et al.*, 2006b.

This is because, even in the absence of climate change, a number of factors will change over time and can have an effect on the longer-term achievement of objectives.

It is important that surveillance monitoring should be able to detect climate change trends and that these serve as the basis for the update of the River Basin Management Plan. To this end, the surface water monitoring network established under Article 8 is required to provide information to assess 'long-term changes in natural conditions' and 'long-term changes resulting from widespread anthropogenic activity'. For groundwater characterisation (where recharge time-lags are particularly important to resource management), Member States should have 'sufficient data to calculate the long-term annual average rate of overall recharge'. In addition, the economic analysis procedure established under Article 5 requires long-term forecasts of supply and demand for water services in the river basin district.

As a result of changes in climate change, long-term changes in ecology are to be expected. This will imply changes in type-specific reference conditions. Looking to reference conditions and status definitions, Member States must undertake an initial characterisation of water bodies to differentiate them by ecosystem type ([8]). A number of the factors used to characterise water bodies are a function of climate and, thus, are subject to variation under climate change (JRC, 2005). As a result of climate change, water bodies (especially those located near the boundary of the type characteristics) may change in type. While climate change is a global phenomenon and all types will be affected, some water bodies may be more sensitive than others. Unless reference conditions are updated, any deterioration in status would then imply that the objectives for the water body required under the WFD would not be met. Changes in ecology do not necessarily imply worsening the status of water bodies. In many cases that will occur, but in most cases what will happen is that the changes will affect the reliability of the assessment systems in use. For example, changes in species composition makes an assessment method no longer valid because the 'new' species that appear as a result of climate change are not taken into account in the monitoring.

The main issue is therefore how climate change can be accommodated in the methodological assessment used to establish type-specific reference conditions for water bodies.

Annex II of the directive provides some guidance for reference conditions under the existing provisions for characterisation. Where it is not possible to establish reliable type-specific reference conditions for a quality element in a particular type of surface water body, due to a high degree of natural variability in that element (not just as a result of seasonal variations), then that element may be excluded from the assessment of ecological status for that surface water type. This implies that, where climate change introduces even greater variability, there is scope within the provisions to exclude that element.

Furthermore, Article 5(2) requires that characterisation and determination of reference conditions in accordance with the technical requirements of Annexes II and III of the WFD is undertaken within four years and reviewed (and if necessary updated) at least 13 years after entry into force and every six years thereafter.

So the WFD does not assume that type-specific reference conditions will remain static, and the cyclical review, together with 'climate change' proofing of the reference conditions for individual quality elements, can be used to achieve good integration of climate change in the WFD.

The need, and scope for revision to account for climate change and improved understanding has also been recognised in various discussions ([9]).

2.3.2 Economic analysis and climate change uncertainty

The role of economic analysis in decision-making for the WFD is very important for the delivery of all aspects of the directive. Having identified measures to address pressures, cost-effectiveness analysis (CEA) should be used to identify the

([8]) This is supported by an intercalibration process under the Common Implementation Strategy for the WFD, to ensure that reference conditions are derived similarly within the same geographic region.

([9]) See minutes of WFD Committee in Brussels on 28 May 2004. The Commission mentioned that 'the WFD, Annex V requires a complete and comprehensive intercalibration. Since Member States will not be in the position to cover all types, quality elements and pressures on the basis of existing data and classification systems, the remaining gaps will have to be completed at a later stage. In addition, the review of the characterisation including the reference conditions in 2013 (cf. Article 5) provides another basis to introduce a review clause in the proposed decision. Finally, adaptations to scientific progress and changes in the ecosystem through, e.g. climate change, also justify such a revision clause.'

best package of measures to address these. Furthermore, economic analysis should be used to determine whether meeting an objective for a water body entails a disproportionate cost ([10]). The term 'economic' is not restricted here to narrow financial criteria but is an expression of all values — use and non-use values.

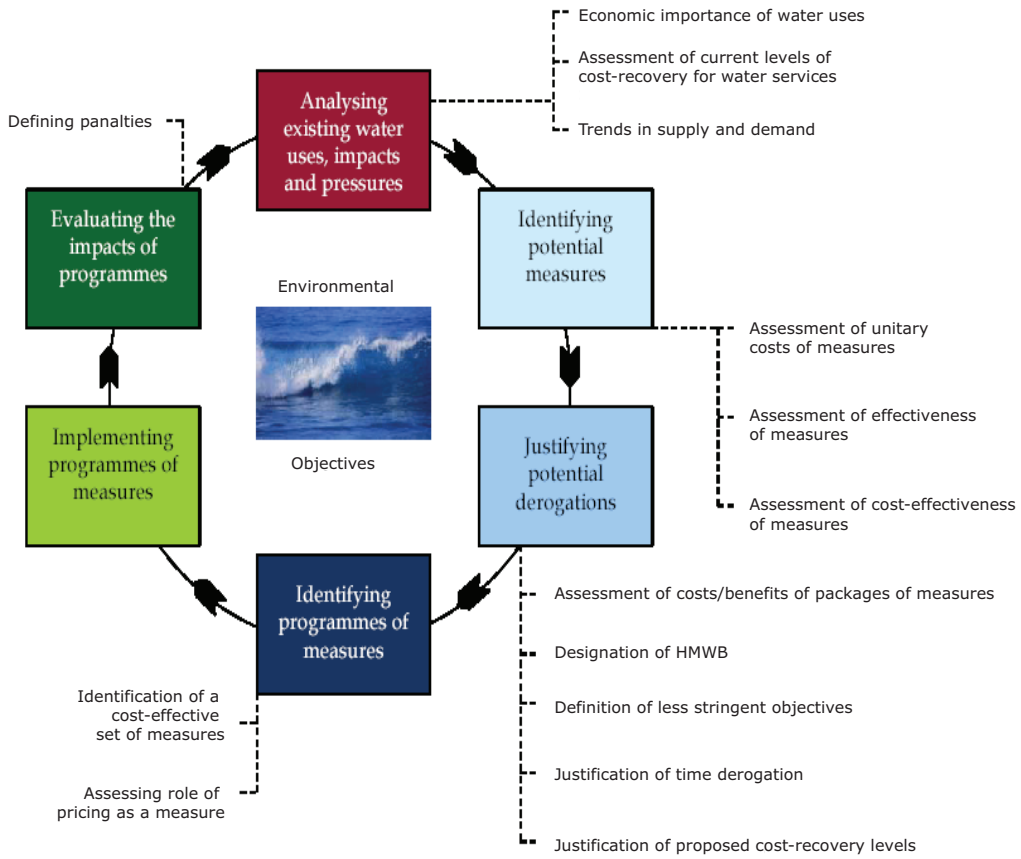
The CIS has therefore developed guidance for economic analysis, and the need to account for change and uncertainties, including specific reference to climate change (see Figure 2.1) ([11]).

A core function of the economic analyses is to ensure that remedial measures are selected for implementation on the basis of their cost-effectiveness and, in addition, that they do not represent a 'disproportionate cost' ([12]).

The guidance sets out the following process:

- assess trends of key hydrological and socio-economic factors/drivers that are likely to affect pressures (demography, climate, sector policies, e.g. common agricultural policy, technological development);
- identify proposed measures and planned investments for implementing existing water legislation;

Figure 2.1 Integration of economic analysis in the WFD decision making process



Source: Guidance document.

([10]) Where 'disproportionate cost' does not mean that the cost:benefit ratio is greater than 1, but that the costs outweigh the benefits significantly.
([11]) The CIS WATECO Guidance Document 1 on the Economics Supporting the WFD.
([12]) In terms of the latter, the WFD permits limited exceptions to achieving water quality objectives either by a time derogation or by setting less stringent conditions.

- forecast changes in pressures based on changes in economic sectoral and physical drivers and proposed water-related measures;
- construct a business-as-usual scenario for pressures;
- conduct a sensitivity analysis on the baseline scenario and identify low and high pressure scenarios.

The guidance advises that in scenarios Member States should 'ensure coherence with projections and trends used for other river basins for national and EU policies and climate change'. It also advises that the business-as-usual scenario needs to be updated beyond 2004 in order to integrate changes in uncertain parameters. With regard to this, it identifies information requirements including forecasts of the impact of climate change and also studies on existing and projected water balance. The Guidance notes that the construction of the long-term forecasts is needed to:

- identify whether there is a gap in water status between the projected situation and the directive's objectives for 2015;
- identify potential measures to bridge that gap (if there is one) and construct a cost-effective programme of measures;
- make the relevant calculations necessary for taking into account the principle of cost recovery of water services, taking into account long-term forecasts of supply and demand for water in the river basin distric.

The approach focuses on the forecasting of pressures and of key socio-economic sectoral drivers that are likely to affect pressures. It distinguishes between variables that can be derived with a high degree of confidence and those that are uncertain. Climate change is specifically mentioned as a critical uncertainty.

The same principles apply when a water body achieves 'good ecological status' by 2015 because of the successful implementation of a programme of measures, but subsequently degrades due to climate change, assuming that the degradation is not the result of an extreme event (which is treated separately by the WFD and discussed below).

As mentioned earlier, there might also be the possibility of changing characterisation/reference conditions in the next review. Thus the WFD may resign itself to long-term sustained changes but still require that anthropogenic pressures are reduced to minimise deterioration. In this way, River Basin Management Plans (RBMP) under the WFD would tend to switch to a new baseline and promote adaptation to the new conditions.

2.3.3 Disproportionate cost and technical feasibility

The extent to which measures might be introduced to counteract further deterioration will be determined mainly by costs and technical feasibility. Article 4(5) provides that Member States may aim to achieve less stringent environmental objectives for specific bodies of water 'when they are so affected by human activity, or their natural condition is such that the achievement of objectives would be infeasible or disproportionately expensive'. A 2005 policy summary ([13]) notes that a 'less stringent objective' does not mean that (a) the other quality elements are permitted to deteriorate to the status dictated by the worst-affected quality element or (b) the potential for improvement in the condition of other quality elements can be ignored. This means that just because objectives for one element cannot be met, all other objectives for all other components are automatically less stringent. In addition, the achievement of a so-called 'less stringent objective' may require the implementation of measures that are as stringent, if not more so, than the measures that are required for water bodies for which the objective is good status.

If, however, a Member State wishes to apply for a derogation (in time under Article 4.4 or objectives under Article 4.5) for a water body for one or more elements, it will have to demonstrate that the costs of corrective action substantially exceed the benefits of taking that action. Here, the disproportionate cost condition effectively requires Member States to take action to reduce the pressure to the extent that it makes (economic) sense to do so ('economic' is not restricted to narrow financial criteria but is an expression of all values — use and non-use values).

2.3.4 Identifying programmes of measures

At present, Member States are only in the early phases of identifying measures that may be a part of

([13]) Environmental Objectives under The Water Framework Directive — Policy Summary and Background Document — Final version, 20 June 2005 — discussed and the policy summary endorsed at the Water Directors' meeting on 20 June 2005 in Mondorf-les-Bains which presented an informal consensus agreed by all partners (although not necessarily represent the official, formal position of any of the partners).

identified to address the pressures from agricultural diffuse pollution:

- source measures (such as dietary improvements, reduced stocking rates, land use changes);
- mobilisation measures (such as direct injection of slurries, manure spreading timing restrictions);
- transport measures (such as grass buffer strips to intercept run-off, catch-pits).

Again, taking climate change into account, several observations can be made about the relative effectiveness of the agricultural measures:

- the effectiveness of source control measures (such as dietary improvements, reduced stocking rates and (well planned) land-use changes) are unlikely to be compromised by an increase in the frequency of extreme rainfall events;
- the effectiveness of mobilisation measures is likely to be reduced in the situation of increased severity and frequency of extreme rainfall;
- the effectiveness of transport interception measures may be compromised unless they are designed to accommodate likely increases in the severity and frequency of extreme rainfall.

In considering the most cost-effective approach to reducing nutrient pollution in the RBMP as a whole, it is important to chose a package of measures that is less likely to be compromised by future climate changes. Here, even if the measures are more expensive to implement, it may be worth considering a package consisting of:

- source control measures to address agricultural diffuse pollution, complemented by mobilisation control measures;
- upgrading of storm sewers and the water treatment plant (impacts from which can only be increased in the river basin district;
- implementing pollution control at the food processing plant (which is unlikely to be effected by climate change and, thus, is a measure that is unlikely to be compromised.

In this way, allowing for climate change in the process of identifying packages of measures improves the quality of decision-making and, thereby, the delivery of cost-effective packages of measures to achieve good ecological status.

Conversely, a failure to take sufficient account of climate change could increase the risk of selecting a package of measures that is not only sub-optimal in terms of effectiveness in reaching the objectives in the longer term, but is also sub-optimal from the point of view of the associated investments.

2.3.5 Climate change, natural variability and programmes of measures

Climate changes relating to precipitation are likely to be dominated by natural variability until the 2030s (Section 1.2.6). This will mean that measures aimed at managing precipitation-driven changes to existing 'pressures' on water bodies will be especially problematic to define. This is because of the high natural variability of precipitation, and the large uncertainty attached to future precipitation scenarios (especially for summer months, on regional scales and for extremes) (Goodess *et al.*, 2007). For example, uncontrolled discharges of wastewater are not permissible under the WFD because they are neither 'exceptional' nor 'unforeseeable', but the cost of building extra wastewater storage capacity or retro-fitting urban drainage systems to cope with more frequent/extreme (yet highly uncertain) precipitation events could be considered 'disproportionately expensive'. Other precipitation-dependent pressures include patterns of diffuse nutrient run-off, sediment supply and habitat modification in river channels.

Despite the large uncertainties attached to climate change projections over WFD timescales there are several strategies that could be pursued to ensure that programmes of measures (POMs) realise their intended environmental outcomes:

- measures should be considered in terms of the time needed to implement them and the intended design life with respect to anticipated rates of climate change. 'No regrets' POMs that are quick to implement and have low climate sensitivity (such as changing food-stuffs for livestock to reduce diffuse nutrient loads, as above), may be preferable to measures that have long planning horizons, high capital costs and structural inertia (such as new water treatment works);
- improved long-range forecasts are a further example of a 'no regrets' adaptation option. Although decadal forecasting is still in its infancy, early results show promise. As with seasonal forecasting, there may be scope for collective action on improving forecasting

systems for Europe (McKenzie Hedger and Corfee-Morlot, 2006);

- measures can be appraised using the full range of historic climate variability data made possible by data-mining or reconstruction. If WFD objectives are not met under these circumstances it is unlikely that the measures will be robust to climate change over the coming decades. The appraisal process may even lead to a revision (downwards) of baseline goods and services. For example, inclusion of data about early nineteenth century droughts reduces estimates of present reliable water supplies from some reservoirs in the east of England by as much as 16 % (EA, 2006);

- in the absence of certain climate change projections or lengthy historic records, climate sensitivity testing can still be applied to each option. For example, the costs and benefits of flood defence schemes in the United Kingdom are evaluated using a 10 % increase in peak flows up to 2025 and 20 % increase thereafter up to 2100. Screening of options using standard climate change allowances can help test the relative robustness of each measure in the face of deep uncertainty (Dessai *et al.*, 2005);

- finally, even with perfect knowledge of the climate evolution over the next few decades, the outcome of different POMs may be far from certain. For example, monthly river flow projections for the 2020s prepared for the UK water companies strategic water plans show large uncertainties due to the water resource model structure and parameterisation (Wade and Vidal, 2006). These arise because of poorly characterised or partially understood representation of natural processes in the models. Improving existing decision-support tools may be a more tractable option than reducing uncertainty in near-term climate change projections.

2.4 Flooding and climate change

2.4.1 WFD aspects: temporary deterioration and extreme events

The occurrence of extreme events such as floods and droughts, expected to occur more frequently as a result of climate change, receives separate treatment in the WFD. Article 4(6) provides that temporary deterioration in the status of bodies of water is not in breach of the requirements of the WFD if it is the result of 'circumstances of natural cause or force majeure which are exceptional or could not reasonably have been foreseen, in particular extreme floods and prolonged droughts, or the result of circumstances due to accidents which could not reasonably have been foreseen'. The following conditions apply to this article:

- all practicable steps must be taken to prevent further deterioration in status including in other bodies of water not affected by the circumstances;

- the conditions under which circumstances that are exceptional or that could not reasonably have been foreseen may be stated, including the adoption of the appropriate indicators, in the river basin management plan;

- the measures to be taken under such exceptional circumstances are included in the programme of measures and will not compromise the recovery of the quality of the body of water once the circumstances are over;

- the effects of the circumstances that are exceptional or that could not reasonably have been foreseen are reviewed annually and, subject to the reasons set out in paragraph 4(a), all practicable measures are taken with the aim of restoring the body of water to its status prior to the effects of those circumstances as soon as reasonably practicable;

- a summary of the effects of the circumstances and of such measures taken or to be taken in accordance with paragraphs (a) and (d) are included in the next update of the river basin management plan.

Temporary deterioration is thus only permitted in cases that are truly 'exceptional' or 'unforeseeable', and some effort must still be made by the Member State (before or after the event) to prevent deterioration.

This means that Member States are effectively required to plan contingencies for extreme events. They are also required to take all practicable measures to restore the water body, with the possibility of an exemption if (Article 4(a)),

I the scale of improvements required can only be achieved in phases exceeding the timescale, for reasons of technical feasibility;

II completing the improvements within the timescale would be disproportionately expensive; or

III natural conditions do not allow timely improvement in the status of the body of water.

In the EEA/German Ministry questionnaire that was circulated as part of this study, a number of Member States identified that the WFD was potentially obstructive to the development of flood control structures and measures.

A recent WFD CIS document ([14]) makes explicit reference to this issue. Under the WFD, different environmental objectives are given to particular categories of water bodies, in particular to achieve 'good ecological and good chemical status' for surface water bodies in general or 'good ecological' potential for the specific case of heavily modified and artificial water bodies by 2015.

For artificial and heavily modified water bodies (as a result of substantial physical alterations by human activity), the environmental objectives are 'good chemical status' and 'good ecological potential'. For all categories, exemptions are allowed in the form of extension of deadlines (from 2015 to 2027) or less stringent objectives. They need to be justified by technical ('infeasible') or economic ('disproportionately expensive') reasons and reported in the river basin management plans. Also new modifications to existing physical characteristics, such as flood defences, can be exempted under Article 4.7 if,

I all practical steps are taken to mitigate the adverse effect;

II the reasons are set out and explained in the River Basin Management Plan;

III the reasons are of overriding public interest;

IV there are no reasonable alternatives.

Thus, the WFD requires infrastructure owners, users or developers to mitigate the impacts of their existing and new activities. They will not only have to investigate and apply good practice but may also need to develop alternatives to the traditional solutions in order to avoid deterioration.

The CIS document notes that, at first glance, there might be a risk of conflict between the implementation of different policies because of the importance of favourable hydro-morphological conditions for good ecological status, while hydropower generation, navigation infrastructures and activities, and flood defence facilities often require major hydro-morphological changes.

However, in response the document highlights that:

- while impacting on aquatic ecosystems, such activities can also deliver important environmental benefits in other areas (e.g. reducing the impacts of climate change) or benefits to human safety and/or generate or secure employment;
- negative impacts on aquatic ecosystems can be avoided or reduced if those responsible for undertaking/regulating such activities recognise and take account of environmental protection as part of the multi-purpose uses of water bodies.

2.4.2 Proposed directive on floods

The Commission Communication of July 2004 on Flood Risk Management, Flood Prevention, Protection and Mitigation (COM/2004/472) acknowledged that while the WFD will contribute to mitigating the effects of floods, this was not one of the principal objectives of the directive. To address this gap, a proposed directive on the Assessment and Management of Floods (COM/2006/15 Final) was adopted by the Commission in January 2006. The proposal identifies climate change as one factor that will produce an increased flood risk (in terms of frequency and severity).

The proposed requirements are that Member States will undertake:

- preliminary flood risk assessment: to establish areas where potentially significant flood risks exist or are reasonably foreseeable taking climate change into account;
- flood risk maps: flood risks should be mapped for the river basins and sub-basins with significant potential risk of flooding, in order to increase public awareness; support the

([14]) Common Implementation Strategy for the Water Framework Directive — WFD and Hydro-morphological pressures — focus on hydropower, navigation and flood defence activities — Recommendations for better policy integration (Draft, September 2006).

process of prioritising, justifying and targeting investments and developing sustainable policies and strategies; and support flood risk management plans, spatial planning and emergency plans;

- flood risk management plans: flood risk management plans should then be developed and implemented at the river basin/sub-basin level to reduce and manage the flood risk. These plans should include the analysis and assessment of flood risk, the definition of the level of protection, and identification and implementation of sustainable measures: not passing problems on to upstream or downstream regions, and preferably contributing to reducing flood risks in these regions.

The proposed directive includes a number of links to coordinate implementation with the WFD. Thus Article 13 of the proposal identifies that the development of the first flood risk maps and their subsequent reviews should be carried out in close coordination with and, if considered appropriate, integrated into the reviews under the WFD.

Amendments to further strengthen the proposed directive in relation to climate change are discussed in the recent Communication from the Commission to the European Parliament of 6 December 2006 ([15]). The second reading in the European Parliament is scheduled for March 2007.

Outstanding issues in the negotiations between the European Parliament and the Council include how and at what stage to address climate change and coordination with the WFD

2.5 Climate change, water scarcity and drought

2.5.1 Action on water scarcity and drought

Increases in drought frequency and water scarcity resulting from climate change are very high on the policy agenda and are driving the development of suitable responses in combination with the other components of water regulation in the EU.

In 2003, an ad-hoc activity on water scarcity and droughts led by France and Italy was created under the CIS. This group presented a report in June 2006 on Water Scarcity Management in the Context of WFD ([16]). The report provides definitions and assessments of drought and imbalance phenomena, and addresses drought planning and management as well as long-term imbalances in supply and demand. It also proposes common principles (conclusions and recommendations).

The extent to which the WFD considers drought and scarcity issues was clarified in a Working Paper ([17]) from the European Commission of May 2006. This was produced after the request to initiate a European action on water scarcity and droughts made during the Environment Council of 9 March 2006.

The Commission, with the help of Member States, is now assessing the extent of both water scarcity and drought issues at the EU level. After the dissemination of an interim report in December 2006, an updated and refined version will be made available in June 2007 and a final version at the end of 2007, after compilation of the information to come from the research side.

In July 2007, the Commission will also present a Communication on water scarcity and drought, setting out what further action might be taken at the EU level.

2.5.2 Water scarcity and drought and the WFD

The difference between demand and abstraction has to be taken into account with respect to ecosystems to comply with Article 1(a) of the WFD namely 'to prevent further deterioration and protect and enhance the status of aquatic ecosystems and, with regard to their water needs, terrestrial ecosystems and wetlands directly depending on the aquatic systems'.

The Working Paper of May 2006 underlines that in all the areas where the quantitative situation undermines the achievement of WFD objectives, the river basin management plans (RBMP) and their associated programmes of measures should consider quantitative and qualitative

([15]) COM(2006)775 final: Communication From the Commission to the European Parliament concerning the Common position of the Council on the adoption of a European Parliament and Council Directive on the assessment and management of floods, Brussels, 06.12.2006.
([16]) Water Scarcity Output Med Joint Process WFD/EUWI Water Scarcity Drafting Group : Water Scarcity Management In The Context Of WFD — May 2006.
([17]) Working Paper (in Progress), European Action on Water Scarcity & Drought — First Analysis of Water Scarcity and Drought Issues — 23 May 2006.

measures together. When and where needed, a specific drought management (sub) plan could be included in WFD RBMP under Article 13.5 ([18]). It also notes that public participation (under WFD Article 14) should be organised around addressing water management issues, including long-term imbalances.

However, it acknowledges that the integration of specific quantitative measures into the programmes of measures might add supplementary constraints (technical and financial) for concerned countries. Under WFD Articles 4.4 and 4.5, these additional constraints should be taken into account when setting the environmental objectives of the water bodies.

The paper also discusses the WFD Article 9 requirements that Member States must ensure by 2010 that water-pricing policies provide adequate incentives for users to use water resources efficiently. It mentions that a first review of the economic analyses of water services and uses by Member States (as part of Article 5 reporting) suggests that in many cases the structure and levels of water tariffs do reflect part or all of the financial costs borne by the supply systems. However, it notes that the resources and the environmental costs are very often poorly taken into account at present and efforts are needed by the Member States to adapt their water-pricing policies to the issue of water scarcity.

The paper concludes that there are already several mechanisms to address long-term imbalances including:

- a legislative instrument (the WFD) which allows Member States flexibility to adapt their measures according to the problems faced;
- financial tools — through the CAP (agriculture sector) and structural and cohesion funds, that could be utilised for supporting water-demand management measures.

2.6 Summary

This section has considered a number of aspects of the overarching EU regulatory framework in relation to water with a view to identifying the extent to which climate change is integrated into its operation, and how it may perform under climate change. This suggests that there are a number of aspects of the regulatory framework and its implementation that either address, or provide further strategic opportunities for adaptation to climate change.

The most favourable aspect of the legislation in this respect is the stepwise and cyclical procedure for identifying and managing anthropogenic pressures over time at the river basin level and within the bounds of disproportionate cost and feasibility (given natural variations).

Climate change will affect the very conditions and pressures that regulatory measures such as the WFD seek to manage. In terms of water management under the WFD, this leaves two possibilities:

- if the implications of climate change are not taken into account sufficiently, the extent to which the WFD can meet its objectives and/or the efficiency with which it will achieve them could be limited;
- because the WFD seeks to manage the very conditions and pressures that will be affected by climate change, if sufficient account of climate change implications is taken, the WFD could provide a powerful mechanism for adaptation to climate change.

The effectiveness of the Water Framework Directive in the face of climate change clearly depends on the extent to which scenarios are introduced into the river basin management plan process. As is clearly set out in the WATECO Common Implementation Strategy Guidance on economics, it is important to consider uncertainties in the identification of cost-effective packages of measures. Here, a predictive element is required within the management planning process to determine the effectiveness and adequacy of measures in the light of changing conditions.

One of the most critical timetable issues is the question of relevance of climate change aspects and possibly required action for RBMPs in the first cycle. If climate change aspects are not taken into account in the first round of RBMPs (and associated investments) there is a risk that non-optimal measures will be selected and investment will have to be changed, with associated costs. This

([18]) 'River basin management plans may be supplemented by the production of more detailed programmes and management plans for sub basin, sector, issue, or water type, to deal with particular aspects of water management'.

is because precipitation changes will not be distinguishable from natural variability for many decades to come (at river-basin scales). Over the next decade the main climate risk to achievement of good ecological status comes from rising air/water temperatures, and/or more intense heat waves.

The framework thus provided by the WFD addressing all aspects of climate change, including flooding, water scarcity and droughts, is being complemented by the proposed Floods Directive to provide an integrated package to address flooding issues. The possible need for further development of the EU framework to more adequately address water scarcity and droughts is currently being assessed by the Commission.

In terms of the development of future guidance and documentation on the issues, the WFD Common Implementation Strategy — Improving the comparability and quality of the Water Framework Directive implementation 2007–2009 (16 November 2006) discusses a number of proposals for further work on implementation of the WFD for 2007–2009 including:

- water scarcity and droughts, including the establishment of a stakeholder forum;
- climate change which will focus on the options and opportunities provided by the EU Water Policy Framework for adapting to the impacts of climate change;
- a working group on floods and an information exchange on flood protection-related issues;
- a network and information exchange with the pilot river basins and other river basins on implementation issues.

In terms of climate change it is noted that the work will have to mesh in closely with other CIS activities. It is noted that the mandate will be drafted after the outcome of the German symposium in February 2007 ([19]).

([19]) http://europa.eu.int/comm/environment/water/water-framework/implementation.html

3 National practices and issues

3.1 Introduction

Countries have always had to respond to extreme weather events caused by climate variability and have developed ways of coping with floods and droughts. Recent experience of floods and droughts have given these efforts new impetus within countries as well as at the European level. Climate change is a new driver for action, but adaptation measures are likely to be implemented in many cases through modifications of existing policy frameworks for floods, droughts and the management of water quality or better coordination of existing mechanisms — a climate-proofing or main-streaming exercise. It is also clear that some step-changes in action will be needed to handle the expected level of accumulated incremental change over time, and to address the possibility of new extreme events.

This section uses information from several sources to provide an overview both of existing practise and of envisaged policy and investment developments for adaptation to climate change, principally:

- a specific 'climate change and water survey' — a cooperative effort between EEA and the German Ministry for Environment (also using an analysis by Ecologic). The questionnaire was designed jointly and distributed on behalf of the German Federal Ministry for the Environment and the EEA to the national focal points and the pilot river basins;
- UNFCCC national communications;
- responses to a questionnaire circulated by the European Commission on the issues of water scarcity and drought.

The climate change and water survey was undertaken to provide a stock-take of existing practise. Its aim was to collect information on the degree of awareness of the impacts of climate change on water resources in Europe, to assess vulnerability to climate change, and to compile potential adaptation measures and strategies, and information on implementation experience. By November 2006, responses had been received, from Austria, Belgium, Bulgaria, Cyprus, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Hungary, Iceland, Ireland, Lithuania, Luxembourg, Malta, the Netherlands, Norway, Romania, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, and the United Kingdom (England and Wales, and Scotland) (The EEA covers Europe and not just the EU). It should be noted it was not possible to quality assure the results for consistency in approach for this report.

Under the provisions of the UNFCCC, countries are obliged to report regularly on progress on their commitments. A latest fourth round of reports is currently emerging and these were used where they are available.

Information from a drought and water scarcity questionnaire has also been used. A number of EU Member States requested European action on water scarcity and droughts during the Environment Council of 9 March 2006. The Commission presented a first analysis of these issues during the Environment Council of 27 June 2006 and is now strengthening the assessment. A first interim report at the technical level was discussed with the water directors in December 2006. This survey also investigated the use of EU funding mechanisms for these problems and a summary of these aspects is also included in this section.

Further details for each country for which information was available are given in Annex 1. This annex can be regarded as a living document that can be revised and expanded.

3.2 Activities in relation to drought and scarcity

3.2.1 Overview

Most of the information on drought and water scarcity results from the questionnaires described above. A wide range of actions is evident. In some cases the results of analysis of water supply and demand indicate no effects of climate change on public water use in countries such as Estonia and Sweden which have no drought protection measures. In the southern countries such as Greece, desertification has become a very significant concern (as well as drought and water supplies)

and a number of activities are in place to address the issues.

In addition to extreme events, the sources of water resource problems and issues from climate change vary. In some countries saltwater intrusion into groundwater is due mainly to increased abstraction, while in low-lying coastal countries such as Denmark, concerns over saline intrusion relate to the effects of rising sea levels.

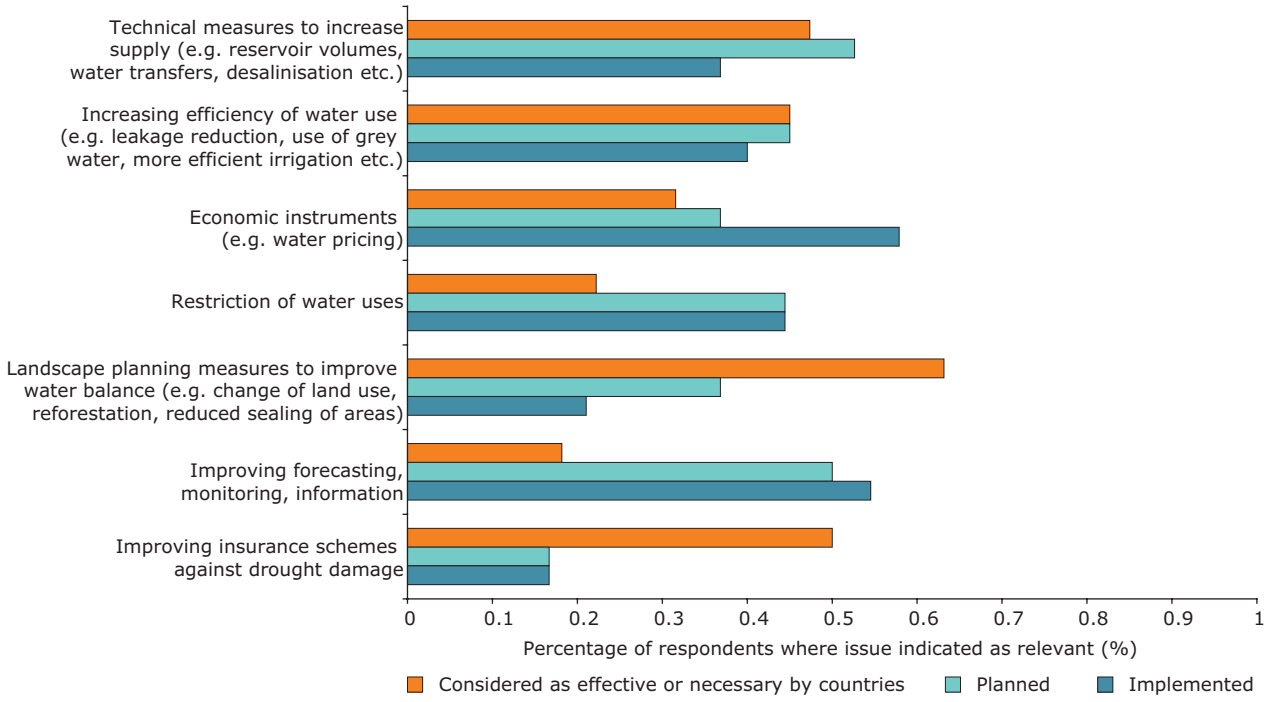
In almost all countries there are implications for public water supply scarcity (associated with tourism in some cases), agricultural irrigation and direct or indirect effects on river levels and water quality. The impacts vary widely in nature and severity, from effects on agricultural production, public health and security, and biodiversity, to the possibility of reduced power production (for example hydropower in Norway and Sweden) and navigation issues.

Clearly, responses and adaptation measures differ, depending on the issues and priorities. However, factors other than climate change also come into play, such as population change and agricultural development, and these are not easy to plan for. For example in the Czech Republic National Communication to the UNFCCC indicates that the consumption of drinking water is expected to fall as a consequence of population decrease. However, demand for irrigation water may increase, depending critically on political and economic conditions in agriculture, which are difficult to predict because of unknown future developments in world agricultural markets and the EU common agricultural policy.

In contrast, in Ireland (UNFCCC Communication) the most notable reductions in surface water are expected for the Ryewater and Boyne, and these catchments are among the most heavily populated in the country. With the population of the region projected to double by around 2030, existing primary sources of water supply will be unable to cope with projected demands over the coming years.

Implementing appropriate strategies requires careful consideration of a number of complex (and often uncertain) variables as well as climate change. For example, changes to aquifer levels in Belgium have consequences on the timescale of a year or more and differences between summer and winter precipitation may offset each other. Thus, due to the high uncertainty over precipitation changes, it is very difficult to determine what action to take.

Figure 3.1 Implementation and future planning for drought control and water scarcity measures



Source: EEA and German Ministry survey.

3.2.2 Country activity

Results from the joint (EEA/German Ministry for Environment) questionnaire show that countries, particularly in southern Europe, are aware of the strongly negative impact of decreased precipitation from climate change on water supplies. Responses relating to drought and scarcity measures have been compiled in Figure 3.1.

Six possible actions were identified:

- technical (hard engineering) measures to increase supply;
- increasing water efficiency;
- using economic instruments;
- restricting water use;
- spatial planning, forecasting and monitoring;
- insurance schemes.

Countries were asked to categorise their actions in categories: the three categories used in this analysis are: implemented, planned, necessary but not planned. Responses from a small number of countries which did not think action on a specific issue was necessary were excluded (for example countries where droughts are not perceived as a major problem, or where the institution completing the questionnaire was not the competent authority). Some countries are both implementing and planning measures.

Existing measures involve new infrastructure, demand-side measures and economic instruments. Measures to improve forecasting have already been implemented in many cases. Engineering measures are not the only responses planned; there is already a considerable amount of planning related to all the other possible strategies and actions. In particular, further actions are envisaged on insurance schemes and on land management to improve water balances. Measures such as improving insurance schemes are the least developed. However, this may reflect priorities: it may have been decided to try first to address the issues directly through other types of measures.

Information from the national communications to the UNFCCC, as well as the responses to the water scarcity and drought questionnaire, provide more detail on new actions on water scarcity in southern European countries.

3.2.3 Examples of action

Greece
Detailed climate modelling is continuing, but results are already feeding into a number of activities and policies. Desertification is a significant concern and over the period 2000–2004, members of the National Committee for Combating Desertification, in collaboration with universities and research institutes in Greece and abroad, undertook a significant number of research projects and studies on the process of desertification in Greece, as well as on prevention and adaptation techniques.

These activities provided the scientific basis for compiling a map of areas threatened by desertification in order to prioritise actions. This also resulted in a national map of the quality of different soils, their vulnerability to degradation and desertification and appropriate sustainable uses. This map will be used for implementing the new EU agricultural policy. In addition, a special report on research studies related to desertification was published.This provides a scientific basis for planning and implementing technical and socio-economic measures and actions to combat desertification. Actions related directly or indirectly to integrated approaches to address desertification and the rational management of water resources include:

- collective land reclamation projects (reservoirs for surface run-off, irrigation networks including their maintenance/improvement, implementation of new technologies for the efficient exploitation of irrigation, pond reservoirs);
- enhancement of underground aquifers and actions to prevent the increase of salinity;
- emergency actions for droughts;
- measures for treatment and reuse of wastewater.

Italy
In order to address water crises, an ordinance on water emergencies has been issued to provide both technical and financial emergency measures. Ad hoc organisations have been created to provide crisis management, for example, a 'drought control room' for the Po river basin, and a coordination unit for the management of water resources shared between the Puglia and Basilicata regions, to regulate the use of water and take measures to prevent water crisis. For the agricultural sector, Italy has implemented a national plan for irrigation, and specific funds are

allocated to alleviate the effects of extreme events (including droughts) ([20]).

France
In 2006, France enacted a major legislative framework (the Water Act 2006) with the aim of ensuring that the need to adapt to climate change is taken into account in water management. There are a number of instruments and initiatives already in place, for example on water charging, where there is already a level of cost recovery of over 85 % for households and industry.

Cyprus
Cyprus is undertaking a large number and variety of projects and programmes, including construction of dams, desalination of sea water, re-use of treated wastewater, aquifer recharge, drilling of boreholes, metering of water services, water charges, installation of improved farm irrigation systems, construction of modern efficient conveyance and distribution systems, application of leakage detection methods, water-saving measures, user education and information, quota system for the allocation of government irrigation water in combination with penalty charges for over-consumption, subsidies for saving good quality domestic water, law banning the use of hosepipes for washing cars or pavements, a Drought Management Committee, and establishing a new Directorate for Integrated Water Management ([21]).

Portugal
Several legislative instruments have been prepared, to be implemented soon, with technical, economic and financial provisions that will influence water uses:

- new water law: Decree Law 58-2005, 29 December (includes WFD transposition);
- new economic and financial regime for water, including all instruments for enforcement and a specific scarcity coefficient, at the discussion and finalisation stage;
- national plan for water efficiency;
- related technical instruments: a special effort is being put into producing national databases with reliable data on water use, compiling existing data and campaigning for new data ([21]).

Spain
The integrated management plans for water resources in Spain are one component of the approach to adaptation to climate change. The National Water Plan, Law 10/2001 of 5 July (Analysis of Water Systems) accounts for potential climate change-induced reduction in water availability and analyses the effects of such reductions on management and planning. River-basin drought plans are currently being developed to determine emergency protocols when facing drought and scarcity episodes. These plans include, for example, specific measures to be taken for urban supply, and defining priorities for water uses ([21]).

Recent emergency legislation includes the use of market instruments and investments for improving the technical efficiency of irrigation networks. These should be approved by 2007 within the Hydrological National Plan Law, and applied by all river basins and autonomous communities. The Ministry of Environment has launched a broad public awareness campaign to promotes water saving and inform the public about the different domestic actions' ([21]).

Hungary
Drought mitigation has been recognised as a national priority. The improvement of drought forecasting, for example through the development of reliable drought indices, is recommended as an important adaptation measure. A national drought mitigation strategy is to be developed ([22]).

3.2.4 Integration and use of EU funds

The Water Framework Directive as a planning tool for an integrated management of water resources needs to be complemented by operational instruments from other EU policy areas. These are essential for realising the water quality objectives established via the WFD process.

There are a number of examples of Community funds being adapted and applied to address pressures relating to drought and water scarcity, including the common agricultural policy (CAP), structural and cohesion funds and the LIFE instrument. These have been applied with varying degrees of impact, taking into account the limitations in the design and application of the funding conditions.

([20]) Responses to European Commission's Drought and Scarcity Questionnaire.
([21]) Source: UNFCCC National Communication.
([22]) Source: Hungary's third national communication to the UNFCCC (http://unfccc.int/resource/docs/natc/hunnc3.pdf).

CAP instruments
It offers a variety of instruments which can be used to counterbalance adverse climate effects although the CAP is primarily designed to support farmers' income or structural change in the agriculture sector and the broader rural economy.

Rural development policy in particular offers a number of measures related directly or indirectly to water issues, such as support to irrigation plans, infrastructure modernisation and incentives for water savings, or preventive measures and restoration after natural disasters. While climate change is not their primary driver, these measures could help to reduce vulnerability and facilitate adaptation to climate change.

In addition, the regulation underpinning future EU rural development policy in 2007–2013 already contains explicit references to the EU water policy and targets for climate change mitigation, as well as the need to anticipate the likely effects of climate change on agriculture production and policy.

According to the subsidiarity principle, in their rural development programmes Member States and regions can include the combination of measures most appropriate to their objectives, thus leading to a great diversity of strategies and levels of intervention. Mediterranean countries have usually devoted substantial investments and support to irrigation systems. Irrigation infrastructure may occasionally help to offset seasonal droughts, but it is mostly intended to solve the uneven distribution of rains across time and territories, with a view to ensure regularity in supply and higher added value for agriculture production.

Funding through the CAP rural development policy has been applied in a number of ways to help address drought and water scarcity issues. The following national examples are focussed on maintaining and improving security of supply (including enhancing efficiency) and, more specifically, reducing pressures on water supplies.

In terms of improving efficiency, actions in Cyprus concerning the establishment of improved irrigation systems (sprinklers, drip irrigation, etc.) are eligible for co-financing.

In Finland, some projects have included elements to improve insufficient or insecure water supply to crops, and similar support seems possible in the next programming period. There is concern, however, that if agriculture moves away from grain and towards special crops, the need for irrigation will increase and there may be pressure to increase funding for drought-related measures in that sector.

In Slovenia, rural development measures include irrigation schemes (including water reservoirs), but possible gaps include the need to include adaptation measures such as new crops and practices to reduce pressure and dependency and thus help address water scarcity issues.

In Italy, maintaining the quantities and improving the quality of water resources is identified as a main objective to be tackled at the regional scale. and the National Strategic Plan includes specific measures for protection of supplies especially under Axis 1 (Improvement of agricultural sector and forestry competitiveness) and Axis 2 (Environmental and rural areas improvement).

Under the 2000–2006 programming period France's included 175 agro-environmental measures classified into 30 types. Only one type, 'reduction of withdrawals at farm scale', was directly related to measures addressing water scarcity and droughts; this included two measures:

- reduction of irrigated crop areas;
- reduction of the level of irrigation per hectare.

France identified that the 2000–2006 rural development programme only contributed weakly to reducing vulnerability to droughts and water scarcity. In the next programme period (2007–2013), funds specifically aimed at water scarcity and droughts will remain limited, with only the 'reduction of the farm irrigated area' measure planned.

Traditionally, irrigation policy has been of major importance in Spain, as part of the rural development policy. For the next programming period, Spain also identifies that there will be a number of examples of actions eligible in the context of water scarcity and drought.

A number of Member States (including Cyprus and Portugal) note that, while rural development measures are valuable, they can not solve all the problems. These funds are not focused on water scarcity and droughts. Member States themselves have numerous priorities and do not inways address water demand management measures first. In addition, payments are often under the second (optional) funding pillar of CAP and are dependent on uptake by farmers and other stakeholders.

Structural and cohesion funds
The cohesion policy, financed by the structural and cohesion funds, makes available a number of instruments which could contribute to adaptation to climate change. According to the Community guidelines, Member States and regions have to define and implement their programmes from a territorial, cross-sectoral perspective. In general terms, the prevention of climate hazards is integrated into programmes together with other measures aimed at stimulating sustainable economic growth and the competitiveness of regions.

One of the challenges for the new programming period 2007–2013 will be to strengthen the synergies between environmental protection and growth. One of the actions recommended by the Community guidelines focuses on risk prevention measures through improved management of natural resources, more targeted research and better use of integrated communication technologies (ICTs).

Structural policy aimed at cross-border and trans-national cooperation also offers opportunities for common solutions to water management and flood control and the prevention of natural hazards. Examples of cross-border cooperation projects on water management and prevention of environmental risks can already be found under INTERREG IIC 1997–1999.

The increasing awareness of climate change effects may lead to a better targeting of measures towards prevention and compensation for water scarcity, floods and other risks related to climate variability. However, the final strategies and measures applied will vary widely among and within Member States, given the great diversity of regional conditions.

Some examples of national implementation of structural policy measures related to water management are presented below.

In Finland during 2000–2006, Structural Objective 1 and 2 funding has covered aspects of improvement of water supplies, particularly in rural communities. In the next programme period, 2007–2013, funding for similar support is likely to be much less and in practice will be limited to the area covered by the Objective 1 structural funds aimed at regions lagging in development (eastern and northern Finland).

In France, in most programmes, several types of action relating to water issues are combined in a single measure. Only Corsica and overseas 'departments' are eligible for Objective 1 funds. Water issues are mentioned in all the programmes, drinking-water supply being frequently highlighted, but not explicitly water scarcity issues.

All France's regions (except Corsica) have part of their area eligible for Objective 2 funds and water issues are mentioned in all regional programmes. However the description of the eligible action remains general ('protection and restoration of water resources', 'water management', 'water protection',…). There is no evidence that funds are partly used to address water scarcity and drought issues, as qualitative water issues may be addressed first. However, cohesion policy strategy and resources for the 2007–2013 programme period have been reorganised and highlight that 'with respect to WFD objectives, saving water resources notably to anticipate climate change, looking for new sustainable resources and ensuring quality and proximity supplying need to be encouraged.'

A number of structural funds apply in Italy, including (for 2000–2006) irrigation networks and drinking-water distribution networks (not only for water emergencies). In Italy there is no immediate progression from promoter actions to the adoption of advanced tools that ensure effective monitoring, forecasting and prevention systems. Italy has a water programme funded through the cohesion funds. European funds are important (in addition to national resources) for implementing comprehensive metering of macro-consumption and monitoring of available supply systems (natural and artificial) in order to provide the necessary information for water crisis prevention.

In Portugal, 2000–2006 funds were used for completing infrastructure, some of it related to water imbalances. Example include: new multi-year and multi-purpose storage reservoirs in Alqueva which is a strategic source of supply for the southern provinces; urban water supply sources, new distribution networks and rehabilitation of old networks. The 2007–2013 programme of measures aims to improve the efficiency of use of large water users (for example, agriculture).

Slovenia has used funds for the construction of a reservoir for regional water supply in a drought-sensitive area.

In Spain, a number of specific actions have been selected for funding that have positive secondary environmental effects (reforestation, desalination, sewage treatment improvements etc).

LIFE funding
The Financial Instrument for the Environment (LIFE) contributes to the implementation and development

of the Community's environmental policy and legislation. Among its objectives, LIFE funding may include water-related projects with potential benefits for the state of water resources and, eventually, for protection against droughts and floods.

For instance, Italy has proposed inserting protection of water supplies among the priority areas of action in the new LIFE + programme, under the theme 'Environment and health and quality of life' of LIFE + Component 2 (Environment Policy and Governance).

In Spain, during the 2000–2006 period, various projects have been developed on:

- improvement in management of irrigated areas;
- improved water management, including reduction of water use;
- reduction of pollution in surface waters;
- treatment and recycling of saline waters from mining and industrial activities.

EU solidarity fund, drought damage and community mechanism for civil protection

The EU has set up a solidarity fund so that it can respond in a rapid, efficient and flexible way to help any Member State in the event of a major natural disaster. Its annual allocation is EUR 1 billion. To qualify for aid, countries must provide a documented estimate of the damage which is examined by the Commission in the light of specific criteria, which are intended to ensure that EU funds are used to meet the most urgent needs.

France has not received any support under the Solidarity Fund for drought events. The only supports obtained from this fund were related to inundations in 2002 (Gard) and 2004 (Rhône). The French request for funds for forest fires (which may have been linked to a drought event in 2003) was rejected. According to France it is rarely possible to fulfil the condition that at least half of the region's population is affected. France further comments that the Community Mechanism for Civil Protection is adapted to cases of urgent situations to give quick material and human support to Member States, but this tool is not fully adapted to drought and water scarcity events.

According to Portugal the criterion of at least EUR 1 billion of damage costs to get access to the Solidarity Fund is too high a threshold to allow Portuguese drought damage to receive financial support.

Similar views were expressed by Slovenia, which notes that damages do not correspond to the criteria for support under this fund.

It is important to note that, while there are specific EU funds to address extreme events as floods, there are no equivalent instruments for droughts or water scarcity.

3.3 Flooding

3.3.1 Countries' actions

The need for protection against floods has received a higher general level of attention than protection against water scarcity and droughts. Northern European countries that lie on major flood plains have a great concern about increased flood risk. Sea-level rise is an issue for low-lying coastal states and islands.

For some countries, such as the Baltic States of Latvia and Estonia, the perceived priorities are mostly related to coastal flooding and erosion. This is anticipated because of the combined effects of sea-level rise, increased storm surge and earlier melting of shallow-water sea ice, which reduces the extent of natural coastal protection at a time of year corresponding with storms. Similar issues are identified by Sweden.

Other low-lying coastal countries and areas such as the Netherlands, Denmark, and Belgium identify priorities and a need for integrated solutions to address the combined effects of increased frequency of fluvial flooding combined with increasing sea level, storm surge and continental river discharge.

Individual country responses in the climate change and water survey concerning the level of planning and implementation of different adaptation measures are presented in Annex 1. Responses relating to flood protection measures have been compiled in Figure 3.2 ([23]). Some countries were both implementing and planning measures.

([23]) In drawing together the data in Figure 3.1, responses under each category have been compiled as a percentage of the total number of responses where the measures was indicated as being effective or necessary in that country. Where a measure was neither implemented nor planned, countries were asked to indicate whether the measure was necessary and/or relevant.

Response categories identified are:

- technical (engineering) flood protection measures covering dykes, walls, improved drainage;
- natural landscape measures for retention of water;
- restriction of building development in risk areas;
- building standards, codes and regulations;
- improved forecasting and information;
- improved insurance schemes;
- improved coastal protection infrastructure;
- managed coastal retreat.

Countries were asked to categorise their actions in categories: implemented, planned, necessary but not planned. Responses from a small number of countries which did not think action on a specific issue was necessary were excluded (for example where conditions did not apply, e.g. coasts).

A high level of activity in this area is evident. A number of countries identified that flood defence is already a priority, even in the absence of climate change. Climate change adaptation involves adapting existing standards, policies and programmes as well as implementing new ones as necessary. This is perhaps reflected in the fact that about 65 % of respondents have implemented as well as are planning engineering flood-prevention measures.

A high level of existing and planned actions is indicated on improved information and forecasting systems — by 70 % of countries. Other measures that are relatively well developed include those for the natural retention of floodwaters and the restriction of settlements/building in risk areas. Regulation of new buildings and new construction is an area of planned activity. Specific measures in European countries, are described in more detail in Annex 1. Further actions are envisaged and planned for coastal areas. One of the key issues identified by a number of (particularly lower-lying) countries is the need to look beyond simply upgrading and extending technical flood defence measures.

There is also evidence of the international cooperation that is required to address the management of flooding issues across territorial borders. For example Switzerland has been involved in cooperative efforts to address transboundary issues ([24]). The Flood Early Warning System for the River Rhine (FEWS-Rhine) has been developed by a Swiss-Dutch-German consortium in close coordination with Germany and the Netherlands. This system enables the issuing of flood forecasts and flood warnings for the Rhine and its tributaries, and also for the big lakes in the Swiss part of the Rhine basin. The forecasts from Switzerland are transferred into the warning centres further downstream for integration into their forecasting systems.

A forecasting and flood management system (MINERVE) is being developed for the river Rhône, which is heavily influenced by many reservoirs, diversions and power plants. The flood management model proposes an original solution for the reduction of flood damage. The proposed method is to reduce the peak flow by storing the water in the reservoirs of hydropower schemes in catchment areas. This can be a valuable solution for regions such as the Valais, where there are many major hydropower schemes.

3.3.2 Actions by specific countries ([24])

The Netherlands

In the Netherlands, climate change and adaptation measures are explicitly integrated into the water policy agenda. Emphasis is placed on 'no regrets' strategies. Although flood risk dominates the adaptation agenda in water policy, the increased risk of dry spells and water shortages is also recognised. The spatial implications of the government's position on water management and the associated adaptation measures have been incorporated into the Dutch spatial policy. Inclusion in the rural policy offers an opportunity to combine the implementation of measures in rural areas for increased safety and flood prevention with measures with other objectives such as improving water quality, combating falling water-tables, reconstructing rural areas and improving the ecological infrastructure.

The Netherlands' water policy (Ministry of Transport, Public Works and Water Management, 2000) recognises that in the coming years increasing

([24]) Source: UNFCCC, National Communication.

water levels in the rivers and the accelerated rise in sea levels will mean that technical measures, such as raising dykes, will no longer be sufficient. A new policy of allowing more space for water is therefore being followed. Under this policy, rivers are allowed to expand into side channels and wetland areas in order to prevent floods. Greater emphasis is also being placed on managing water levels rather than keeping the water out. Safety continues to be the top priority. Other goals are to avoid destruction of the considerable cultural, historical and natural value of the river landscapes. The guiding principles are:

- anticipating instead of reacting;
- following a three-step strategy (first retention, then storage and, as a last resort, drainage);
- allocating more space for water (e.g. assigning emergency flood areas) in addition to implementing technological measures (e.g. dyke reinforcement);
- raising beach levels.

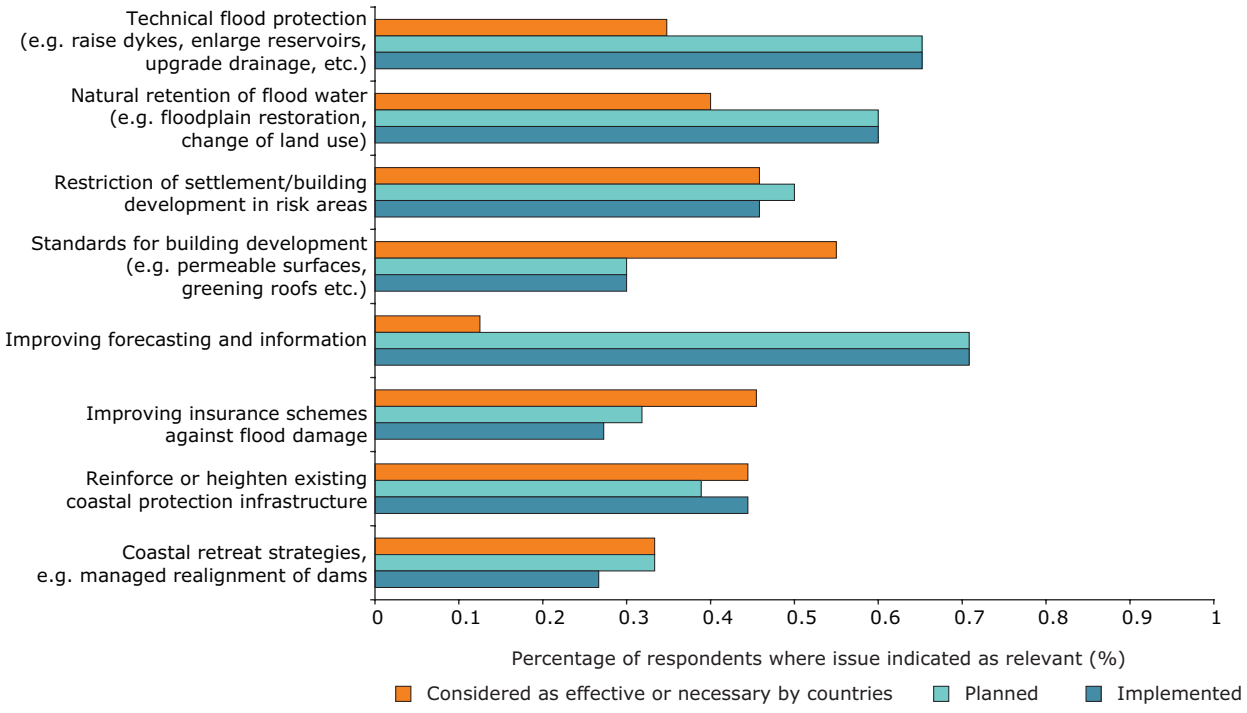
The present water policy aims to prepare and protect the Netherlands by 2015 for discharges from the river Rhine of up to 16 000 m^3/s. A follow-up programme is to protect against discharges of up to 18 000 m^3/s after 2015 (the highest measured discharge at Lobith ([25]) was 12 600 m^3/s, in January 1926).

Belgium

Similarly, in Belgium there is an emphasis on integrated approaches, which include specific consideration of the impacts of increased infiltration into buildings from rising catchment levels. In Flanders, building plans, as well as any plan that might have consequences for water resources, are checked for their hydrological consequences. It applies in particular to zones prone to flooding, , and close to a drinking water catchment area. The objective is to avoid negative impacts on the water system, but also to reduce the risk and consequences of flooding. As a consequence, the authorities can demand specific measures if required, such as the use of permeable ground surfaces. Maps identifying flood risks have been prepared to facilitate the implementation of these measures.

In the Brussels-Capital region of Belgium, flood policy is based on both a palliative and a preventive approach. The principal palliative measure is the construction of a network of storm drains, generally underground, to recover rainwater from heavy

Figure 3.2 Implementation and future planning for flood control measures



Source: EEA and German Ministry survey.

([25]) Where the Rhine enters Dutch territory.

precipitations so as to regulate the arrival of run-off water in the sewage system. The region has more than 10 storm drains, which are big enough to absorb floods likely to occur once every 10 years. If the volume of heavy rains increases by 10 %, which is a possibility within 50 to 100 years, flood frequency would increase to one in six years. An additional drain is being built and another is in the planning stage. Prevention includes two dimensions: improving soil infiltration and retaining water at the source. Various measures are being implemented to recover rain water (the installation of rainwater tanks is compulsory for new housing and promoted through regional grants for existing housing) and to increase infiltration and evapo-transpiration (limit on built-up areas, choice of porous materials, plantings and 'green roofs').

Denmark
In Denmark there are problems of low-lying areas that are exposed to both increases in the sea level and pressures from increasing drainage from the land. Many of the coastal towns near the estuaries of larger rivers or at the bottom of fjords have complex problems. Technical solutions such as building higher dykes are unlikely to provide a long-term solution to the problem of backwater flooding as a result of river water being unable to flow freely into the sea. A long-term solution requires the involvement of river valleys further inland, to make space for rivers, and to allow flood plains to flood regularly to take some of the pressure off river mouths. One of the tools to change land use in river valleys could be to use the EU agricultural subsidy schemes to make river valleys far more multi-functional.

The Danish Board of Technology has held workshops aimed at the public on local possibilities for adapting to a global sea-level rise of half a metre. One of the more surprising results was that promoting the construction of fixed installations to secure against flooding of agricultural land was not seen as important. There was some agreement on an approach based on appropriate adaptation through slow, natural development of the coastline, if necessary at the expense of agricultural areas.

Austria
To address fluvial flooding, it is recognised that there is a need for:

- a more integrated approach to the management of floods to address all phases of the flood risk cycle, including activities and measures on prevention, protection, preparedness, emergency response and recovery after the flood event;
- cooperation of all public authorities and other parties concerned, applying a broad range of tools at the different stages of the flood cycle. Promoting public participation and awareness-raising are identified as key prerequisites for successful implementation;
- the planning process to reflect the reality that even well-built flood control systems may fail if the discharge exceeds design values. The residual risk must be reflected in the planning process and has to be properly communicated to the public that is potentially affected.

These actions have already been partially implemented and will be further implemented, for example through guidelines (for regional planning, etc.) and with respect to public awareness. Simulation models for hazard assessment of torrential flows, debris flows, snow avalanches, and rock fall have been developed. A nationwide information and knowledge base on natural hazards for the entire national territory has been developed over recent years. Hazard zone plans are now available for the greater part of Austria.

3.4 Overview of adaptation initiatives

3.4.1 National adaptation initiatives

The questionnaire invited countries to give examples of adaptation actions or initiatives underway. Responses varied widely with respect to the types of initiatives mentioned and the level of detail provided. A number of countries clearly indicated that many of the measures mentioned in the questionnaire (such as the drought and flood activities listed in the previous section) were being implemented or were under discussion outside the context of climate change.

The initiatives indicated by the respondents are presented in Table 3.1.

The responses can be summarised under the following categories:

- Long term planning/policy/research. Many strategies are currently at the stage of research or policy investigations. These include policy guidelines, planning strategies and consultation processes. These are often in

response to the large uncertainties in climate change but reflect the country's intention to prepare for managing adaptation (countries include Germany, the Netherlands, the United Kingdom, Slovakia, Sweden, Spain). National or regional action plans or strategies for adaptation were mentioned by the United Kingdom, Spain and Romania.

- Flood defence and management. Largely in response to observed trends, as well as projected climate change scenarios, many countries have invested in projects to enhance their capacity to deal with flood events (including Austria, the Netherlands , Belgium, the United Kingdom, Slovenia, Hungary). The scope of these initiatives differs widely and may include research, technical measures, and land-use management.

- Coastal defence. Countries with vulnerable coastlines are adapting defence systems and management structures to better prepare for and deal with storm surges and sea-level rise (Belgium, Germany, the Netherlands).

- Water scarcity management. Relatively few initiatives related specifically to water scarcity management are mentioned. Most prominently, demand and supply management such as improving irrigation systems and water metering or leakage reduction and desalinisation are referred to by Malta and Cyprus.

Some of these initiatives are small and relatively low-budget projects, while others are massive undertakings with large budgets involving the coordination and support of several agencies, departments and stakeholders. Funding for such schemes comes from a variety of local, regional, national and EU sources, as well as from stakeholders. Before most large-scale initiatives receive funding, thorough cost-benefit analyses are usually conducted. So some potential adaptation projects with uncertain or hard-to-calculate benefits may never get over these thresholds. Indeed, uncertainties are a major obstacle to these projects, according to the responses, as are a lack of resources and political disagreements about large-scale initiatives that involve several stakeholders. One country (Norway) points out that whilst design parameters are constantly evaluated and adjusted in response to any (climatic) changes, the uncertainties remain too high for specific adaptation measures to progress from the discussion phase to action at this moment.

3.4.2 Need for EU level action — country views

The survey asked which adaptation activities should be coordinated or decided at the EU level. The responses reflect very different concerns among Member States. Recommendations included the following:

- Framework for adaptation. Several respondents suggested that a more consistent framework for adaptation should be created at the EU level, and that adaptation should be mainstreamed under the existing instruments dealing with water policy (e.g. WFD, Floods Directive, Groundwater Directive). It was suggested that such an adaptation framework could include an obligation on Member States to conduct national impact assessments, and a common reporting mechanism to communicate the results. One Member State also suggested that the EU could request Member States to draw up national adaptation strategies.

- Monitoring and information exchange. Several EU-level activities were suggested that would improve information exchange and mutual learning, for instance the dissemination of 'success stories' and monitoring information, the development of a European observational climate network, and the creation of a database containing examples of adaptation activities in the EU.

- Coordination between sectors and sectoral policies. Some respondents saw a role for the EU in mainstreaming adaptation efforts in water-related sectors such as agriculture and the energy sector. It was suggested that the common agricultural policy be adjusted to take account of climate change impacts and adaptation needs.

- Strengthening international cooperation on climate change adaptation was mentioned by one respondent as a possible area of activity for the EU.

- Subsidiarity. Several countries emphasised that the implementation of adaptation measures had to remain the responsibility of the Member States to ensure that they can respond flexibly to the specific challenges in their countries.

- Awareness-raising and education. Education and public awareness were often seen as overarching activities that might be coordinated at EU the level.

Table 3.1 Examples of adaptation initiatives

Country	Adaptation initiative	Notes	Triggers and drivers
Austria	FloodRisk — integrated flood management	Adaptation is main objective	Felt impacts, recent incidences
	StartClim (flexible focus — heat waves and droughts, health, tourism)		
Belgium	Veilige Kust (Flanders): coastal management	Adaptation is additional motivation	Weather events, risk assessment, CBA, land use pressure
	Sigma Flood Protection Plan: Regional initiative, focus flood protection and control	Adaptation is additional motivation	Weather events, risk assessment, CBA
Bulgaria	Initiatives are mentioned but not specified		
Switzerland	Flood risk management measure	Long-running programme, initially adaptation as side-effect, growing importance	Weather events
Cyprus	New and improved irrigation systems and desalinisation units	Adaptation is main objective	Felt impacts, e.g. decrease of agricultural production due to water scarcity
Germany	Improvement in landscape water balance guideline (Brandenburg)	Adaptation is main objective	Policy and authorities, research results
	Adaptation to climate trends and extreme weather conditions and sustainable groundwater management strategy (Hesse)	Adaptation is main objective	Risk assessment
	Master Plan Integrated Coastal Defence Management	Sea Level Rise scenario important	Observations and research
	KLIWA and ESPACE projects (Bavaria)	Mainly research/capacity building Adaptation is main objective	Weather events, research results
Spain	National Adaptation Plan	Water resources is priority as key driver for many other systems and sectors; Adaptation is main objective	Evidence, social awareness, political support
Finland	Improve Dam Safety and re-Design of Major Dam Discharges	Adaptation is main objective	Recent events
France	Flood risk management measures	Adaptation main objective	Weather events, risk assessment
	Sustainable water management measures	Research/capacity building	Land use pressures
	Study on adaptation recently launched		
Hungary	VAHAVA project (coordination, publication/ dissemination, expert debates on climate change issues)	Not specified	Not specified
	The New Vásárhelyi Plan (emergency reservoirs along Upstream- and Middle Tisza sections to enhance flood safety, covering conservation ecotourism, agro-ecological farming, rural development)		
Ireland	Inter-basin water transfer	Planning stage Main objectives: growing population, decreasing resources, and climate change	Risk assessment, CBA, research results
Latvia	National initiative, demand management and water quality		
Malta	Water conservation and water-saving measures (e.g. reducing leakage from distribution network; water metering in households and establishments	Adaptation is main objective	Weather events, heightened awareness resulting from research on climate change
Netherlands	Space for the river — long term spatial reservation	In some cases adaptation is main driver, it is always one of several objectives	Wave and climate research; reassessment of risks
	Agreement between authorities on incorporating climate change into planning for 2015		
	Increase capacity (pumping, discharge capacity of sluices)		
	Strengthening coastal defence to incorporate sea level rise and extension of beach nourishment programme		

Table 3.1 Examples of adaptation initiatives (cont.)

Country	Adaptation initiative	Notes	Triggers and drivers
Romania	Adaptation under different water legislation; National Action Plan on Climate Change (2005) highlights the need for an Action Plan on Adaptation by 2007	Measures to be implemented to enhance resilience and reduce vulnerability; adaptation is main objective	Risk assessment
Sweden	Ongoing survey on vulnerability of society	Research/survey	
	Permit system for water users	Adaptation is side effect	
Slovakia	Planning strategies	Adaptation is side effect	Weather events, research results, risk assessment, CBA
Slovenia	Strategies for flood and drought mitigation under National Environmental Programme (determination of risk areas; regulation of land use)	Adaptation is not the main objective	Weather events, policy/ legislation
United Kingdom	Incorporating climate change in long term coastal planning –iterative changes	Adaptation is main objective	Scenarios and felt impacts
	Climate change allowances and flood risk management associated with spatial planning and new investments	Adaptation is main objective	Scenarios, extreme weather events, insurance industry public opinion
	New building standards and guidance for developers		
	UK Climate Impacts Programme — supporting organisations to adapt — since 1997		
	Changing Our Ways — impacts and adaptation strategy (Scotland)	Adaptation is main objective	

Source: Benzie *et al.*, 2006, EEA and German Ministry survey.

3.5 Country views on Water Framework Directive issues

3.5.1 The Water Framework Directive and adaptation

The survey also asked respondents to suggest ways in which elements of the Water Framework Directive (WFD) could be used to address climate change impacts. The general impression given by the responses ([26]) is that implementation of the WFD overlaps with many of the aims of adaptation measures, such as maintaining the quality and quantity of water resources. The greater control and quality of information offered by the WFD policy system will aid water managers in their efforts to adapt to changing conditions.

However, while the suggestions made in response to the specific question on the WFD and climate change were all positive, elsewhere in the questionnaire it was indicated that some of the requirements of EU policy, such as meeting 'good status' in all waters, might hinder adaptation efforts. This was especially the case when contemplating the upgrading of certain water courses as part of flood defences, and the impact that this might have on the ecological condition of water systems.

One country (Norway) replied that the Floods Directive was a more relevant EU policy in terms of climate change adaptation than the WFD, again revealing the focus of many respondents on physical impacts and adaptation, especially flooding.

The responses received can be summarised under the following categories:

Programmes of measures (POMs): examples of and ways in which PoMs will help increase the adaptive capacity of water systems in respondents' countries.

Suggestions include that each river basin district should conduct a climate change impact assessment and then take account of this in the Programme of measures using formal cost-benefit analysis. Some respondents called for the measures to pay more attention to trends related to water availability, and to introduce measures for mitigating water scarcity, including control of groundwater abstraction. Another respondent argued that the WFD did not pay sufficient attention to extreme events, and called

([26]) Not all respondents offered answers to this question.

for additional management plans for flood and drought management

Water management: ways in which water management principles and models associated with the WFD will help countries to adapt to changes in water systems.

Some respondents pointed out how the implementation of the WFD might have the synergetic effect of improving adaptive capacity. Catchment-wide solutions as required by the WFD are considered more suitable to adaptation management than existing management systems. The cyclical review process of river basin management plans means that procedures are amended regularly using the latest evidence and information, which makes the management system more flexible and therefore adaptive. Furthermore, respondents emphasised that WFD assessment of flood risk is relevant to adaptation planning, as are cross-border management and early warning systems.

Monitoring: the role of monitoring and information in helping the adaptation process.

According to the responses, monitoring and risk assessment as foreseen under the WFD will provide valuable information for regional planning and development and thus create an adequate knowledge base which is a key prerequisite for adaptation. The collection of information under the WFD would provide information on water systems that are at, or near to, capacity, and would help establish which impacts are the result of climate change. One respondent pointed out that flood risk mapping would support policy makers in flood management ([27]).

3.6 Research needs

3.6.1 Overview

Respondents were asked to make suggestions for further research, especially at the European level. The general role of European research in assisting national adaptation efforts was recognised. Respondents identified research needs in the following areas:

- Climate modelling: there was general agreement on the need for enhanced regional climate change scenarios, or the scaling-down from global to regional and from regional to local climate scenario information. Uncertainties also need to be addressed and the consequences of climate change versus natural variability are still not known.

- Modelling of changes in water resources: requests were made for regional and local data to be merged with hydrological models, and to improve the accuracy of hydrological and hydraulic models, including groundwater. The need to improve the coupling of climate and hydrological models was also highlighted.

- Observation: with respect to the observation of climate change trends, respondents pointed to the need to maintain observation networks, and suggested including remote sensing techniques in hydrological monitoring.

- Impacts and vulnerability: the need for research on the vulnerability of European societies to climate change impacts was felt by many Member States. Respondents were concerned about several specific issues, including water-related climate change impacts on individual sectors (for example impacts of heavy rainfall and drought on the sewage system), the quantification of impacts, the socio-economic consequences of climate change impacts (for example of sea-level rise), the relationship between climate change impacts and land use (e.g. impacts on peatlands, sensitivity and responses of habitats and species), research into the long term use of recycled water in agriculture, and desertification.

- Adaptation: several respondents saw a need for research to develop adaptation measures and assess their effectiveness and efficiency. For example, research should help to design tools that demonstrate the economic benefit and cost-effectiveness of adaptation at the river-basin scale, and to develop indicators for successful adaptation measures.

3.6.2 Research needs for climate change and variability issues

Most water and flood risk planning horizons end before the 2050s, the point at which climate-driven changes in regional rainfall (and some river flows) are expected to emerge from natural variability.

([27]) Note that the forthcoming EU Floods Directive was not mentioned by the questionnaire.

A recent online survey of UK stakeholders found that the majority of respondents needed climate information for the next 20–50 years, with a significant proportion favouring the next 5–10 years (UKCIP, 2006). These findings match the timescale of Water Framework Directive activities, with environmental objectives to be met by 2015, the second round of river basin management plans by 2021, and the third round by 2027 (Wilby, 2006). Some suggestions for research were made at the September JRC/DRTD water workshop with these perspectives in mind (see Box 3.1).

Box 3.1 Priorities for water research to support adaptation over the next 20–50 years

- Comprehensive appraisal of water-sector risks related to rising temperatures in all sectors and biomes (air, river, ground, estuaries, and coasts).
- Robust statistical techniques for separating climate change signals in 'noisy' environmental data sets from natural variability.
- Frameworks for capturing key sources of uncertainty affecting regional climate change scenarios and impacts in the 2020s.
- Integrated tools for demonstrating economic and environmental benefits of adaptation at river-basin scales over the next few decades and beyond.
- Data mining and modelling campaigns to test that existing water supply and flood defence infrastructure can cope with the full range of natural variability (especially known historic extremes), as the first step in climate-proofing.
- Better data collection on impacts and responses to current extreme weather events (which are expected to become the normal experience later in the century).

Source: Hedger and Wilby, 2006.

4 Discussion and future challenges

4.1 Overall awareness

Direct impacts of climate change on water resources in Europe are well understood. In recent decades heavier rainfall events, increased floods and more frequent and longer drought periods have been observed in several parts of Europe. Temperature is projected to increase everywhere (with the highest increases in southern Europe); precipitation is projected to increase in northern Europe and decrease in southern Europe. However, critical uncertainties remain about the level and extent of increases and decreases in precipitation in specific locations. The temperature signal is much clearer and where extreme temperatures coincide with drought periods, consequences for water quality and quantity can be acute. Natural variability is likely to dominate until the 2030s so it will be important to quantify and understand the full range of natural variability which will be accentuated by climate change.

Extreme flood and drought events require actions to address the adverse impacts on natural resources, human health and critical economic sectors. Climate change is projected to have significant adverse impacts on key economic activities such as agriculture, hydropower and other forms of energy production, tourism and navigation in some countries. Serious impacts on biodiversity are also envisaged. Reducing vulnerabilities to current extreme weather events can be a first step to increasing resilience to climate change.

Despite some inconsistencies in the detail and quality of the information provided, the set of replies from the EEA/German Ministry survey in particular allows some clear conclusions about the level of awareness and adaptation initiatives underway to be drawn.

Responses reveal that awareness of climate change impacts is generally high, that European countries expect significant changes in water resources and hydrology as a consequence of climate change, and that the respondents are well informed about the results of up-to-date scientific research. There is a wide range of actions being launched or in place, covering institutional development, technical investments, spatial planning and regulatory measures, and increased investment in research.

4.2 Frameworks

Questionnaire responses suggest that European countries would welcome support of their adaptation efforts at the European level. While many respondents highlight the subsidiarity principle and the need for Member States to react flexibly to the specific challenges in their countries, many see a role for the EU in the coordination of sectoral policies, in supporting monitoring and information exchange, and in awareness-raising and education.

Policy and regulation is needed at all governmental levels (EU, national, sub-national, local) with clear frameworks and roles for all involved, as well as involvement of the private sector. Progress in the EU is still in the early stages. There is a need to develop measures that use the regulatory framework fully, to encourage investments that are resilient to climate change. Long-term strategies for public goods such as natural resources, coastal protection and emergency preparedness are needed at both the national and the EU level. There is a wide variety of possible responses to tackle the impacts of climate change impacts in the water sector Increases in investment and other regulatory and institutional actions are required. It is possible to envisage approaches which may be sustainable and incorporate climate change adaptation into EU and national sustainable development policies, though this has not yet been undertaken to any great extent.

4.3 European level aspects

There are a number of aspects of the existing regulatory framework and its implementation that may either address or provide further strategic opportunities for adaptation to climate change. Such a climate-proofing process has started under the European Climate Change Programme. The Commission is expected to publish a Green Paper on climate change adaptation in 2007.

To address impacts of floods, and to a much lesser extent also droughts and water scarcity, Member States are making use of funding under CAP, structural and cohesion funds, and LIFE. However there is a need to include climate change and natural variability considerations in these instruments. A number of constraints on their use were identified by countries so there is a need to determine how these funds are or are not to be used for climate change adaptation. In addition, new demands will create competing resource pressures.

4.4 Water Framework Directive

The Water Framework Directive is seen as a vehicle for adaptation strategies by many respondents, but a need is also expressed to create a consistent framework for adaptation involving all existing instruments in European water policy and related policies.

The WFD may also be one building block for the development of a sustainable adaptation framework at the European level. Its stepwise and cyclical procedures for identifying and managing anthropogenic pressures over time at the river basin level can provide a powerful mechanism for adapting to the changing pressures of climate change. Climate change will affect the very conditions and pressures that regulatory measures such as the WFD seek to manage.

The effectiveness of the WFD in the face of climate change clearly depends on the extent to which long-term projections and scenarios are introduced into the river basin management plans (RBMP) process. It is important to consider uncertainties in the identification of cost-effective packages of measures, for example, through sensitivity analyses — this will help to determine the effectiveness and adequacy of measures in the light of changing conditions. Measures should also be considered in terms of the time needed to implement them and their longevity compared with climate change projections. Measures that are quick to implement and have low climate sensitivity (such as changing food-stuffs for livestock to reduce diffuse nutrient loads), may be preferable to measures that have long planning horizons, high capital costs and structural inertia (such as new water treatment works) while uncertainties are high.

Delivery of adaptation by programmes of measures for 'pressures' will only tackle indirect climate change impacts manifested through, for example, changing patterns of nutrient run-off. This will not address direct effects such as the loss of species like salmon, due to rising water temperatures. It may therefore be helpful to distinguish more explicitly between indirect impacts of climate change (addressed by reducing anthropogenic pressures) and direct impacts (addressed by modifying reference conditions).

Successful adaptation to climate change (or otherwise) will depend on the extent to which these issues are integrated into the implementation of EU water regulation. As this is in the domain of Member States, success depends on Member State activity in relation to the issues.

One of the most critical timetable issues is the question of relevance of climate change and possibly require action on RBMPs in the first cycle, notably their completion by 2009 to make the programme of measures operational by 2010 for implementation by 2015. If climate change aspects are not taken into account in the first round of RBMPs (and associated investments) there will be a risk that non-optimal measures will be selected and investment will have to be changed, with associated costs. That said, precipitation-driven climate impacts would not be expected to be a major threat to the achievement of good ecological status by 2015.

In terms of the effects of climate change on increases in the frequency and severity of events such as flooding, a proposed directive on flooding, to supplement the provisions of the WFD, is awaiting its second reading in the European Parliament (expected in 2007).

In addition, the European Commission is considering drought issues and water scarcity, the first step being an in-depth analysis based on improved data from the Member States (to be finalised by mid-2007). Based on this analysis, the Commission will then consider which further action might be taken to address water scarcity and drought issues at the EU level.

In all cases, successful and efficient adaptation within the context of EU water regulation depends on continuing development and implementation in Member States.

In this way, allowing for climate change in the process of identifying packages of measures improves the quality of decision-making and, thereby, the delivery of cost-effective packages of measures to achieve good ecological status.

Conversely, a failure to take sufficient account of climate change could increase the risk of selecting a package of measures that is not only sub-optimal in terms of effectiveness in reaching the objectives in the longer term, but is also sub-optimal from the point of view of the associated investments.

4.5 National practices

However, given the high degree of awareness, the actual implementation of adaptation activities seems to be less developed, at least in certain areas. A number of adaptation measures and initiatives are mentioned by respondents, but many of these are still at the planning stage. Furthermore, adaptation activities currently seem to be focused on flood management and defence, while adaptation measures related to the management of water scarcity and drought, although recognised in the vulnerability assessment as equally damaging, do not yet seem to be widespread.

Not all of the adaptation activity recorded by the questionnaire was claimed by the recipients to be motivated mainly, or even primarily, by climate change considerations. Often adaptation to climate change is incorporated into existing planning instruments by way of update or revision. Generally adaptation seems to be facilitated if it coincides with other objectives, and 'no regrets' or win-win solutions can be implemented that also benefit other purposes. It also becomes clear from the questionnaires that countries are more likely to take concrete steps towards adaptation measures when they are sure of the costs and benefits involved.

4.6 Research and policy support

There is a need to deliver high quality climate change information with improved regional predictions. A need for research in several areas related to climate change impacts and adaptation is also identified by respondents. There is a significant agenda for further research:

- There is a general agreement about the need for higher spatial and temporal scenario information with enhanced regional climate change scenarios and scaling for local climate scenario information.
- Uncertainties also need to be addressed as well as the consequences of climate change versus natural variability.
- Requests were also made for regional and local data to be merged with hydrological models, and to improve the accuracy of hydrological and hydraulic models, including groundwater. The need to improve the coupling of climate and hydrological models was also highlighted.
- With respect to the observation of climate change trends, respondents pointed both to the necessity of maintaining real-time observation networks and also using novel technologies such as remote-sensing techniques in hydrological monitoring.
- The need for research on the vulnerability of European societies to climate change impacts was felt by many Member States, particularly for the water sector.
- The widely held assumption that (near) pristine systems are better able to adapt to climate change needs to be tested.
- Respondents saw a need for research in order to develop adaptation measures and assess their effectiveness and efficiency, for example, any trade-offs between adaptation and higher carbon emissions.

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Annex 1 Country level activities on climate change in relation to water resource issues

A1.1 Introduction and sources of information

This annex provides a summary of activities in EEA member countries in relation to climate change adaptation and water management issues. The annex is largely based on a collation of information on Member State activity and summarises relevant information from the following sources:

- UNFCCC National Communications;
- responses to a questionnaire circulated as part of this study (in a cooperative effort between EEA, Ecologic and the German Ministry for Environment (BMU)); and
- supplemented by responses to a questionnaire circulated by the European Commission on the issues of water scarcity and drought.

The aim of this study has been to present information on the range of issues faced by different countries, the problems that are emerging, and the solutions that are being applied. It does not aim to provide a comprehensive review of all activities in all countries, which would be needed to compare progress in different countries. The study has sought to use the evidence from the sources mentioned above as a means of identifying core issues, progress and obstacles across Europe as a whole. It has not tested the data for consistency as the countries themselves have supplied the data.

This compilation of information could be developed further.

A1.2 Austria

A1.2.1 Overview of issues and adaptation actions

In 2004–2005 the research program Floodrisk focused on all aspects of floods and flood prevention in Austria. With participation of many institutions recommendations with respect to meteorology/hydrology, geomorphology, economic aspects, spatial planning, flood control measures and disaster protection have been established. Some of the key results of the study were:

- a more integrated approach to the management of floods should address all phases of the flood risk cycle, including activities and measures on prevention, protection, preparedness, emergency response and recovery after flood events;
- integrated flood risk management calls for the cooperation of all public authorities and other parties concerned, applying a broad range of tools at the different stages of the flood cycle. Promoting public participation and awareness-raising were identified as key prerequisites for successful implementation;
- flood events in the past few years have shown that even well-built flood control systems may fail if the discharge exceeds design values. This residual risk must be reflected in the planning process and has to be properly communicated to the public that is potentially affected.

These recommendations have already been partly implemented and will further be implemented, for example in guidelines (for regional planning etc.) and with respect to public awareness.

Within the next ten years a special effort will be made to identify inundation areas and to speed up hazard zone mapping. Simulation models for hazard assessment of torrential flows, debris flows, snow avalanches, and rock fall have been developed. Considerable amounts of the budget are spent on avalanche, erosion and torrent control measures. In 2005 for example, federal funds to the amount of EUR 69 million were invested in protective measures. Total investments including the contributions by federal provinces, municipalities etc. amounted to EUR 122 million.

Analysis and evaluation of the natural hazard potential in the catchment area of torrents and avalanches have developed in recent years into a nationwide information and knowledge base on natural hazards for the entire national territory.

Hazard zone plans are now available for the greater part of Austria. The hazard zone plan is used as a basis for regional planning by the Länder and for the construction sector, but it does not have a

formal status. The objective is to develop settlements away from threatening natural hazards.

A1.2.2 Summary of adaptation actions and status

A summary of actions and their implementation status is provided in Table A1.2, drawn from the questionnaires sent to EEA member countries by the EEA and the German Federal Ministry for the Environment (BMU).

A1.2.3 Information on the use of community instruments and other national policies in the context of adaptation, water demand and management

Austria has responded that the WFD helps to promote cross-border adaptation measures for flood protection and drought management (e.g. for the river Danube catchment) and the establishment of cross-border monitoring and early warning systems such as those that already exist for the river Rhine.

No specific information on consideration of climate change in the application of Community policies such as the WFD has been identified.

A1.3 Belgium

A1.3.1 Overview of issues and adaptation actions

Fluvial flooding
There is considerable uncertainty over precipitation changes: the country is small, natural variability is quite large and models involve errors. The frequency of heavy precipitation events is likely to increase, but more research is needed to quantify

Table A1.2 Water resource adaptation status in Austria

Adaptation measure	Implemented	Planned	Effective/necessary (but not planned yet)	Not relevant/ necessary
Flood protection				
Technical flood protection	X	X		
Natural retention of flood water	X	X		
Restriction of settlement/building development in risk areas	X			
Standards for building development		X		
Improving forecasting and information	X (in some provinces)	X		
Improving insurance schemes against flood damage		X		
Others, please specify:				
Drought/low flow protection				
Technical measures to increase supply			X	
Increasing efficiency of water use			X	
Economic instruments			X	
Restriction of water uses			X	
Landscape planning measures to improve water balance			X	
Improving forecasting, monitoring, information		X		
Improving insurance schemes against drought damage	X			
Others, please specify:				
Coastal zones				
Reinforce or heighten existing coastal protection infrastructure	n/a			
Retreat strategies, e.g. managed realignment of dams				
Others, please specify:				
General adaptation measures				
Awareness raising or information campaigns	X	X		

this change, which could range from insignificant to relatively large.

During the winter months, the ground-water recharge is expected to increase. This may partly compensate for the summer drying, but in specific regions (mining areas in particular) higher aquifers may possibly contribute to flooding. Projected changes in winter precipitation and the likely increase of extreme events are nonetheless expected to raise the risk level further.

In the Walloon region, a new flood prevention plan was approved in 2003 (PLUIES plan). This global plan aims to improve knowledge of the risk of flooding, reduce and decelerate the run-off of water on slopes, improve the management of rivers, decrease vulnerability in zones liable to flooding and improve crisis management. Rules banning the construction of buildings in areas prone to flooding have been imposed and SETHY (Services d'ETudes Hydrologiques) is responsible for real-time monitoring of watercourses, hydrology studies, coordination and flood alert. Its work is based on a network of stations measuring the level of watercourses and amounts of rain.

In the Brussels-Capital region, flood policy is based on both a palliative approach (network of storm drains) and a preventive approach. The principal palliative measure is the construction of a network of storm drains, generally underground, to recover rainwater from heavy precipitations so as to regulate the arrival of run-off water in the sewage system. The region has more than 10 storm drains, big enough to absorb floods likely to occur once every 10 years. If the volume of heavy rains increases by 10 %, which is a possibility within 50 to 100 years, flood frequency would drop to one in six. An additional drain is currently being built and another is in the planning stage. The preventive approach is being given priority and can contribute to adaptation to increased precipitation. Prevention includes two dimensions: improved soil infiltration and retention of water at the source. Various measures are being implemented to recover rain water (the installation of rainwater tanks is compulsory for new housing and promoted through regional grants for existing housing) and to increase infiltration and evapo-transpiration (limit on built-up areas, choice of porous materials, plantings and green roofs).

In Flanders, building plans, as well as any plan that might have consequences on water resources, are checked for their hydrological consequences (procedure called 'water-toets', in the framework of the Coördi-natiecommissie Integraal Waterbeleid). It applies in particular to zones prone to flooding, important for infiltration, or close to a drinking water catchment area. The objective is to avoid negative impacts on the water system, but also to reduce the risk and consequences of flooding. As a consequence, the authorities can demand specific measures if required, such as the use of permeable ground surfaces. Maps identifying flood risks have been prepared to facilitate the implementation of these measures.

At the federal level, recent legislative changes require the inclusion of cover against flooding and other natural hazards in household fire insurance policies. Unlike the previous situation, the cover against natural disasters will not be provided by state funds, except when the global cost exceeds a threshold linked to the turnover of the insurance companies. While not primarily targeted at adaptation to climate change, this measure will also have a dissuasive effect on residential construction in areas where the risk of flooding is higher. There are plans to draw up a map of the high-risk zones in cooperation with the three regions and to exclude any new construction in these zones from the premium limitation mechanism, making such constructions probably uninsurable.

Coastal flooding issues

Climate change exposes the coastal region to a number of impacts including floods. The Belgian coast has a length of 65 km, half of which is protected by a dyke. Beaches and dunes also have an important role in protection against flooding. Since 1960, erosion has been compensated for by moving sand to the beaches, as was done recently in Ostend, where the level of the beach was raised to temporarily decrease the risk of flooding in the town. It is currently considered that compensating for erosion by adding sand when needed will continue to be possible.

When dykes need to be built, a 60 cm rise in sea level is taken into account. For the 21st century, the cost of adaptation is regarded as moderate, but a further rise in sea level would make adaptation much more difficult. Belgian researchers are taking part in the new EU project Safecoast aimed at protecting North Sea coasts.

Flooding occurred in the past in the Schelde estuary and its tributaries, leading to the adoption of the so-called 'Sigma-plan' several decades ago. In this framework, 13 'controlled flooding zones' were established. With the current climate, the risk level is estimated at one flood every 350 years, but the risk is expected to rise to up to one in 25 years by 2100 due to climate change and related sea level rise.

The Sigma-plan was prepared in 1976, implemented in 1977 and updated in 2005. The updated plan involves new controlled flood zones. A 60 cm rise in sea level is now taken into account.

Water scarcity and drought issues
Summer demand will increase, in particular if irrigation becomes a widespread agricultural practice. Dry summers, with increased evaporation and possibly reduced precipitation, will probably reduce the groundwater level significantly. In contrast, increased winter precipitation will contribute to larger groundwater recharge.

Changes to aquifer level have consequences on the timescale of a year or more, and should thus partly cancel each other out. Due to the high uncertainty over precipitation changes, particularly in summer, it is very difficult to come to a conclusion. Increased evaporation due to temperature change is a fact, and it may be that parts of Belgium will increasingly need to import water from others.

In parts of the country, specifically in Flanders, the availability of water per capita is low. Water management is already an important concern in Flanders, which imports a significant proportion of its drinking water from Wallonia. During present-day dry years, the availability of water is also reduced in canals, so that groups of ships have to cross the locks together.

Measures have been taken to tackle the current issues of water management in Flanders, and will contribute to mitigate future water resource problems. A large-scale information campaign to promote water savings was launched in 2000 and is still underway. Part of the measures for flood storage and prevention will also contribute to water availability. Current measures to improve surface and groundwater quality (e.g. in connection with nitrates from agricultural fertilizers) will help sustain the availability of affordable drinking water.

Future investigation
There is still high uncertainty over regional climate change and extreme events. Belgium is, however, beginning to build significant knowledge of the future climate in connection with socio-economic and emission scenarios. The knowledge of impacts seems more limited, particularly when it comes to a quantitative assessment on a local scale. Damaging processes are frequently known, but with little or no indication of their possible extent or severity. It has been very difficult to analyse and compare vulnerability to climate change in different sectors. The new multi-annual research programme 'Science for Sustainable Development' (2004–2009) launched by the Federal Science Policy Office is expected to help fill this need.

A1.3.2 Summary of adaptation actions and status

A summary of actions and their implementation status is provided in Table A1.3, drawn from the questionnaires sent to EEA member countries by the EEA and the German Federal Ministry for the Environment (BMU).

A1.3.3 Information on the use of community instruments and other national policies in the context of adaptation, water demand and management

Perceptions on the delivery of drought/scarcity measures and adaptation through the Water Framework Directive (WFD)
For the Flemish region of Belgium, water scarcity is limited to a few aquifers and the problem is covered by the WFD (good quantitative status of groundwater).

In terms of drought, despite the links mentioned in the WFD, there is a lack of transnational coordination concerning the availability of surface water in periods of droughts. It is very difficult to make bilateral agreements on the level of river basin district.

Water pricing measures implemented
Incentives to use the water resources efficiently are incorporated in the Flemish legislation by means of the taxes on groundwater and in the legislation on drinking-water. The taxation for a cubic meter groundwater is differentiated according to the total pumped amount of groundwater, to the aquifer in which the extraction well is situated and the existing pressure head of the groundwater in the region. The index is defined on a yearly basis. Every year each inhabitant gets a volume of 15 m^3 drinking-water free of charge. Those who need more drinking-water have to pay for the surplus.

The taxation for a cubic meter surface water is differentiated according to the total amount of surface water abstracted and to the sector of the water use. The abstraction of surface water for agricultural use is charged with a fixed price.

Other national policies
Belgium is applying social cost-benefit analysis to evaluate the effect of measures (both structural and operational). Low flow bulletins are issued by the Hydrological Information Centre (HIC).

Table A1.3 Water resource adaptation status in Belgium

Adaptation measure	Implemented	Planned	Effective/necessary (but not planned yet)	Not relevant/ necessary
Flood protection				
Technical flood protection	X	X		
Natural retention of flood water	X	X		
Restriction of settlement/building development in risk areas	X	X	X	
Standards for building development	X	X	X	
Improving forecasting and information	X	X		
Improving insurance schemes against flood damage	X		(X)	
Others, please specify:				
Drought/low flow protection				
Technical measures to increase supply		X	X (Flanders)	
Increasing efficiency of water use	X	X		
Economic instruments	X	X (Flanders)	X	
Restriction of water uses	X (Flanders)	X (Flanders)		
Landscape planning measures to improve water balance	X	X	X	
Improving forecasting, monitoring, information	X (Flanders)	X		
Improving insurance schemes against drought damage			X	(?)
Others, please specify:				
Coastal zones				
Reinforce or heighten existing coastal protection infrastructure	X	X		
Retreat strategies, e.g. managed realignment of dams				X
Others, please specify:	X (Flanders) slufters implemented in 'De Panne'	X (Flanders) slufters planned in 'het Zwin, Knokke'		
General adaptation measures				
Awareness raising or information campaigns	X		X	

A1.4 Bulgaria

A1.4.1 Summary of adaptation actions and status

A summary of actions and their implementation status is provided in Table A1.4, drawn from the questionnaires sent to EEA member countries by the EEA and the German Federal Ministry for the Environment (BMU).

A1.5 Cyprus

A1.5.1 Overview of issues and adaptation actions

Core concerns relate to decrease of water quality and quantity and impacts on irrigation and water uses.

A1.5.2 Summary of adaptation actions and status

A summary of actions and their implementation status is provided in Table A1.5, drawn from the questionnaires sent to EEA member countries by the EEA and the German Federal Ministry for the Environment (BMU).

A1.5.3 Information on the use of community instruments and other national policies in the context of adaptation, water demand and management

Drought/scarcity measures under the common agricultural policy (CAP)

There are no major measures in the Cyprus 2004–2006 Rural Development Plan addressing water scarcity. However, in the sub-measure

Table A1.4 Water resource adaptation status in Bulgaria

Adaptation measure	Implemented	Planned	Effective/necessary (but not planned yet)	Not relevant/ necessary
Flood protection				
Technical flood protection		X		
Natural retention of flood water			X	
Restriction of settlement/building development in risk areas			X	
Standards for building development			X	
Improving forecasting and information		X		
Improving insurance schemes against flood damage		X		
Others, please specify:				
Drought/low flow protection				
Technical measures to increase supply				
Increasing efficiency of water use		X		
Economic instruments		X		
Restriction of water uses		X		
Landscape planning measures to improve water balance				
Improving forecasting, monitoring, information		X		
Improving insurance schemes against drought damage				
Others, please specify:				
Coastal zones				
Reinforce or heighten existing coastal protection infrastructure				
Retreat strategies, e.g. managed realignment of dams				
Others, please specify:				
General adaptation measures				
Awareness raising or information campaigns				

1.1.1: 'Support of investments for the improvement of competitiveness of agricultural holdings', actions concerning the establishment of improved irrigation systems (sprinklers, drip irrigation, etc) are eligible for co-financing. It is expected that in the new Rural Development Plan 2007–2013 the same conditions as in the current period, will exist.

Cyprus notes that the above instruments are valuable elements but they can not solve all the problems since they are not directly designed to tackle specific issues such as water scarcity and droughts. It notes that perhaps a new instrument will have to be developed or better adaptation of EU funds to water scarcity and droughts will be needed in future.

LIFE funding
The LIFE 02 TCY/CY/019 project entitled 'Development and Implementation of an Integrated System for the Control and Monitoring of the Urban Wastewater Treatment Plants in Cyprus — COMWATER) started in September 2002.

Perceptions on the delivery of drought/scarcity measures and adaptation through the Water Framework Directive (WFD)
Measures can offer sustainable management of water resources and a water quality conservation.

Although it seems that the WFD is largely more focused on qualitative issues and is not directly designed to tackle quantitative issues, its implementation is expected to contribute to the mitigation of water scarcity and drought effects.

The gaps in the use of the WFD to address scarcity and drought issues are clearly explained in the paper 'Why do we need an EU political initiative on water scarcity?' written in collaboration between the member states concerned by water scarcity and drought management, including Cyprus.

Water pricing measures implemented
Charges set by the Water Boards usually comprise a fixed and maintenance charge and a series of block charges where successive blocks of water are sold at higher prices (rising block tariffs).

Water for irrigation purposes is supplied through government and non-government schemes. Irrigation water in government schemes is delivered directly to individual farmers (retail supplies) and in isolated cases is also provided on a bulk basis to irrigation divisions. Non-government schemes consist of small irrigation schemes, which are managed by committees chaired by the District Officer. For irrigation provision through the government schemes, charges are established on a volumetric basis and are uniform for all schemes covering a high proportion of the total financial cost.

Consultancy Services are currently in progress for the design of a protocol of information related to the economic analysis process and the implementation of the water pricing policies of the WFD. The protocol of information will be able to support the future steps leading to the implementation of the WFD and will enable future studies including the assessment of the incentive properties of the current pricing policies for all water services in Cyprus. The study on the assessment of the incentive properties of the current pricing policies is expected to be completed by the end of 2008.

Other national policies
Cyprus is undertaking a large number and variety of projects and programmes including construction of dams, desalinization of sea water, re-use of treated waste water, aquifer recharge, drilling of boreholes, metering of water services, water charges, installation of improved farm irrigation systems, construction of modern efficient conveyance and distribution systems, application of leakage detection methods, water saving measures, users education and information, quota system for the allocation of government irrigation water in combination with penalty charges for over consumption, subsidies for saving good quality domestic water, law banning

Table A1.5 Water resource adaptation status in Cyprus

Adaptation measure	Implemented	Planned	Effective/necessary (but not planned yet)	Not relevant/ necessary
Flood protection				
Technical flood protection			X	
Natural retention of flood water			X	
Restriction of settlement/building development in risk areas	X			
Standards for building development	X			
Improving forecasting and information	X			
Improving insurance schemes against flood damage	X			
Others, please specify:				
Drought/low flow protection				
Technical measures to increase supply	X	X		
Increasing efficiency of water use	X	X		
Economic instruments	X	X		
Restriction of water uses	X	X		
Landscape planning measures to improve water balance	X	X		
Improving forecasting, monitoring, information	X	X		
Improving insurance schemes against drought damage	X	X		
Coastal zones				
Reinforce or heighten existing coastal protection infrastructure	X	X		
Retreat strategies, e.g. managed realignment of dams	X	X		
Others, please specify:				
General adaptation measures				
Awareness raising or information campaigns	X	X		

the use of hosepipes for the washing of cars or pavements, Drought Management Committee, efforts for establishing a new Directorate for Integrated Water Management, etc.

A1.6 Czech Republic

A1.6.1 Overview of issues and adaptation actions

Floods
A greater frequency of floods in the winter can be expected as a consequence of increased outflow in the colder season of the year. Simulations of the precipitation-outflow process have also indicated that heavier rain occurring in connection with summer storms will constitute a greater risk of flash floods even if the long-term total precipitation does not change. The consequences of climate change very substantially affect the size of the storage space in the reservoir that would be necessary to preserve the existing level of water withdrawals.

General water issues and measures
Trends in the production and consumption of drinking water in the future will depend on natural, social-economic and political conditions. It is expected that there will be a tendency towards a reduction in the consumption of drinking water as a consequence of the population decrease. In agriculture, increased requirements for irrigation water will depend substantially on political and economic conditions in agriculture, which, at present, are difficult to predict in relation to membership in the EU. Longer-term projections of the national economy have not been prepared. Consequently future demands on water resources are made on the basis of expert judgement.

Decreased yield of water will substantially worsen the currently relatively unfavourable hydrological conditions in some river basins. The BILAN (CR), CLIRUN (Poland) and SAC-SMA (USA) models were used in a territorial study of climate change in the Czech Republic to determine the sensitivity and assess impacts in parts of the river basins of the Labe (Elbe), Želivka and Úpa Rivers. Most of the results indicated a decrease in surface and underground outflow. The results of a subsequent study indicated that the reduction in outflow will be greater than indicated in previous works and that there will be a significant impact on water resources.

Under the conditions of climate change, there may be a very substantial change in the distribution of outflow in the annual cycle in that there would be a reduction in accumulation of water stored in the form of snow. Outflow would increase substantially in the winter months, whereas flow rates will be reduced in the other seasons (e.g. due to less spring thaw).

In 2001–2002, a team of hydrological specialists examined the application of newly developed methods of assessing the impacts of climate change on water resources in the Czech Republic. This will lead to an improved proposal for adaptation measures, to be submitted to the Ministry of the Environment and Ministry of Agriculture.

The adaptation measures proposed in the T.G. Masaryk Water Research Institute are the result of comparison of changes in water management and the capacities of water resources with the current conception of developmental policy, with the state water management structure and with the state of the environment in the Czech Republic. Input data for each region in the competence of the Povodí state enterprises will consist of requirements that will include particularly:

- assessment of the technical condition of the individual water structures and the potential for further intensification;
- revision of the management regulations for water structures as a consequence of changes in requirements on water use after 1990;
- estimation of the surplus of water resources and proposals of their use on the basis of re-evaluation of the proposed parameters of water works;
- determination of the present state of demands on resources as the starting state prior to climate change;
- determination of the future requirements for water use in the region. In addition to these measures, measures adopted in the past are still in place, i.e. promotion of a further reduction in water consumption in industry, energy production, agriculture and households;
- reduction of water losses through repair and reconstruction of pipeline systems;
- promotion of more effective water use;
- trading in water and its transfers;
- controlled management of surface and underground waters.

The measures can be divided into two groups. The first group contains measures that are currently defined as part of the environmental policy of the Czech Republic. They focus on sustainable development and are necessary regardless of any expected climate change. The second group contains adaptation measures that supplement the first group in that they propose modifications taking into account a change in climatic conditions in the Czech Republic.

In terms of agricultural measures of relevance to water, the following measures appear to be necessary and feasible:

- prepare a new land assessment for ecological land units that takes into account a change in the climate and evaluate the production potential of the units;
- protect the soil against erosion and other negative effects caused by cultivation, e.g. by compacting, reduction of fertilization with organic fertilizers;
- change the structure of agricultural crops. In dry areas, concentrate on crops with a shorter vegetation period and lower moisture requirements;
- select agro-technical procedures that minimize the loss of soil moisture;
- choose cultivation procedures to reduce the risk of erosion processes as a consequence of flash storms and strong winds;
- consider irrigation carefully from the standpoint of water-management, production and economy. On the basis of experience to date, micro-irrigation should be considered.

A1.6.2 Summary of adaptation actions and status

A summary of actions and their implementation status is provided in Table A1.6, drawn from the questionnaires sent to EEA member countries by the EEA and the German Federal Ministry for the Environment (BMU).

Table A1.6 Water resource adaptation status in the Czech Republic

Adaptation measure	Implemented	Planned	Effective/necessary (but not planned yet)	Not relevant/ necessary
Flood protection				
Technical flood protection		X		
Natural retention of flood water	X	X		
Restriction of settlement/building development in risk areas	X	X		
Standards for building development			X	
Improving forecasting and information	X	X		
Improving insurance schemes against flood damage				
Others, please specify:				
Drought/low flow protection				
Technical measures to increase supply		X		
Increasing efficiency of water use			X	
Economic instruments	X			
Restriction of water uses				
Landscape planning measures to improve water balance		X		
Improving forecasting, monitoring, information		X		
Improving insurance schemes against drought damage			X	
Coastal zones				
Reinforce or heighten existing coastal protection infrastructure				
Retreat strategies, e.g. managed realignment of dams				
Others, please specify:				
General adaptation measures				
Awareness raising or information campaigns	X	X		

A1.7 Denmark

A1.7.1 Overview of issues and adaptation actions

Flooding issues
Net precipitation is expected to increase as a result of the increasing difference between winter and summer precipitation. A change in precipitation patterns with fewer rain events, but of greater intensity will, however, affect surface drainage and thus the formation of groundwater.

Two studies in 2003 and 2004 have indicated the need for extraordinary action in the water area. In its report, the Academy of Technical Sciences pointed in particular to the need to plan the renovation of drainage systems so that they will also be able to function in a future wetter climate. Furthermore, in 2003 the Danish Board of Technology held workshops aimed at the public on the local possibilities for adapting to a global sea-level rise of half a metre. One of the more surprising results was that it was not important to promote construction of fixed installations to secure against flooding of agricultural land. There was some agreement on an approach based on appropriate adaptation through slow, natural development of the coastline if necessary at the expense of agricultural areas.

About 80 % of the population live in urban areas connected to the coast. A total of about 1 800 km of coastline is protected by dykes or other fixed installations. In recent years beach nourishment has increasingly been used to protect exposed stretches of coastline. A special problem is linked to low-lying areas that are exposed to both increases in the sea level and pressure from increasing drainage from the land. In particular, many of the coastal towns near the estuaries of larger rivers or at the bottom of fjords could have complex problems. Merely building higher dykes, for instance, is not a long-term solution as the problem of backwater flooding will just become greater as a result of river water being unable to flow freely into the sea. A long-term solution requires the involvement of river valleys further inland.

There is a need for space for rivers to allow flood plains to flood regularly to take some of the pressure off at river mouths. One of the tools to change land use in river valleys could be through the EU agricultural subsidy schemes, to make river valleys far more multi-functional.

Scarcity and drought issues
The size of the water resource is influenced by both access to ground-water and consumption of water. With the prospect of warmer summers, with greater risks of heavy downpours and longer periods without precipitation or even of drought, Denmark can expect an increased demand for water for several purposes:

- in urban areas a need will arise for cooling and watering of green areas. The existing problems of over-use of groundwater resources close to urban areas could be exacerbated;

- in rural areas the need to irrigate will increase significantly, and the current problems with conflicts of interest between agriculture and natural aquatic environments could be exacerbated.

Just as important as the quantity of groundwater is its quality. Along low-lying coasts, the intrusion of salt water may affect the quality of groundwater. With a rising sea level, salt penetration would present a greater risk, which may lead to limitations on water-extraction possibilities in more places than is the case today.

A1.7.2 Summary of adaptation actions and status

A summary of actions and their implementation status is provided in Table A1.7, drawn from the questionnaires sent to EEA member countries by the EEA and the German Federal Ministry for the Environment (BMU).

A1.7.3 Information on the use of community instruments and other national policies in the context of adaptation, water demand and management

Perceptions on the delivery of drought/scarcity measures and adaptation through the Water Framework Directive (WFD)
Denmark believes that implementing environmental objectives for groundwater will, especially with respect to quantitative status, call for closer scrutiny of the relation between groundwater and surface water in and around urban areas. Drought events are generally not considered to be problem in Denmark today. Recurring and prolonged dry spells in recent summers can signal that they may become so.

Denmark believes that the economic aspects will have to be investigated in relation to the importance of the groundwater abstractions, where the provisions for this are available in the WFD.

Through integrated water resources management as specified in WFD it will be possible to address climate change impacts.

Table A1.7 Water resource adaptation status in Denmark

Adaptation measure	Implemented	Planned	Effective/necessary (but not planned yet)	Not relevant/ necessary
Flood protection				
Technical flood protection	X	X	X	
Natural retention of flood water	X	X		
Restriction of settlement/building development in risk areas		X	X	
Standards for building development			X	
Improving forecasting and information			X	
Improving insurance schemes against flood damage			X	
Drought/low flow protection				
Technical measures to increase supply			X	
Increasing efficiency of water use			X	
Economic instruments	Taxes in order to reduce water consumption were introduced in 1994, but not because of climate change			
Restriction of water uses	X			
Landscape planning measures to improve water balance			X	
Improving forecasting, monitoring, information			X	
Improving insurance schemes against drought damage			X	
Coastal zones				
Reinforce or heighten existing coastal protection infrastructure	X		X	
Retreat strategies, e.g. managed realignment of dams				X
General adaptation measures				
Awareness raising or information campaigns			X	

Water pricing measures implemented
Denmark notes that the use of water pricing has generally had a positive effect on both water use and loss in distribution systems.

Other national policies
Measures operate mostly through financial incentives (levies) and technical (reduction of water loss in distribution systems).

A1.8 Estonia

A1.8.1 Overview of issues and adaptation actions

The impacts of climate change in Estonia are relatively small compared with southern and northern region of Europe. Therefore no significant consequences on biodiversity and public health are expected. Some species may disappear and some new species will probably occur, but these changes will be quite negligible.

The rise in temperature and precipitation will have positive rather than negative effect on the Estonian economy. For example it will probably be favourable for agriculture, especially grassland husbandry. The total growing season will lengthen and a greater number of harvests will be possible. In the case of higher temperatures and higher rainfall, the growth and development of herbaceous plants will quicken, and harvesting times will shift to an earlier period. Livestock will be better provided with fodder in summer and winter.

The main hazards and economic losses in Estonia will result from sea-level rise, which will cause flooding of coastal areas, erosion of sandy beaches and the destruction of harbour constructions. Different models and scenarios forecast different sea-level rise. The maximum expected rise will probably not exceed 1.0 metre. According to this scenario, considerable changes in coastal ecosystems will take place and significant economic hazards can be expected. Different regions of Estonia would suffer for different reasons. Increasing erosion and changes in sedimentation would cause serious disturbance for sandy beaches and dunes, particularly in south-western and north-eastern Estonia. In addition, vanishing sandy beaches will have a negative impact on recreation.

In the western part of Estonia (including the large islands), the direct destruction of the coast will not be so strong. Although seashore plant and animal communities would migrate inland, the interaction of changing water level and land use would result in a decrease in species richness. The economic hazards will be the highest in the urban areas, particularly in Tallinn, the capital, where roads, houses and other constructions are often very close to the present shoreline.

The impacts of climate change in Estonia are relatively small and there is no need to implement specific measures solely because of climate change. As such, factors such as sea-level rise will be solved in connection with water management plans under the WFD, regional planning and requirements on construction.

The results of analysis of water supply and demand indicated no effect of climate change on water use in Estonia. The groundwater resources can guarantee a sufficient supply of good quality domestic water in all regions of the country. Water consumption in towns and other settlements would be independent of the quantity and quality fluctuations of rivers.

A1.8.2 Summary of adaptation actions and status

A summary of actions and their implementation status is provided in Table A1.8, drawn from the questionnaires sent to EEA member countries by the EEA and the German Federal Ministry for the Environment (BMU).

A1.9 Finland

A1.9.1 Overview of issues and adaptation actions

An adaptation strategy was published in January 2005 (Ministry of Agriculture and Forestry, 2005) ([28]). It is based on a set of scenarios for future climatic and economic conditions. The objective of the Adaptation Strategy is to reinforce and increase the capacity of society to adapt to climate change. Adaptation may involve minimising the adverse

Table A1.8 Water resource adaptation status in Estonia

Adaptation measure	Implemented	Planned	Effective/necessary (but not planned yet)	Not relevant/ necessary
Flood protection				
Technical flood protection			X	
Natural retention of flood water				X
Restriction of settlement/building development in risk areas			X	
Standards for building development			X	
Improving forecasting and information		X		
Improving insurance schemes against flood damage				
Drought/low flow protection				
Technical measures to increase supply				X
Increasing efficiency of water use				X
Economic instruments				X
Restriction of water uses				X
Landscape planning measures to improve water balance				X
Improving forecasting, monitoring, information				X
Improving insurance schemes against drought damage				X
Coastal zones				
Reinforce or heighten existing coastal protection infrastructure			X	
Retreat strategies, e.g. managed realignment of dams			X	
Others, please specify:				
General adaptation measures				
Awareness raising or information campaigns				

([28]) See: http://www.ymparisto.fi.

impacts of climate change, or taking advantage of its benefits. While the national energy and climate strategy focuses on mitigation measures to be taken in the near future, the scope of the adaptation strategy extends as far as 2080. The starting point for implementation of the Strategy is that the detailed evaluation of the impacts of climate change and the definition of adaptation measures are integrated into the operations of different sectors and institutions, their planning, implementation and follow-up.

The methods for adaptation, both those by the public sector and those by the private sector, were preliminarily defined in the strategy. The findings in key sectors with particular relevance to water are presented in the Tables A1.9a and A1.9b.

One of the foremost adaptation initiatives is to establish what the risks are. The ongoing research in Finland includes, for example, the development of methods to analyse the risk of hazardous events, regional climate model simulations for projecting the change in the probability of extreme events under a changing climate, and use of regional climate model simulation results in community planning. In addition to the mentioned need for information on flood dangers it is also important to improve society's awareness of the flood risk, noted for example in the final report of the Finnish working group on extreme floods. In land-use planning, the areas vulnerable to floods or high sea levels should be mapped and building on these areas avoided. Furthermore, the ongoing research on flood water retention in the Finnish catchments has led to the need to evaluate the possibilities to increase flood water retention (Silander *et al.*, 2006).

A survey was published by the Finnish Environment Institute in 2004 on how the exceptional severe drought of 2002/2003 affected the use of water resources. The survey, financed by the Ministry of Agriculture and Forestry, included 11 proposals for action in order to be better prepared for severe drought periods in future. As one result of this survey the issue of 'Improving buffering capacity of different types of water use' can be seen comparable to the issues in the Table A1.9b.

A1.9.2 Summary of adaptation actions and status

A summary of actions and their implementation status is provided in Table A1.9c, drawn from the questionnaires sent to EEA member countries by the EEA and the German Federal Ministry for the Environment (BMU).

A1.9.3 Information on the use of community instruments and other national policies in the context of adaptation, water demand and management

Drought/scarcity measures under the common agricultural policy (CAP)
The rural development programmes include investment support to farmers and direct support to small-scale development projects in rural areas. Some of the projects have included elements to improve insufficient or insecure water supply caused by drought conditions. In the next programming period, 2007–2013 similar support seems possible. However, if agriculture moves more from grain to special crops, the need for irrigation will increase and there may be pressure to increase funding for drought-related measures in that sector.

Finland notes that the funds available are probably very limited and that if one compares the cost of the drought 2002–2003 and the EU funds used to cover these costs or to alleviate the problems, it can be concluded that EU funds covered only a very minimal fraction of the costs. Accordingly, it concludes that either EU funds are not sufficient or that those responsible for water supply (utilities, property owners) should take sufficient precautions against the drought events.

Use of structural and cohesion funds
In Finland during 2000–2006, Structural Objective 1 and 2 funding covered elements of improvement of water supplies, particularly in the rural communities. In these projects it is difficult to separate drought-related elements from general improvement of water supply service levels or from improvement of water quality. In the next programming period, 2007–2013, funding available for similar support is likely to be much less and in practice will be limited to the area covered by the Objective 1 (eastern and northern Finland).

Perceptions on the delivery of drought/scarcity measures and adaptation through the Water Framework Directive (WFD)
Finland notes that the WFD will promote a balance between use and need for water and the available water resources and, where imbalances exist, it will define measures to secure justified water use with an acceptable security level. The implementation programme will include these measures and show how these measures will be funded.

In addition it highlights that WFD planning has to define the drought vulnerability of water sources of different abstractions and, where necessary, plan

Table A1.9a Adaptation measures in relation to flooding issues in Finland

Administration and planning	• The evaluation of the impact of climate change will be included in the long-term planning of regional and urban structures • Town planning processes will be associated with a requirement to carry out additional investigations on adaptation to climate change in particularly vulnerable areas (flood risk areas, observation of the micro-climate, terrain and soil, conduction of rainwater and surface waters, construction in shore areas, potential increase in windiness, protective city block areas, avoidance of hollows) • Flood-sensitive areas and structures will be surveyed • Planning of water management • Surveying of risk targets and preparation of general plans for risk targets • Acquisition of temporary flood control structures • Emergency preparedness planning • Land-use planning to reduce flood risks and especially to avoid construction in flood areas • Taking rain-induced floods into account in zoning and urban planning • Flood forecasts • Planning of trenching and stormwater management • Operational flood prevention • Cooperation between authorities
Research and information	• Anticipatory systems and warning systems for extreme phenomena will be developed • Regional and local impacts and means of adaptation will be investigated • Surveying the quality requirements for water at cattle farms and dairy farms • Improvement in the predictability of floods (heavy rains): weather forecasts, weather radar, follow-up of soil dampness and snow/satellites and observation • Studying the impacts of rain induced floods • Surveying the need for temporary flood protection structures, their acquisition and the responsibilities associated with use • Information about flood dangers • Information in flood and drought situations • Instructions from the authorities to reduce flood damage • Restrictions on water use
Economic-technical definitions of policy	• Raising of flood banks • Construction of reserve water intake plants • Compensation for damage caused by exceptional flooding of water systems • Use of temporary flood protection structures • Use of reserve systems • Water management utility companies, disinfection
Normative definitions of policy	• The need to amend the Land Use and Building Act and Decree and municipal building codes will be investigated • Recommendations will be issued at different levels of planning as necessary • Changes to regulation permits • Execution of building regulations • The conduction of rain and surface waters will be improved
Private	• Taking out insurance in the context of a wider action to improve flood damage legislation and insurance. • Construction of buildings farther away from flood areas • Protection of buildings against flood • Increasing the discharge capacity of dams

Table A1.9b Adaptation measures in relation to scarcity and water demand issues in Finland

Economic-technical definitions of policy	• Interconnection of the networks of water management utility companies • Investments in projects that improve preparation for special situations and regional cooperation • Expansion of water supply and sewer networks • Supporting the construction of irrigation systems for agriculture • Transportation of water, water pickup points, bottling of water • Purchasing water from another water management utility company • Distribution of lower quality water
Private	• Construction of irrigation systems • Joining the network of a water management utility company/choosing the location for a well and maintaining its condition • Economising with water, recycling water, introduction of lower-quality water

Table A1.9c Water resource adaptation status in Finland

Adaptation measure	Implemented	Planned	Effective/necessary (but not planned yet)	Not relevant/ necessary
Flood protection				
Technical flood protection		X		
Natural retention of flood water		X		
Restriction of settlement/building development in risk areas	X			
Standards for building development			X	
Improving forecasting and information	X			
Improving insurance schemes against flood damage		X		
Drought/low flow protection				
Technical measures to increase supply	X			
Increasing efficiency of water use			X	
Economic instruments			X	
Restriction of water uses				X
Landscape planning measures to improve water balance			X	
Improving forecasting, monitoring, information	X			
Improving insurance schemes against drought damage				X
Coastal zones				
Reinforce or heighten existing coastal protection infrastructure				X
Retreat strategies, e.g. managed realignment of dams				X
Others, please specify:		X		
General adaptation measures				
Awareness raising or information campaigns			X	

measures to secure the acceptable minimum levels of supply.

Finland believes that the WFD process will use and provide hydrological data that are required when dealing with drought and water scarcity issues and Finland sees no gaps other than that additional elements/refinements may need to be added into the WFD process.

Water pricing measures implemented
In Finland practically all irrigation systems are constructed and operated by individual farmers. There is, therefore, no common pricing policy for irrigation. For other agricultural water (e.g. for livestock and dairy farming) water supply pricing policy applies whenever the water is obtained through public piped water supply system.

The present pricing policy for water supplies is full cost recovery, i.e. the consumer tariff has to cover all costs (capital and operation and maintenance). There are also many sparsely populated areas with long pipelines, where water consumption reduction is not reasonable, because a certain amount of consumption is needed to secure good water quality.

For industries which obtain their water through public piped water supply system, a water supply pricing policy applies.

A1.10 France

A1.10.1 Summary of adaptation actions and status

In 2006, France enacted a major legislative framework (the Water Act 2006) with the aim of ensuring that climate change is taken into account so far as water management is concerned and that France adapts successfully to unavoidable climate change. In 2003, another piece of legislation (the Flood and Risks Act 2003) was enacted, concerning flood risks in particular, which complemented former legislation. Two issues related to climate change are addressed: water demand and supply, and floods.

Water demand and supply
Legislation, such as the Water Act 2006 and the EU WFD, provides a suitable framework for the better management of water demand and supply. This legislation and the drought plan of action, initiated in 2004, also help to organise central government action to better anticipate drought periods and take timely steps. Altogether, the aim is to attain a high level of awareness of climate change to bring about significant change in practices and consumption and help attain a sustainable water management strategy through:

- Priority list of functions in periods of water shortages;
- Finance through taxes on water abstraction;
- Water reservoirs, common management of scarce water resources;
- Regulation of water abstraction;
- Treatment and re-use of wastewater and rain water.

On average, around 34 billion m^3 of water are annually abstracted, of which 82 % is taken from surface waters. As this is practiced mostly during low-water periods, it can have significant effects on aquatic environments and can therefore have an important chronic effect on groundwater, and on surface water resources when groundwaters feed and regulate rivers.

Floods
A piece of legislation was enacted in 2003 (*Loi n° 2003-699 du 30 juillet 2003 relative à la prévention des risques technologiques et naturels et à la réparation des dommages*) which sharpened the tools already available to facilitate the Government Strategy for Flood and Risk Management in France, which is based on:

- land-use, planning and policy guidance (So far around 4 800 hazard exposure plans (*d'exposition aux risques PER*) and risk prevention plans (*de prévention des risques , PPR*), have been approved and implemented;
- flood risk maps, are today available on the internet for almost the whole of France;
- building adaptive capacity : as of today, 42 river basins have been selected to experiment flood risk adaptation measures (budget : EUR 190 million;
- systematic risk awareness culture amongst all stakeholders, public awareness (when buying or renting a place people are informed about flood risks).

An insurance scheme was implemented 25 years ago (Loi n° 82-600 of 13th July 1982) which introduced a special system for the compensation of physical damage caused by natural disasters. On average, EUR 250 million a year are spent to reimburse flood damages. The Flood and Risks Act 2003 and the Water Act 2006 allows the spending of part of these financial resources on adaptation measures rather than reimbursement of flood damages.

A national centre in Toulouse, together with 22 basin centres, in charge of flood alerts was implemented in 2005.

Recently, a study on adaptation was launched. Four pilots are to be implemented on river basins (Meuse, Loire, Gironde and Rhône).

A summary of actions and their implementation status is provided in Table A1.10a, drawn from the questionnaires sent to EEA member countries by the EEA and the German Federal Ministry for the Environment (BMU).

A1.10.2 Summary of adaptation actions and status

A summary of actions and their implementation status is provided in Table A1.10a, drawn from the questionnaires sent to EEA member countries by the EEA and the German Federal Ministry for the Environment (BMU).

A1.10.3 Information on the use of community instruments and other national policies in the context of adaptation, water demand and management

Drought/scarcity measures under the common agricultural policy (CAP)
Under the current programming period (2000–2006) the French rural development programme included 175 agro-environmental measures classified into 30 types. Only one type was directly related to measures addressing water scarcity and droughts: 'reduction of withdrawals at farm scale' and included two measures:

- reduction of irrigated crop areas;
- reduction of the level of irrigation per hectare.

The 2000–2006 rural development programme contributed only weakly to reducing vulnerability to drought and water scarcity situations.

In the next programming period (2007–2013), the national rural development strategy describes the different priorities that need to be covered through each axis. As many issues still need to be covered, compared with the last programme, funds specifically aimed at water scarcity and droughts will remain limited.

Only the 'reduction of the farm irrigated area' measure is planned in order to address scarcity issues. The main improvement in the next programme should be agro-environmental measures in priority areas. However, insufficient local motivation, a priority on farm revenues and coupled support for irrigated crops could limit farmers' commitment to measures of crop conversion.

In addition to agro-environmental measures, the national rural development programme will include investment support to reduce withdrawal pressure on water resources. Two main types are envisaged:

- decision-making tools: meteorology station, thermo-hygrometer, anemometer, material to measure and estimate water needs (tensiometers, soil captors, plant captors etc.), software to pilot irrigation with automatisms, capacimetry sounding lines;

- specific measures to save water: measures for water distribution, system of electronic regulation for irrigation, collecting system to store rain water, sprinkling systems adapted to flower, tree and vegetable production, recycling and treatment systems for washing water used in specialized production in view of their recycling, the use of water-saving washing machines for some production processes.

Use of structural and cohesion funds
For the 2000–2006 programming period it is extremely difficult to estimate the proportion of

Table A1.10a Water resource adaptation status in France

Adaptation measure	Implemented	Planned	Effective/necessary (but not planned yet)	Not relevant/ necessary
Flood protection				
Technical flood protection	X			
Natural retention of flood water	X			
Restriction of settlement/building development in risk areas	X			
Standards for building development	X			
Improving forecasting and information	X			
Improving insurance schemes against flood damage	X	X		
Drought/low flow protection				
Technical measures to increase supply	X			
Increasing efficiency of water use	X			
Economic instruments	X			
Restriction of water uses	X			
Landscape planning measures to improve water balance	X			
Improving forecasting, monitoring, information	X			
Improving insurance schemes against drought damage	X	X		
Others, please specify:				
Coastal zones				
Reinforce or heighten existing coastal protection infrastructure	X	X		
Retreat strategies, e.g. managed realignment of dams		X		
Others, please specify:				
General adaptation measures				
Awareness raising or information campaigns	X			

Note: Most measures taken were implemented even before climate change awareness became of paramount importance.

funds actually supportive of measures or projects aimed at mitigating droughts or water scarcity. In most programmes, several types of action in favour of water issues are gathered in a single measure.

Objective 1 funds are aimed at regions lagging in development. In France, only Corsica and overseas 'departments' are eligible for these funds. Water issues are mentioned in all their programmes, drinking water supply being frequently highlighted, but not explicitly water scarcity issues.

All French regions, except Corsica, had a part of their area eligible for Objective 2 funds. Water issues are mentioned in all regional programmes but the description of the eligible action remains general ('protection and restoration of water resources', 'water management', 'water protection' etc.). There is no evidence that funds are partly used to address water scarcity and drought issues, as qualitative water issues (diffuse pollution for instance) may also be addressed first.

For the 2007–2013 programming period, cohesion policy strategy and resources have been reorganised. The diagnosis on dynamic and diversity of French metropolitan territories points out the bad effects of some excessive withdrawals on water tables and the need for strict water management rules in case of water shortage.

In the next period the programme highlights that 'with respect to WFD objectives, saving water resources notably to anticipate climate change, looking for new sustainable resources and ensuring quality and proximity supplying need to be encouraged. Efforts should be put on adapting consumption behaviours (agriculture, industries).' The 'transboundary and interregional cooperation' objective identifies water management as an issue for possible cooperation.

LIFE funding
From 2000 to 2006, several French projects benefited from LIFE supports but few of the selected projects dealt with water issues; none of them addressed drought and water scarcity issues but focused only on wastewater treatment, diffuse and point-source pollution.

For the next period France is preparing its national annual LIFE + operational programmes, taking into account the draft Commission multi-annual strategic programme. The need of developing an economical management of the water resources was seen by the Ministry of ecology and sustainable development as one priority field for action. But, the tight national envelope and the other priorities that will need to be taken into account will probably permit few funds for water issues. Regarding this last point, it should be noted that several Member States want LIFE + to be used for mainly financing the Natura 2000 network.

EU solidarity fund
France has not received any support for drought events. The only supports obtained in this framework were related to inundations in 2002 (Gard) and 2004 (Rhône). The French request for funds due to forest fires (link with drought event) in 2003 was rejected. Forest fires are a special case due to their nature, which generally only involves a limited part of the population directly affected. It is rarely possible to fill the condition that at least half of the region population is being affected.

Community mechanism for civil protection
France did not use this mechanism in the case of drought events, but did use it once in order to cope with the strong inundations in December 2003, to provide high capacity pumps. The Community Mechanism for Civil Protection is adapted to cases of urgent situations in order to give rapid material and human support to Member States. This tool is not totally adapted to drought and water scarcity events.

Perceptions on the delivery of drought/scarcity measures and adaptation through the Water Framework Directive (WFD)
In terms of scarcity, France notes that as the WFD promotes integrated river basin management it expects an integration of both quantitative and qualitative issues in order to reach good ecological status. This integration is expected when establishing the programme of measures and associated river basin management plans of the Article 11. However, it notes that the integration of both qualitative and quantitative elements is probably not well developed in Article 11. It qualifies this by identifying that while most of the qualitative measures (nitrates, urban waste water, drinking water, priority substances, etc.) are considered as basic measures, all the quantitative measures (new resources, water savings etc.) are considered as supplementary measures. France identifies that this could threaten the achievement of good ecological status in a number of river basins if the main efforts are only concentrated on basic measures. It notes that added quantitative measures will be needed and the question of added costs and social affordability of quantitative measures could be raised in many basins.

In terms of drought events, France notes that it will be taking drought events into account when setting

environmental objectives and potential exemptions to them according to Article 4. However, it notes that droughts could have a significant effect on reaching environmental objectives of the WFD. In relation to this it identifies that a clear common understanding of what constitutes a 'prolonged drought' according to Article 4.6 should be established.

Water pricing measures implemented
In France, there is no specific water pricing for the dry season. As far as possible, the cost of the water and the associated services and also of environmental and resource costs is reflected in the tariffs.

The level of cost recovery in France is over 85 % for households and industry. This cost recovery includes environmental charges (abstraction and discharge) representing an average of about 15 % of the tariffs. All sectors (households, industry, agriculture) have tariffs based on metering, in order to reflect water scarcity. For some cities where there are many tourists in summer, some specific tariffs are in place to take accountof these factors.

Table A1.10b Summary of instruments and initiatives in place in France

Good agricultural and environmental condition **Measure: irrigation water for large-scale farming systems**	Type of measure: statutory requirement conditioning granting of CAP aid	Objective: conserve soil structure by preventing effects of heaping and carrying along upper soil layers. Target: all farmers benefiting from special irrigation aid for cultivation of cereals and oil and protein crops. Contents: obligation of possessing an administrative report receipt and irrigation authorisation certificate and presence of means of evaluating volumes. Inspection methods: checking of possession of receipt and certificate and presence of appropriate means of measuring volumes drawn off.
Fiscal measure **Fees (received by water agencies)**	Draft law on water	Water use fees are assessed on volumes drawn off over the year. Rates are adapted to the resource status: they are higher for sampling carried out in sectors classified as a water distribution zone where there is a shortfall between supply and demand. In water distribution zones, a discount is operated if the water drawn off for agricultural usage is organised by a collective management body. The purpose of this measure is to encourage collective management of resources. Rates also depend on water usage: there is differentiation between domestic use (drinking water) and the various economic uses (agriculture, cooling, industry and navigation).
Fiscal measure **Fees (received by water agencies)**	Draft law on water	Adaptation of fee rates to incorporate diversity of territories concerning the target results adopted in management plans. Fee zoning is to be consistent with statutory zoning.
Management measure	Plan for environmental modernisation of equipment	Encourage farmers to adopt well thought-out practices and better conduct of irrigation.
Statutory measures related to management measures	Plan for management of water scarcity	On the scale of catchment areas lacking in water, programmes can be drawn up based on the following measures: • Reduce water volumes allocated to irrigation in certain basins in a particularly critical situation, in order to supply water catchment areas and conserve the aquatic environment. Financial aid can be provided. Reduction in volumes can be made compulsory, if needs be. • Foster creation of substitution reservoirs as long as they are managed collectively in catchment areas where this is ecologically feasible and under reasonable economic conditions. The water agencies will conduct studies on the overall impact per catchment area in order to identify basins and appropriate measures. • On the initiative of district councils, authorise the administrative authorities to set up quantitative backup zones to conserve catchment area volumes required to supply water to the locals under good conditions.

For agriculture, the cost recovery can vary from 40 % for some collective systems (with dams and channels) to 100 % for individual systems.

Other national policies
A number of instruments and initiatives are in place. these are summarised in Table A1.10b.

A1.11 Germany

A1.11.1 Overview of issues and adaptation actions

Flooding issues
Flood control will, in future, take into account possible increases in the frequency and probable increases in discharge volumes. For example, Baden-Württemberg and Bavaria — following studies in the Neckar catchment area which revealed for 2050 an increase of around 40 to 50 percent in small and medium flood discharges and of around 15 percent in 'hundred-year' floods — introduced a 'climate change factor' which is to be taken into account in any new plans for flood control measures.

Appropriate flood precautions should ensure adequate retention of floodwater in suitable areas and give preference to a precautionary approach to land designation that restricts building and other uses on flood plains, encourages a preventive line in building and other aspects of human behaviour, and takes in disaster prevention and technical flood control.

In a survey of experts, most of the flood-control measures were regarded as already partially introduced. Further efforts are required for giving more space to the rivers and for the designation of flood areas. There are, however, differences in implementation between the individual *Länder*, partly due to regional differences in flood risk. There is a need for further implementation of flood prevention measures including the Flood Control Articles Act which entered into force in May 2005. These include improvements in short-term forecasts of high water, the designation of flood areas, and implementation of hydraulic engineering and maintenance measures in a manner that has a neutral impact on flooding and takes account of environmental criteria.

Dyke retrenchment measures, restoration of flood-plain forests and re-connection of old river arms are regarded by experts as effective flood control measures for rivers. These measures are regarded as partially implemented. Restrictions on use in flood areas, such as restrictions on new building and on handling substances dangerous to water — e.g. non-use of oil-fired heating systems — are already regulated by law.

Insurance for flood damage is already possible. To date, however, there has been little demand for such damage policies. Nevertheless, since insurance for flood damage is a significant factor in the context of individual flood control precautions by the public, the possibility of introducing compulsory insurance for damage due to the elements, such as flooding, hail and windstorms, has already been discussed — most recently in the wake of the Elbe floods in August 2002.

Water demand and scarcity issues
Those areas that already have an unfavourable water balance and possess low water retention capacity as a result of their geological situation and soil conditions are particularly sensitive to dry periods and drought. This applies especially to the central parts of eastern Germany. Here it is mainly the agricultural and forestry sectors that are affected.

Different sectors (navigation, energy, agriculture or water supply and sanitation) may be affected by low water conditions. Conflicts between different sectors or different water requirements could be intensified, e.g. using water for cooling in power plants may further increase water temperature and have an effect on the living conditions of aquatic ecosystems. Therefore low water and dryness require not only sustainable land-use management that safeguards the residence time of the water in the countryside, but also appropriate infrastructural precautions, such as adequate water stocks in reservoirs or facilities for making sufficient water available in the areas affected by means of long-distance water pipelines. Industry should exhaust all possibilities of water-saving production and — where possible — reduce power plant capacities and use modern cooling technologies to reduce water requirements. Agriculture and forestry should prepare for possible water shortages by using crops adapted to drought stress and modern water-saving irrigation systems. The public must be made familiar with sensible water-saving measures. Experts estimate that such water-saving measures are already partially introduced.

A1.11.2 Summary of adaptation actions and status

A summary of actions and their implementation status is provided in Table A1.11, drawn from the

Table A1.11 Water resource adaptation status in Germany

Adaptation measure	Implemented	Planned	Effective/necessary (but not planned yet)	Not relevant/ necessary
Flood protection				
Technical flood protection	X	X		
Natural retention of flood water	X	X	(X)	
Restriction of settlement/building development in risk areas	X	X	(X)	
Standards for building development	X	(X)	(X)	(X)
Improving forecasting and information	X	(X)	(X)	
Improving insurance schemes against flood damage	(X)		X	(X)
Drought/low flow protection				
Technical measures to increase supply	X	(X)	(X)	(X)
Increasing efficiency of water use	X	(X)		
Economic instruments	(X)	(X)	X	(X)
Restriction of water uses		(X)		X
Landscape planning measures to improve water balance	X	(X)	(X)	
Improving forecasting, monitoring, information	X	(X)	(X)	
Improving insurance schemes against drought damage			(X)	X
Coastal zones				
Reinforce or heighten existing coastal protection infrastructure	X	(X)		
Retreat strategies, e.g. managed realignment of dams	X	X		
General adaptation measures				
Awareness raising or information campaigns	X	X	(X)	

questionnaires sent to EEA member countries by the EEA and the German Federal Ministry for the Environment (BMU).

A1.11.3 Information on the use of community instruments and other national policies in the context of adaptation, water demand and management

Perceptions on the delivery of adaptation through the Water Framework Directive (WFD)
The Water Framework Directive aims at achieving good surface water status, this includes improvement of water quality as well as improvement of the ecological structures. The impacts of climate change could indirectly influence water quality. Such investigations have not yet been made. The effects of climate change on the water balance are not part of the Water Framework Directive. Positive effects could be reached indirectly by an improvement in the hydromorphology structures. Altogether, the planned Directive on assessment and management of flood risks will have a greater relevance to adaptation to climate change.

A1.12 Greece

A1.12.1 Overview of issues and adaptation actions

Investigations
The first systematic efforts for the estimation of future climate change in Greece and in the broader Balkan region were carried out recently (2004–2005) by the research group Climate, Weather, Water and Sustainability of the National Observatory of Athens (NOA). The implementation of a regional climate model was selected, which allows for the supply of information and climate projections in a small geographical scale. This research effort constitutes the first attempt of Greek scientific institutions to carry out simulations of climate change in the long-term future. Specifically, the research group established and calibrated PRECIS, a regional climate model which was developed at the Hadley Centre (The MetOffice, UK).

At the beginning of 2005, the research group, of NOA carried out a research activity on the assessment of climate change impacts on agricultural cultivation in Greece.

An integrated study at the national level for estimating the vulnerability of Greek coastal areas to climate change is yet to be carried out. Some research studies focus on some particular regions of the country, as for example the wetland Alyki Kitrous in the Delta of the river Axios (2003), the Kotihi lagoon (2003), and Kos (2002). The research group Energy Planning and Sustainable Development of NOA is in the progress of assessing climate change impacts on Greek coastal areas.

In January 2003 a study on the management of water resources (Draft Programme for the Management of Water Resources in Greece) was completed. In addition, an important project was the development of the National Bank of Hydrologic and Meteorological Information, the implementation of which was assigned by the MEPPPW to the National Technical University of Athens (NTUA).

Water management
Major issues within the sector are the promotion of sustainable management of water resources and the integrated protection of the aquatic environment and aquatic ecosystems. Within this framework, full implementation in practice of the demands of the WFD is particularly important. The compilation of national plans for the management of water resources for the whole country is in progress (while on the island of Crete the relevant plan has already been completed) under the responsibility of the Ministry for Development.

Desertification
Desertification is a significant concern and constitutes a complex phenomenon, resulting from the extreme degradation of soil and water resources in a region. Necessary actions for dealing with this problem, as foreseen by the National Action Plan for Combating Desertification (2001) and the relevant Common Ministerial Decision for its implementation (Common Ministerial Decision 996005/31719), are integrated within the general national development programme and specifically for endangered regions. The National Action Plan sets as an objective to combat efficiently desertification trends in 35 % of the Greek territory that is under direct threat, and to prevent the desertification process in 60 % of the national territory. The following main actions have been implemented to date:

Over the period 2000–2004, members of the National Committee for Combating Desertification, in collaboration with universities and research institutes in Greece and abroad, undertook a significant number of research projects and studies on the process of desertification in Greece, as well as on prevention and mitigation techniques. These activities represented the scientific basis for compiling a map of areas of Greece threatened by desertification in order to prioritize actions and a national map of the quality of different soils, their degree of vulnerability to degradation and desertification and appropriate sustainable uses. This map will be used for the implementation of the new agricultural policy of the European Union.

In addition, the National Committee for Combating Desertification collected and published a special volume of relevant research studies carried out by Greek researchers on issues related to desertification, which provides a scientific basis for planning and implementing technical and socio-economic measures and actions to combat desertification. The National Committee has carried out specific studies concerning:

- control and warning system for the risk of desertification;
- communication system for informing competent authorities;
- national reports on the actions undertaken for combating desertification;
- participation in the compilation of a programme against nitrogen pollution.

Ongoing activities in relation to water and adaptation
A number of ongoing actions are related directly or indirectly to the integrated management of desertification and the rational management of water resources. These include:

- implementation of the Framework Directive 2000/60/EC for Community action in the field of water policy (the WFD);
- collective projects for land reclamation (reservoirs for surface run-offs, irrigation networks including their maintenance/improvement, implementation of new technologies for the efficient exploitation of irrigation, pond reservoirs);
- enhancement of underground aquifers and actions preventing the increase of salinity;
- emergency actions for water drought and
- measures for treatment and reuse of wastewater.

A1.13 Hungary

A1.13.1 Overview of issues and adaptation actions

In order to tackle the increasing risk stemming from global climate change, and to support the improvement of the domestic climate policy, the Ministry of Environment and the Hungarian Academy of Sciences launched a common research programme titled VAHAVA — *'VAltozas-HAtas-VAlaszadas'* (change-impact-response), 'The domestic effects of global climate change, and the answers to be given to the challenge' in 2003.

The final report from the project will be published in 2006 and will summarise the unfavourable effects of varying frequency and intensity of meteorological events from global climate change, the main elements of the national strategy on adaptation to climate change (preparation, mitigation, harm reduction, restoration), and will suggest measures for the future to mitigate and adapt to climate change.

The most important recommendation of the VAHAVA project is that the Hungarian Parliament should enact a decree on long-term greenhouse gas emission reduction and adaptation in the frame of a National Climate Change Strategy, including the National Drought Strategy. The climate strategy is to be harmonised with international commitments, integrated into existing development plans and concepts, set priorities, and define the role and responsibility of the Government in execution, evaluation and monitoring of progress.

In Hungary the hydrological impacts of climate change, with increased flood frequency and intensity, are that the water stock parameters are likely to decrease.

With the predicted changes, due to increased evaporation, the surface area of several smaller lakes will decrease significantly, and several of the lakes in the Great Hungarian Plain will dry up which will decrease the extent of wetland habitats and cause a loss of natural values of the country. Along with the decrease in the water circulation, their saline content and the risk of eutrophication are increasing. These impacts will have a negative influence on biodiversity and the economy.

Hungarian agriculture and forestry has suffered from extensive droughts in successive years. This condition has been a research interest of several scientists, investigating whether climate change could be an explanation of droughts. It has been found, among other results, that in Hungary an average temperature increase of 1.5 % and an average precipitation decrease of 15 % would result in a 30 % increase in the drought index. Such a change would significantly increase the exposed agricultural areas. The ecological balance of saline pasturelands is very sensitive to climate change. Also there is a likelihood of significant increase of forest and bush fires even in the case of modest increase of average temperature.

A1.13.2 Summary of adaptation actions and status

A summary of actions and their implementation status is provided in Table A1.13, drawn from the questionnaires sent to EEA member countries by the EEA and the German Federal Ministry for the Environment (BMU).

A1.13.3 Information on the use of community instruments and other national policies in the context of adaptation, water demand and management

Drought/scarcity measures under the common agricultural policy (CAP)
Hungary notes that it has no EU tools under CAP for activities in connection with water scarcity and drought (or under other funds).

Perceptions on the delivery of drought/scarcity measures and adaptation through the Water Framework Directive (WFD)
Hungary believes that the RBMP process will indirectly help resolve the balancing of water availability, and meeting of water demands, where this is meant to be in connection with public involvement, especially in finding generally acceptable and sustainable solutions.

In terms of droughts, it believes that the accompanying appropriate and purposeful water management and infrastructure for water retention (and possible treatment) will reduce the damage caused by serious and prolonged drought events. In terms of gaps, Hungary notes that drought prevention and mitigation measures should be included in the programme of measures as they would serve the objectives of the WFD as well as others.

Water pricing measures implemented
In Hungary, water pricing policy varies depending on the ownership of the water works. In the case of local-government owned works the price is determined by the council of the municipality, while in the case of state-owned works the decision on price is made by the Minister of Environment and Water in agreement with the Finance Minister.

The Water Management Act stipulates that water users shall pay a water resource charge on the quantity of water committed in their water license or used without a license, or on the quantity actually consumed by industrial users. A recent amendment of the Act has erased the tariff system for agricultural use, both from surface and groundwater. This measure unfortunately does not support the sustainable use of water resources.

Other national policies
Resolution 2142/2005. (V2. 14.) of the Hungarian Government identifies the tasks of a Hungarian drought strategy as follows:

(a) development of the Hungarian Drought Strategy and to present it to the government;

(b) development of a National Action Plan based on the National Drought Strategy and to present it to the government.

The present version of the national drought strategy (to be approved) states that drought can affect the whole of society and requires a systematic approach to mitigate its consequences. It envisages the establishment of a National Drought Committee and a Drought Fund.

Table A1.13 Water resource adaptation status in Hungary

Adaptation measure	Implemented	Planned	Effective/necessary (but not planned yet)	Not relevant/ necessary
Flood protection				
Technical flood protection	Raise dykes along the most important rivers	Enhancement of 'emergency reservoirs' in protected floodplains (behind dykes), into which part of floods can be diverted temporarily		
Natural retention of flood water				
Restriction of settlement/building development in risk areas		X		
Standards for building development				
Improving forecasting and information	X	X		
Improving insurance schemes against flood damage				
Drought/low flow protection				
Technical measures to increase supply	Water reservoirs and water transfers are accepted adaptation measure at present			
Increasing efficiency of water use	The water-safe micro-irrigation is at present used in a limited way	X		
Economic instruments				
Restriction of water uses				
Landscape planning measures to improve water balance				
Improving forecasting, monitoring, information				
Improving insurance schemes against drought damage				
Coastal zones				
Reinforce or heighten existing coastal protection infrastructure				
Retreat strategies, e.g. managed realignment of dams				
General adaptation measures				
Awareness raising or information campaigns				

A1.14 Iceland

A1.14.1 Overview of issues and adaptation actions

Most climate change measures adopted in Iceland aim at curbing emissions of greenhouse gases, and emphasis on adaptation measures has been minimal. The IPCC predicts that the rise in sea level will be 21 cm during the period 1990–2050 (3.5 mm per year), and 29 cm from 2050 to 2100 (5.8 mm per year). The most important adaptation measures are likely to involve changes in the design and/or operation of hydropower stations, dams, harbours, bridges and other structures that are affected by changes in the flow of rivers and a rise in sea level. Expected sea level rise has already been taken into account in the design of new harbours in Iceland.

A1.14.2 Summary of adaptation actions and status

A summary of actions and their implementation status is provided in Table A1.14, drawn from the questionnaires sent to EEA member countries by the EEA and the German Federal Ministry for the Environment (BMU).

A1.14.3 Information on the use of community instruments and other national policies in the context of adaptation, water demand and management

Perceptions on the delivery of adaptation through the Water Framework Directive (WFD)

The WFD will help to secure relevant background data free from climate change impacts, so that remedial measures and/or (other) man made impacts may be evaluated separately.

A1.15 Ireland

A1.15.1 Overview of issues and adaptation actions

In Ireland, climate change is likely to result in increased competition for water resources during the summer months. Irrigation is likely to become necessary for some agricultural practices. Projected

Table A1.14 Water resource adaptation status in Iceland

Adaptation measure	Implemented	Planned	Effective/necessary (but not planned yet)	Not relevant/ necessary
Flood protection				
Technical flood protection				X
Natural retention of flood water				X
Restriction of settlement/building development in risk areas			X	
Standards for building development				X
Improving forecasting and information		X		
Improving insurance schemes against flood damage				X
Drought/low flow protection				
Technical measures to increase supply				X
Increasing efficiency of water use				X
Economic instruments				X
Restriction of water uses				X
Landscape planning measures to improve water balance				X
Improving forecasting, monitoring, information		X		
Improving insurance schemes against drought damage				X
Coastal zones				
Reinforce or heighten existing coastal protection infrastructure			X	
Retreat strategies, e.g. managed realignment of dams			X	
General adaptation measures				
Awareness raising or information campaigns			X	

reductions in soil moisture will also have implications for agricultural practices.

Increased winter and spring precipitation as well as more frequent wetting and drying may affect the nutrient status of many soils.

Reductions in groundwater levels are projected to occur. These will have significant implications for groundwater supplies. Therefore private wells and septic tanks are likely to become less viable. The most notable reductions in surface water are simulated for the east of the country including the greater Dublin area which is densely populated and experiencing significant population growth.

The economy of Ireland is largely service-driven. Nevertheless, industrial activities that rely on a substantial supply of water may come under increasing pressures, for example the concrete industry. Likewise, many of the major cities and regional towns have developed along rivers, where increases in flooding are likely to cause significant damage to property and infrastructure. For coastal areas, sea level rise is likely to compound this problem.

In terms of biodiversity, climate change, including changes in precipitation patterns, may result in a loss of biodiversity in salt marshes and sand dunes. Montane heaths and peatlands are also susceptible as an increase in temperature and summer drying is likely to prove detrimental to a habitat already on the cusp of existence.

In terms of human health the main impacts are likely to be derived from changes in hazard exposure, especially increased flooding events. Increased flooding is also likely to be associated with increased outbreaks of cryptosporidiosis where water treatment plants are unable to cope with flow volumes. Those most vulnerable to climate change are likely to be the very old, the very young and the sick.

A1.15.2 Summary of adaptation actions and status

A summary of actions and their implementation status is provided in Table A1.15, drawn from the questionnaires sent to EEA member countries by the EEA and the German Federal Ministry for the Environment (BMU).

Table A1.15 Water resource adaptation status in Ireland

Adaptation measure	Implemented	Planned	Effective/necessary (but not planned yet)	Not relevant/ necessary
Flood protection				
Technical flood protection		X	X	
Natural retention of flood water	X (SUDS*)		X	
Restriction of settlement/building development in risk areas		X		
Standards for building development		X		
Improving forecasting and information	X	X		
Improving insurance schemes against flood damage			X	
Drought/low flow protection				
Technical measures to increase supply		X		
Increasing efficiency of water use		X		
Economic instruments	X	X		
Restriction of water uses			X	
Landscape planning measures to improve water balance			X	
Improving forecasting, monitoring, information	X			
Improving insurance schemes against drought damage			X	
Coastal zones				
Reinforce or heighten existing coastal protection infrastructure	X	X		
Retreat strategies, e.g. managed realignment of dams				X
General adaptation measures				
Awareness raising or information campaigns	X	X		

* SUDS = Sustainable Urban Drainage System.

A1.15.3 Information on the use of community instruments and other national policies in the context of adaptation, water demand and management

Perceptions on the delivery of adaptation through the Water Framework Directive (WFD)
Programmes under the WFD help both to raise awareness of critical water resources issues and to put in place catchment management plans. The latter enable integrated management of river basins and as such provide an important starting point for the assessment of adaptation options. Given the importance of climate change it would be ideal if, under the programme of measures, each RBD were to conduct a climate impact assessment given that important local issues vary much between basins.

In terms of the good quality status of river bodies and the wealth of information that has been gathered on both point and diffuse pollution sources, an assessment of the impact of climate change on water quality is required. The programme of measures, in order to meet the objective of sustainable water use and supply, could include an assessment of the areas from which greater demand is likely in the future.

In Ireland it is likely that in some regions, especially the south and east, irrigation will be required to keep certain crops viable. Irrigation both increases competition for available resources as well as increasing the risk to water quality. The scientific and political systems required for decision making for adaptation could also be capitalised on under the WFD. The structures incorporated into the programme offer a perfect platform from which important decisions can be made and implemented.

A1.16 Italy

A1.16.1 Information on the use of community instruments and other national policies in the context of adaptation, water demand and management

Drought/scarcity measures under the common agricultural policy (CAP)
For the implementation of the Rural Development Plan, Italy (i.e. its Ministry of Agriculture and Forests) identified quantitative protection and improvement of water resources as a main objective to be tackled at the regional scale. As a consequence, the National Strategic Plan includes specific measures for water quantitative protection especially under Axis 1 (Improvement of agricultural sector and forestry competitiveness) and Axis 2 (Environmental and rural areas improvement).

Use of structural and cohesion funds
A number of structural funds apply in Italy including, for 2000–2006, irrigation networks and drinking water distribution networks (not only for water emergencies). Italy identifies that there is no automatic progression from promoter actions to a routine adoption of advanced tools that take account of a regular maintenance of monitoring, forecasting and prevention systems.

In terms of cohesion funds, Italy has a water programme. It notes the importance of European funds (in addition to national resources) for implementing comprehensive metering of macro-consumption and monitoring of available supply systems (natural and artificial) in order to provide necessary information for water crisis prevention.

LIFE funding
In terms of LIFE funding Italy notes that this does not include water scarcity and drought management among the priority areas of action. Regarding this gap, Italy made some comments to the new LIFE + Programme in order to insert water quantity protection among the priority areas of action under the theme 'Environment and health and quality of life' of Life + Component 2 (Environment Policy and Governance).

Perceptions on the delivery of drought/scarcity measures and adaptation through the Water Framework Directive (WFD)
Italy recognises the importance of the WFD as a means of promoting effective water management and providing a means of enforcing the integration of qualitative and quantitative water aspects. It also notes that better integration of quantitative and qualitative elements is necessary.

In terms of droughts, Italy notes the advantages of the WFD for promoting prevention/monitoring/ of sub-plans for proactive measures. It suggests that the adoption of a European Drought Watch and implementation of the National Monitoring Systems would be a useful addition.

Water pricing measures implemented
Italy notes that its water pricing policy does not provide adequate incentives for users to use water resources efficiently, with the exception of a tariff

regulation for the civil sector. It notes that a water pricing policy exists but that water sector reform is incomplete and different prices exist according to the areas of reference. Central Italy is characterised by the highest price of the Integrated Water Service.

Other national policies
The existing national legislative instruments established are L. 183/89, L.36/94, L.152/99 but these provide a sectoral regulatory framework and integrated regulation for WFD implementation is necessary.

Currently a new national law, L. 152/06 (which integrates the new EC environmental directives) has been adopted and implementation is under discussion. Moreover, in order to address water crises, water emergency regulations have been introduced to provide both technical and financial support.

Recently, ad hoc organisations have been created in order to provide crisis management, for example, a 'drought control room' for drought events in the Po river basin and a Coordination Unit for the management of water resources shared between the Puglia and Basilicata regions in order to regulate the use of water and take necessary measures to prevent water crises.

Regarding the agricultural sector, Italy implemented a National Plan for irrigation and specific funds are also allocated to deal with the effects of extreme events (including drought).

A1.17 Latvia

A1.17.1 Overview of issues and adaptation actions

In the past 20–30 years, the force of devastating autumn and winter storms in Latvia (as observed also elsewhere in Europe and globally) has been increasing and the drifts of wind-borne water mass in the coastal area are getting higher. At the same time, winters are getting warmer — without coastal ice in the shallow sea zone and freezing of soil. As a result, erosion of the coast increases. As 62 % of the 496.5 km long coastal line (corresponding to 27 % of the total border length) in Latvia is considered an area of increased risk from erosion, every year monitoring of the geological processes on the sea coast is carried out within the scope of the National Environmental Monitoring Program.

The low sandy coasts with dunes (the Baltic Sea coast from Pape to Jurmalciems and around the furthest point on the western coast of Latvia) are the most vulnerable to erosion. About 2 % of the total coastal line is occupied by coastal areas reinforced with hydro-technical constructions and port territories. Therefore, one of the essential measures to minimise the adverse effects of coastal processes leeward of piers caused by ports, external hydro-technical structures and navigation channels is the dumping of materials regularly dredged from ports and waterways in these shallow water zones (5–6 m). It is worth noting that more than one million inhabitants, constituting a little less than half of the total population, live in a 5–10 km wide area along the coast of the Baltic Sea and the Gulf of Riga. It is important to protect the pre-dunes from trampling (especially in the summer) and construction. The Law on Protected Belts (1997) defines the principles for establishing a protected zone along the coast of the Baltic Sea and the Gulf of Riga — this belt is established to decrease the impact of pollution on the Baltic Sea, preserve forests for their protective function, avert the development of erosion process, protect the coastal landscape, ensure protection, preservation and sustainable long-term use of coastal nature resources and other important public territories, including those needed for leisure activities and tourism.

A national adaptation programme will be elaborated as a result of awareness of the vulnerability of Latvia to the expected climate change impacts in the Baltic Sea region (change of precipitation, temperature, river run-off and ice regime, vegetation period, increased frequency of severe storms and flooding, change of flora and fauna, etc.).

A1.18 Lithuania

A1.18.1 Summary of adaptation actions and status

A summary of actions and their implementation status is provided in Table A1.18, drawn from the questionnaires sent to EEA member countries by the EEA and the German Federal Ministry for the Environment (BMU).

Table A1.18 Water resource adaptation status in Lithuania

Adaptation measure	Implemented	Planned	Effective/necessary (but not planned yet)	Not relevant/ necessary
Flood protection				
Technical flood protection	X			
Natural retention of flood water				
Restriction of settlement/building development in risk areas	X			
Standards for building development				
Improving forecasting and information	X	X		
Improving insurance schemes against flood damage	X	X		
Drought/low flow protection				
Technical measures to increase supply				
Increasing efficiency of water use				
Economic instruments				
Restriction of water uses				
Landscape planning measures to improve water balance				
Improving forecasting, monitoring, information				
Improving insurance schemes against drought damage				
Coastal zones				
Reinforce or heighten existing coastal protection infrastructure	X (particularly important)			
Retreat strategies, e.g. managed realignment of dams				
General adaptation measures				
Awareness raising or information campaigns				

A1.19 Malta

A1.19.1 Information on the use of community instruments and other national policies in the context of adaptation, water demand and management

Perceptions on the delivery of drought/scarcity measures and adaptation through the Water Framework Directive (WFD)
Malta believes that integrated management of water resources will be defined more holistically through the river basin management plan and that this will help to address scarcity issues. However, it notes that a limitation is that there is no recognition of the impact of water scarcity on the achievement of the environmental objectives required under Article 4 of the WFD.

In terms of droughts, Malta notes that clear mitigation measures and contingency plans will be required under the WFD.

Water pricing measures implemented
No pricing policies been developed to date.

Other national policies
No national legislative and financial instruments have been established so far to address water scarcity and droughts. However, 60 % of the public water supplies are procured from desalination facilities.

A1.20 The Netherlands

A1.20.1 Overview of issues and adaptation actions

Adaptation to climate change impacts has gradually gained importance on the political agenda. For example, Parliament recently requested to be informed of the current status of climate research and specifically on adaptation (Dutch Parliament, 2004). In addition the Dutch Senate requested the government to take climate change into account in its long-term policy pans and investment strategies (Dutch Senate, 2005). Ministries increasingly consider adaptation measures for integration into their sectoral policies.

The focus of climate change adaptation is on mainstreaming and 'no regrets' strategies. Climate

change and adaptation measures are strongly integrated into the water policy agenda. The Dutch water policy (Ministry of Transport, Public Works and Water Management, 2000) recognises that in the coming years increasing water levels in the rivers and the accelerated rise in sea levels will mean that technical measures, such as raising dykes, will no longer be sufficient. The policy is to allow more space for water. In order to prevent floods, rivers are allowed to expand into side channels and wetland areas. Greater emphasis is also placed on managing water levels rather than keeping the water out.

Safety continues to be the top priority. Other goals are to avoid destruction of the considerable cultural, historical and natural value of the river landscapes. Guiding principles are:

- anticipating instead of reacting;
- following a three-step strategy (first retention, then storage and, as a last resort, drainage);
- allocating more space for water (e.g. assigning emergency flood areas) in addition to implementing technological measures (e.g. dyke reinforcement); and
- raise beach levels.

The present water policy aims to prepare and protect the Netherlands by 2015 for discharges from the river Rhine of up to 16 000 m^3/s. A follow-up programme is to defend against discharges up to 18 000 m^3/s after 2015 (the highest measured discharge at Lobith is 12 600 m^3/s, in January 1926).

The policy document Room for the River (Ministry of Transport, Public Works and Water Management, 2000), further elaborates on planning for adaptation with regard to the river Rhine. After public consultations the Cabinet submitted the Key Decision to Parliament in 2006 allowing a budget of EUR 2.2 billion to be invested in improving safety against flooding in river areas.

Dredging has been introduced as a way of dynamically managing the main rivers and ports. It offers the opportunity to flexibly interact with, and intervene in, the natural regime of a river.

To secure drinking water supply throughout periods of hot weather, possibilities for fresh water storage in Lake Ussemeer are being investigated.

The provincial authorities are charged with spatial incorporation of water management policy measures. They supervise the municipal authorities in adjusting their zoning plans. These administrative arrangements and an obligatory water assessment ensure that the water policy is integrated into other policy areas, such as spatial planning. The mandatory water assessment was introduced in 2000 for all larger infrastructure and spatial plans that may affect water management. Local authorities implement the water assessment under the supervision of the ministry. The water assessment requires, for example, that where water storage or infiltration capacity is lost this must be compensated for. Climate change adaptation has been an important argument for introducing the water assessment.

Regional authorities and water boards translate the national water policy into so-called Catchment Area Strategies (*Stroomgebiedsvisies*) and Provincial Water Plans. These include the assignment of emergency flood-retention areas.

Adaptation strategies include improved forecasting of extreme weather events to enable farmers to adjust their management practices. Other options that are being studied include crop improvement (with the hep of biotechnology or otherwise), changing planting and harvesting schedules, relocating farms, and insurance. The potential impacts of drought on agriculture are being incorporated into agricultural policy, both at the national and regional levels.

In terms of biodiversity, increase in fresh water peak run-offs causes reduced biodiversity and shellfish stocks, decrease in precipitation and lower groundwater levels in summer cause area loss of wetlands, small rivers and pools, and associated biodiversity.

Increased risk of flooding will mainly affect the coastal zone and lower parts of the Netherlands, which have the highest gross regional product. Floodable areas/low lying parts of the Netherlands are of high economic importance.

A1.20.2 Summary of adaptation actions and status

A summary of actions and their implementation status is provided in Table A1.20, drawn from the questionnaires sent to EEA member countries by the EEA and the German Federal Ministry for the Environment (BMU).

A1.20.3 Information on the use of community instruments and other national policies in the context of adaptation, water demand and management

Perceptions on the delivery of drought/scarcity measures and adaptation through the Water Framework Directive (WFD)

In terms of scarcity, the Netherlands envisages that the WFD will allow Member States to update their insight in structural imbalances between water availability and water demands. It believes that, in order to be ready for facing the future impacts of climate change, countries must have a sound water management system operational now (including the balance between current water availability and water demands). It notes that the obligation to characterise the groundwater status, including insight into these balances, is an important tool in this respect.

In terms of drought events it notes that river basin management plans (RBMP) have to include a summary of the programmes of measures in order to achieve environmental objectives (Art. 4) and may be supplemented by the production of more detailed programmes and management plans for issues dealing with particular aspects of water management. It identifies that when and where needed, a specific drought management sub-plan could be used to supplement the WFD RBMP (Art. 13.5). Many EU Member States already generate drought plans as part of their security of supply procedures.

Anti-eutrophication measures introduced as part of ongoing efforts including the WFD will contribute to maintaining water quality standards in spite of summer droughts and higher temperatures. Restoration of fresh-water marsh, salt marsh and brook systems increase the water storage potential and contribute to flood protection.

Table A1.20 Water resource adaptation status in the Netherlands

Adaptation measure	Implemented	Planned	Effective/necessary (but not planned yet)	Not relevant/ necessary
Flood protection				
Technical flood protection	X (raising dykes)	X (room for the river)		
Natural retention of flood water		x		
Restriction of settlement/building development in risk areas		x		
Standards for building development				
Improving forecasting and information	x			
Improving insurance schemes against flood damage			X (regional water system)	
Drought/low flow protection				
Technical measures to increase supply			X (measures at local level)	
Increasing efficiency of water use			X	
Economic instruments				
Restriction of water uses	X (use of priority list water scarcity)			
Landscape planning measures to improve water balance			x	
Improving forecasting, monitoring, information	x			
Improving insurance schemes against drought damage				
Coastal zones				
Reinforce or heighten existing coastal protection infrastructure	x	x		
Retreat strategies, e.g. managed realignment of dams	X (local. e.g. Wadden islands)	x		
Others, please specify:	X (beach nourishment)	x		
General adaptation measures				
Awareness raising or information campaigns	x	X (within ARK programme)		
Others, please specify:				

Water pricing measures implemented
The Dutch provinces charge for groundwater abstractions in order to cover the costs for groundwater management. On a national basis, there is an environmental levy for groundwater abstractions.

Other national policies
A number of national instruments exist including:

- legislation: for example, national priority list of user functions in periods of water shortages;
- financial: for example taxes for water abstraction; and
- technical: many water distribution structures (66 % of country); many surface water reservoirs (local, regional, national (lake IJsselmeer); groundwater storage (regional).

A1.21 Norway

A1.21.1 Overview of issues and adaptation actions

Norway is in the process of developing a national strategy for adaptation to climate change. The process is lead by the Ministry of Environment but it involves almost all other ministries.

The government recognizes that a number of organizations in both the public and the private sectors should take part in this process. Regional and local levels will also have to be included. Some of the most immediate adaptation priorities fall to organisations responsible for planning and developing major infrastructure, such as transport networks, flood defences and buildings. The Ministry of Environment has alerted and informed the sectoral authorities to ensure that climate change considerations are taken into account in planning processes wherever relevant. An increase in storm activity could increase the demands of the technical installations in the aquaculture industry and ports and sea transport infrastructure. An increase in extreme weather is expected to lead to an increased risk of shipping accidents and oil spills along the Norwegian coast, with an increased risk of farmed salmon escaping and posing a threat to wild fish in Norwegian rivers.

Many sectors are well under way in their response to climate change and research to determine the best measures for adaptation. The national strategy will see all the measures in relation to each other and point out sectors where more work has to be done.

Norway is relatively robust with respect to climate change and climate variability. The country is not particularly vulnerable to sea level rise, it is among the wealthiest in the world and the population is used to a harsh and variable climate. Nevertheless, as the RegClim (national project on climate change scenarios for Norway) results show, climate change will affect Norway, and it will affect some regions, sectors, ecosystems and social groups more than others.

To improve the understanding of climate change and its regional impacts, we will continue to support research on the impact of climate change through national research programmes such as RegClim, Nordic research programmes such as CE (Climate and Energy) and international initiatives such as ACIA (Arctic Climate Impact Assessment), implementing the national follow up from ACIA (NorACIA 2000–2009) and participation in several EU 6. and 7. Framework programme projects.

In Norway, 99 % of the electricity supply is based on hydropower. Therefore a major effect of climate change in water resources will be on the hydropower sector related to e.g. the power production potential, the operation of reservoirs and the flood risk and dam safety. A possible increased frequency and intensity of floods will affect many sectors e.g. urban planning and land planning in general, infrastructure.

Dryer summers or larger variability may affect water supply in general and biodiversity, agriculture, fishery and forestry in particular.

A1.21.2 Summary of adaptation actions and status

A summary of actions and their implementation status is provided in Table A1.21, drawn from the questionnaires sent to EEA member countries by the EEA and the German Federal Ministry for the Environment (BMU).

A1.22 Portugal

A1.22.1 Overview of issues and adaptation actions

The main impacts and vulnerabilities on hydrological resources include:

- a change in the seasonal distribution of river flows, concentrating in winter months, induced by similar distribution patterns of precipitation. This trend exacerbates the seasonal asymmetry

Table A1.21 Water resource adaptation status in Norway

Adaptation measure	Implemented	Planned	Effective/necessary (but not planned yet)	Not relevant/ necessary
Flood protection				
Technical flood protection			X	
Natural retention of flood water				It is not known if this will be relevant
Restriction of settlement/building development in risk areas		X		
Standards for building development				It is not known if this will be relevant
Improving forecasting and information		X		
Improving insurance schemes against flood damage			X	
Others, please specify:	Changed assessment of hydropower production potential A number of the measures mentioned are discussed related to floods in general but not necessarily related to climate change. E.g. Norway has a flood forecasting and information service that is continuously developed and improved.			
Drought/low flow protection				
Technical measures to increase supply				It is not known if this will be relevant
Increasing efficiency of water use				
Economic instruments				
Restriction of water uses				
Landscape planning measures to improve water balance				
Improving forecasting, monitoring, information		X		
Improving insurance schemes against drought damage				It is not known if this will be relevant
Others, please specify:	A number of the measures mentioned are discussed related to droughts in general but not necessarily related to climate change			
Coastal zones				
Reinforce or heighten existing coastal protection infrastructure				
Retreat strategies, e.g. managed realignment of dams				
Others, please specify:				
General adaptation measures				
Awareness raising or information campaigns				It is not known if this will be relevant
Others, please specify:				

in the availability of water in continental Portugal, with a tendency for a reduction in river flows in spring, summer and autumn;

- the relative magnitude of the impact of climate change on river flows increases from the north to the south of the country;
- depending on the scenario, (a) possibility of a reduction in the mean annual flow (in the most pessimistic scenario, a reduction is predicted for 2050 of between 10 %, in the regions on the north of the Douro river, and 50 % in the Algarve region; this tendency may be more pronounced by 2100 assuming that the levels of precipitation are

reduced by 80 % in the Algarve);
(b) possibility of an increase in the annual mean flow between 20 % and 40 % by 2100;

- an increase in the magnitude and frequency of floods, particularly in the north, due to the concentration of precipitation in the winter season, and a predicted increase in frequency of heavy rainfall;
- diminished water quality, particularly in the south region, as a result of a rise in temperature and a reduction in river flows in the summer season;
- falling groundwater tables, especially in near-subsurface aquifers due to the expected reduction in the replenishing rate and increase of evaporation;
- a change in discharge flows from aquifers to rivers due to the expected reduction in replenishment rates;
- degradation of river ecosystems which are dependent on groundwater;
- reduction of the freshwater intake and an increase in saline contamination of coastal aquifers due to saline intrusion, consequence of a rise in sea level resulting from climate change-related increase in temperature;
- change in the level of vulnerability of aquifers to agriculture-related pollution due to changes in land use and agricultural practices.

Continental Portugal is susceptible to droughts, usually associated to the blocking effects of the North Atlantic subtropical high pressure fronts, which impede polar fronts from reaching the Iberian Peninsula. Droughts are common in continental Portugal. However, their frequency and intensity have increased in the last decades of the 20th century. The drought that began in November 2004 was, by the end of the hydrological year (September 2005), the most severe in the last 60 years in terms of land area affected.

A1.22.2 Information on the use of community instruments and other national policies in the context of adaptation, water demand and management

Drought/scarcity measures under the common agricultural policy (CAP)
Portugal identifies that CAP does not include measures explicitly targeted at water scarcity and droughts but notes that there is a diversity of measures that indirectly contribute to prevent scarcity and drought effects (e.g. dams and irrigation works). Portugal is starting to collect data and information for the next CAP period.

Use of structural and cohesion funds
2000/2006: the emphasis is still on completing infrastructure, some of it related to water imbalances (e.g. new over-year and multi-purpose storage reservoirs, major case of Alqueva as a strategic water source for southern provinces of Portugal; urban water supply sources; new distribution networks and rehabilitation).

2007/2013: the emphasis is expected to be an influencing efficiency in main water usages (e.g. Agriculture).

Concerning gaps, there is a lack of criteria for scarcity and efficient use of water for financing selected projects. However, Portugal notes that to evaluate this matter it is starting to collect data and information for the Environment Ministry.

EU solidarity fund
To access this fund there are minimum criteria of EUR 1 000 million or 0.5 % RNB of damage costs. This is much too high to permit Portuguese drought damages to be an accepted candidate for financial support by the fund.

Perceptions on the delivery of drought/scarcity measures and adaptation through the Water Framework Directive (WFD)
Portugal expects that WFD implementation will mitigate present problems related to scarcity and droughts by aiming for sustainable water resource management through the adoption of adequate programmes of measures and river basin management plans.

In particular Portugal notes that, on the demand side some of the fundamental aspects targeting specially mismanagement include: the application of pricing policies; due consideration of the resources and environmental costs; and the promotion of sound management and efficiency in water use.

It is noted that some targets, including compliance with EU directives, are still to be met in Portugal and that EU funds will be a significant tool for implementing these plans. However, it is noted that, even so, some difficulties arising from water scarcity and droughts will continue to be present.

These could be exacerbated by climate change, resulting in episodes with major social, economic and environmental impacts. Significantly, Portugal foresees that the difficulties associated with quantitative problems and resource degradation (small flows, emptying of reservoirs, lowering of aquifers, quality problems, etc.) will ultimately result in not being able to reach the WFD environmental objectives for the affected water bodies.

Concerning gaps, Portugal refers to those previously identified in the 'Why do we need an EU political initiative on water scarcity?' paper.

Water pricing measures implemented
In Portugal all water public services (urban, sanitation, irrigation, navigation and others) apply taxes and tariffs (quantitative calculation). However, these taxes and tariffs do not cover all of the costs and need to be redesigned to include adequate incentives for users to use water resources efficiently.

Data is available for tariffs concerning water supply and sanitation and for irrigation in public schemes, but there is a lack of data in some cases and/or sectors (e.g. industry, private abstractions for agriculture). There are great disparities in tariffs for urban supply, throughout the municipalities, but the Institute for Regulation (IRAR) is establishing a reference model for tariff revision, taking into account principles of cost recovery and equity.

Other national policies
Several legislative instruments have been prepared, to be implemented soon, with technical, economic and financial provisions that will influence water uses:

- a new Water Law: Decree Law 58-2005, 29 December (includes WFD transposition);
- a new water economic and financial regime, which includes all instruments for its enforcement and a specific scarcity coefficient, at finalisation and discussion stages;
- a national plan for water efficiency; and
- related technical instruments: a special effort is being put into producing national databases with reliable data on water use, compiling existing data and campaigning for new data.

A1.23 Romania

A1.23.1 Overview of issues and adaptation actions

Research studies performed by the Romanian Meteorological National Administration climate specialists show an average warming of 0.30 ^{O}C for the period 1901–2000, and is higher in the eastern part of the country than in , the intra-Carpatic region. A decreasing trend of yearly rainfall quantities has been noted, with higher values in the central part of the country and slight increases in the north-east and some southern regions.

Significant statistical changes are noticeable when analyzing the shorter data-series (1961–2000):

- an intensification of the warming phenomenon within the annual average thermal regime, with differences in the spatial distribution of the climate signal compared with the 1901–2000 period (for example, the extent of the regions characterized by significant warming in the south-west and southern part of the country);
- an increase in the annual number of 'tropical' days (daily maximum value > 30 ^{O}C);
- a decrease in the annual number of winter days (daily maximum value < 0 ^{O}C);
- a statistically significant increase in summer minimum average temperature;
- a statistically significant increase in winter and summer average temperatures (up to 2 ^{O}C in the south and south-east during summer time);
- an increase in the maximum duration of periods without rain in the south-west (during winter) and in the west (during summer);
- an intensification of the dry days phenomenon in the south-eastern part of the country;
- a significant increase in the annual number of late frost days in many parts, a phenomenon that has a negative influence on agricultural crops; and
- an increase in the annual number of very rainy days (the highest 12 % daily quantities) and extremely rainy days (the highest 4 % daily quantities) for several stations, during 1946–1999.

To project the impacts of climate change on hydrological resources, a mathematical model of rainfall run-off was used for up to 2075. As a result, the following changes have been projected:

- An increase of evapo-transpiration especially in the summer months due to the increase in the air temperature;
- a reduction in the depth and duration of snow cover due to the increase in the air temperature during winter time. This will lead to a reduction in the pollution risk due to the retention of pollutants in snow cover;
- a reduction in the mean run-off from rivers by 10–20 % due mainly to the increase in evapo-transpiration;
- an earler occurrence of floods and a reduction in mixed spring floods (snow and rain) by desynchronisation of snow melting and rainfall occurrence;
- a decrease in soil moisture, which leads to a reduction in the minimum run-off (in the summer and autumn months) which contributes to an increase in the frequency of pollution eventsand restrictions of water supply.

Due to this situation, in the last ten years, Romania has experienced periods of droughts alternating with extreme floods. The most relevant years have been 2005 and 2006 when Romania was affected by the most severe floods in the last 30 years.

The results of the research carried out on the impact of climatic change on water resources involve the following considerations:

- the development of new criteria and techniques for the design of hydraulic structures to make water management systems more sensitive to modifications of the hydrological regime, due to the impact of climatic variability and climatic changes;
- the elaboration of new procedures for the operation of water management systems to take into consideration the uncertainty in the evaluation of the hydrological regime, due especially to climate changes;
- the development of research on the impact of climatic change on water quality.

Concerning drought issues, there are provisions in the Water Law requiring the development of 'restrictions programmes' in case of droughts. Such programmes have been developed for all river basins. These programmes are updated annually.

Also, each month, the Ministry of Environment and Water Management approves the operation programme of the main reservoirs. When forecasts predict a drought period, restrictions concerning uses other than water supply are imposed.

A1.23.2 Summary of adaptation actions and status

A summary of actions and their implementation status is provided in Table A1.23, drawn from the questionnaires sent to EEA member countries by the EEA and the German Federal Ministry for the Environment (BMU).

A1.23.3 Information on the use community instruments and other national policies in the context of adaptation, water demand and management

Drought/scarcity measures under the common agricultural policy
Measures concerning droughts and water scarcity situations have been provided under the Rural Development Programme. These include measures for irrigation works.

Life funding
The following LIFE projects dealing with adaptation issues have been developed in Romania:

- MOSYM — LIFE 99/ENV/RO/006697 — Modernization of the hydrological information system (three pilot basins Arges, Mures and Siret)
- ASSURE — LIFE 99/ENV/RO/006746 — Implementing of a integrated computational system for urban area pollution (Baia Mare pilot)
- RIVERLIFE — LIFE 00/ENV/RO/000986 –Protection of river life by flood mitigation
- AIRFORALL — LIFE 00/ENV/RO/000987 — Air pollution forecasting in unfavourable climatic and topographical conditions, monitoring and alarm systems
- DIMINISH — LIFE 03/ENV/RO/000539 — Developing an integrated basin management system in a GIS environment for quantitative

Table A1.23 Summary of adaptation actions and status in Romania

Adaptation measure	Implemented	Planned	Effective/necessary (but not planned yet)	Not relevant/ necessary
Flood protection				
Technical flood protection (e.g. raise dykes, enlarge reservoirs, upgrade drainage systems etc.)	x	x		
Natural retention of flood water (e.g. floodplain restoration, change of land use)	x	x		
Restriction of settlement/building development in risk areas	x	x		
Standards for building development (e.g. permeable surfaces, greening roofs etc.)			X	
Improving forecasting and information	x	x		
Improving insurance schemes against flood damage		x		
Others, please specify:				
Drought/low flow protection				
Technical measures to increase supply (e.g. reservoir volumes, water transfers, desalinisation etc.)	x	x		
Increasing efficiency of water use (e.g. leakage reduction, use of grey water, more efficient irrigation etc.)	X	X		
Economic instruments (e.g. water pricing)	X			
Restriction of water uses	X	X		
Landscape planning measures to improve water balance (e.g. change of land use, reforestation, reduced sealing of areas)		X		
Improving forecasting, monitoring, information	x	X		
Improving insurance schemes against drought damage			x	
Others, please specify:				
Coastal zones				
Reinforce or heighten existing coastal protection infrastructure		X		
Retreat strategies, e.g. managed realignment of dams			x	
Others, please specify:				
General adaptation measures				
Awareness raising or information campaigns		X		
Others, please specify:				

and qualitative water monitoring with socio-economic conditions.

Perceptions on the delivery of drought/scarcity measures and adaptation through the Water Framework Directive (WFD)

The Water Framework Directive aims at achieving good water status which is highly focused on qualitative aspects. From this perspective, the impact of climate changes could, on the one hand, indirectly influence water quality. On the other hand, adaptation measures, in order to tackle some effects of climate change, could affect the implementation of the Water Framework Directive. These observations refer to the flood control infrastructure (dykes, river bed regulation, bank protection) and measures taken to deal with the shortage of water during dry seasons (water diversion, building reservoirs on the river).

Water pricing measures implemented

In Romania, economic instruments for water management and protection have been promoted since 1991. Water abstraction charges are the same all over Romania, but differ according to the source of water (inland rivers, Danube, groundwater) and the category of user (industry, household, power plant, irrigation, fisheries).

Water users pay for the quantity of raw water they are entitled to withdraw, (except when water is rationed during drought periods). Substantially higher charges for amounts taken in excess of authorized volumes are imposed.

Other national policies
Based on the painful experience of 2005 and the spring of 2006 , Romania is in the process of reshaping and updating the existing water management schemes and, in this respect, has started to develop a strategy for flood control. This experience has shown that the old patterns are no longer valid in the new climatic conditions and the existing protection works are not effective, as originally designed (because the environmental conditions have changed dramatically). Also, the developments undertaken in the last 50 years have had a major influence in these disastrous floods and require major changes to improve the situation. Romania, also, has started concrete activities in order to enhance its capacity to tackle, particularly, the problem of floods and generally dangerous meteorological phenomena. In this respect the national meteorological system has been modernised and the hydrological system is in process of modernisation.

In order to improve intervention capacity, a large project for improving intervention capacity in the case of floods and accidental pollution is in the process of implementation. This project has a total value of about EUR 135 million and also deals with the improvement of reservoir management, particularly for flood and drought situations.

Romania is also developing a study concerning 'Ecologic and economic re-designing of the Romanian Danube Floodplain' on the basis of which flood control of the Danube will be achieved through a combination of hydrotechical works and wetlands. Table A1.23 summarises adaptation actions and status.

A1.24 Slovakia

A1.24.1 Overview of issues and adaptation actions

Modelling of climate change impacts anticipates a decline in average annual precipitation and an increase in annual air temperature for the total territory of Slovakia for all time horizons. Based on an assessment of run-off distribution, changes in long time-average monthly flows are anticipated in all regions of Slovakia. In all scenarios and all horizons, an increase in winter and spring run-off and a decline in summer and autumn run-off are anticipated.

Adaptation measures to mitigate the negative impacts of climate change are formulated very generally. This is due to the uncertainties of impact assessment. In addition, political, social, ecological, economic and technological considerations are necessary. There is currently a preference for decisions that decrease the risk of negative impacts of climate change and approaches towards sustainable development. The latter includes integrated water resource management.

Basic measures to mitigate potential negative impact in water management deal with several areas:

- direct measures for the water demand side;
- indirect instruments affecting consumer behaviour;
- institutional changes towards better water management; and
- improvement of the operation of existing water management systems.

Measures to address water demand may include a reduction of specific water consumption per capita using technical means, reduction of losses in production and distribution of drinking water, support for the introduction of new technologies in industry, rain harvesting, construction of divided water supply systems in small residential areas and other measures.

Measures to affect consumer behaviour should target subsidies and taxes, charges and fines. At the same time, it will be necessary to enhance public awareness of the impacts of climate change on the quality of life in general, and on the issues of water resources and subsequent measures in particular. The information policy should be connected with education for enhanced environmental awareness of consumers with respect to water resources.

Current water policy does not take into account the need to prepare adaptation measures. The same problem exists in landscape and urban planning. In addition, it is necessary to assess the sustainable use of water resources for existing water reservoirs.

Optimizations of the exploitation and management of existing water systems is required. The forecast trends in the hydrological regime changes indicate

an increased demand to reallocate run-off with respect to individual years and during each year. It will be necessary to consider the possibility of compensating for the decline in the yield of water resources and assess the possibility of the construction of retention reservoirs that would allow for the regulation of run-off.

It is necessary to strengthen the existing systematic monitoring of water quality and water quantity in basins, including smaller ones, in order to improve the identification of water reduction and consequent strategy decisions.

A1.24.2 Summary of adaptation actions and status

A summary of actions and their implementation status is provided in Table A1.44, drawn from the questionnaires sent to EEA member countries by the EEA and the German Federal Ministry for the Environment (BMU).

A1.24.3 Information on the use of community instruments and other national policies in the context of adaptation, water demand and management

Drought/scarcity measures under the common agricultural policy (CAP)

In the current CAP period (2004–2006) no measure is available for addressing water scarcity and droughts. However, in the next period 2007–2013 (which is currently under preparation) Slovakia identifies that the following measures to address water scarcity and droughts are available:

- Rural Development Axis 2 Environment and land management — payments linked to the Water Framework Directive (Art. 38 Council Regulation (EC) No 1698/2005 on support for rural development by the EAFRD);

Table A1.24 Water resource adaptation status in Slovakia

Adaptation measure	Implemented	Planned	Effective/necessary (but not planned yet)	Not relevant/ necessary
Flood protection				
Technical flood protection	X	X		
Natural retention of flood water	X	X		
Restriction of settlement/building development in risk areas			X	
Standards for building development			X	
Improving forecasting and information	X	X		
Improving insurance schemes against flood damage		X		
Others, please specify:				
Drought/low flow protection				
Technical measures to increase supply	X	X	x	
Increasing efficiency of water use	X	X	X	
Economic instruments	X	x		
Restriction of water uses			X	
Landscape planning measures to improve water balance	X	X	X	
Improving forecasting, monitoring, information	X	X		
Improving insurance schemes against drought damage		X		
Others, please specify:				
Coastal zones	n/a			
Reinforce or heighten existing coastal protection infrastructure				
Retreat strategies, e.g. managed realignment of dams				
Others, please specify:				
General adaptation measures				
Awareness raising or information campaigns		X	X	
Others, please specify:				

- incentive pricing of water uses and adequate cost-recovery (rising awareness for water protection and sustainable water consumption).

Perceptions on the delivery of drought/scarcity measures and adaptation through the Water Framework Directive (WFD)
Slovakia identifies that drought and water scarcity is not included in the WFD except in the connection with hydromorphological elements.

The Slovak Hydrometeorological Institute (SHMI) is running many EU projects on the issue, all of them related to the WFD. In 2006 a new project HYDROCARE was started. The task of water balance is being solved as part of the project.

The project will include developing an integrated system for estimation of water sources in the region CADSES — Central, Adriatic, Danubian and South-Eastern European Space, the impacts on hydrological and meteorological events, on the water source quality and quantity, conservation of water sources and environmental magnitudes.

Slovakia has identified that it would welcome more attention on the issue of minimum discharges from the point of view of ecological functioning of rivers as an important factor for the assessment of hydro-ecological status of rivers for the calculation of (and to safeguard) the minimum ecological discharge required.

With regard to this, Slovakia has identified that the hydromorphological assessment supports the assessment of biological assessment and believes that importance of the hydromorphology itself (in the frame of ecological status assessment) is slightly underestimated.

One new task planned for the Slovak Hydrometeorological Institute in 2007 is implementation of, WFD, where the task of drought will be addressed.

Water pricing measures implemented
In the Slovak Republic actual public water supply abstractions are charged (as opposed to the amounts stated in the Water Permission). Irrigation water does not carry a charge.

A1.25 Slovenia

A1.25.1 Overview of issues and adaptation actions

Climate change projections are that meteorological droughts will be more frequent in certain regions. Droughts have also occurred more frequently in Slovenia, even in areas that did not previously experience them.

In 2004 an assessment of the vulnerability of agriculture to the changing water balance for agricultural land was carried out. It was found that every region in Slovenia was experiencing increasing shortages, most of all in northern Slovenia (19 %/10 years) and least in south-east Slovenia (2 %/10 years), while the average for the rest of the country was around 6 %/10 years.

There is also an observable increase in the daily consumption of water from the soil and plants in the past ten years.

Although it cannot accurately be stated how the changing climate will affect regional water resources, it is clear that they are already very vulnerable. Climate change and increased variability will increase competition between sectors for access to water resources. A warmer climate could make droughts and floods more frequent, more serious and longer-lasting. The anticipated higher air temperature, will also increase the reference figure for evapo-transpiration, which will lead to further and more intense droughts.

A range of adaptations will be necessary in the sphere of crop production. These include: changing sowing dates; changing varieties used (exchanging later crops with earlier); more intense fertilisation to compensate for the reduced growing time and water shortage; changes in sowing structure, farm production policy and production technology; changes to crop rotation; improving soil state during droughts by increasing humus/topsoil; construction of irrigation systems to combat negative environmental impact and, if suitable water resources exist for irrigation, guided irrigation using irrigation models and taking into account meteorological conditions and weather forecasts to optimise water use, ensuring permanent and natural balancing of agricultural crop production on irrigated surfaces, and finally protecting agricultural land from extreme conditions.

Table A1.25 Water resource adaptation status in Slovenia

Adaptation measure	Implemented	Planned	Effective/necessary (but not planned yet)	Not relevant/ necessary
Flood protection				
Technical flood protection	X	X		
Natural retention of flood water	X	X		
Restriction of settlement/building development in risk areas	X	X		
Standards for building development		X		
Improving forecasting and information	X	X		
Improving insurance schemes against flood damage		X	X	
Others, please specify:		Management planning to reduce flood risks		
Drought/low flow protection				
Technical measures to increase supply		X		
Increasing efficiency of water use			X	
Economic instruments			X	
Restriction of water uses	X	X		
Landscape planning measures to improve water balance			X	
Improving forecasting, monitoring, information		X		
Improving insurance schemes against drought damage			X	
Others, please specify:		Drought risk management planning		
Coastal zones				
Reinforce or heighten existing coastal protection infrastructure			X	
Retreat strategies, e.g. managed realignment of dams		X		
Others, please specify:		Flood risk management planning		
General adaptation measures				
Awareness raising or information campaigns			X	
Others, please specify:		Land use adaptation		

The numerous problems relating to climate change require training in long-term planning including climate risk analyses, the impact of climate change and variability, methodological recommendations (e.g. water management and quality, and microclimate) and operative decision-making (e.g. crop forecasts, irrigation management, and control of disease and pests). Only in this manner will effective measures be found to prevent or mitigate the consequences of climate change.

The following policies will have to be pursued in relation to supplying agricultural plants with water, given the anticipated changes: preparing preventive measures (i.e. using indicators to monitor agricultural drought), preparing drought management measures (interdisciplinary approach), ongoing analyses of climate change impact in Slovenia (new general circulation models, regional analyses), and updating the methodology for assessment of drought damage.

A1.25.2 Summary of adaptation actions and status

A summary of actions and their implementation status is provided in Table A1.25, drawn from the questionnaires sent to EEA member countries by the EEA and the German Federal Ministry for the Environment (BMU).

A1.25.3 Information on the use of community instruments and other national policies in the context of adaptation, water demand and management

Drought/scarcity measures under the common agricultural policy (CAP)
Measures include actions under Rural Development Programme and irrigation schemes (including water reservoirs). Possible gaps identified by Slovenia include the need to include adaptation measures such as new crops and practices to help address scarcity issues.

Use of structural and cohesion funds
Structural and cohesion funds have been used for the construction of reservoir for regional water supply in a drought sensitive area. There are proposals for using funds in preparation.

EU solidarity fund
Slovenia note that damages do not correspond to the criteria for support under this fund.

Perceptions on the delivery of drought/scarcity measures and adaptation through the Water Framework Directive (WFD)
In terms of water scarcity Slovenia notes the ability to develop criteria for water scarcity areas where WFD objectives are unlikely to be met/difficult to sustain but seems to identify a need for guidance on defining such areas.

In terms of drought events, Slovenia foresees that the WFD will promote the development of management tools to prevent water status deterioration.

Programmes of measures under the WFD should take into account trends related to water deficiency based on different climate change scenarios and based on assessments of the pressures due to climate change on the status of water bodies

Water pricing measures implemented
No water pricing measures have yet been implemented (but the future existence of these is implied under the principles of cost recovery under the WFD).

Other national policies
The national environmental programme has defined the preparation of 'drought-sensitive areas' and possible preventive measures.

A1.26 Spain

1.26.1 Summary of adaptation actions and status

Spain has recently published a National Adaptation Strategy. A summary of actions and their implementation status is provided in Table A1.26, drawn from the questionnaires sent to EEA member countries by the EEA and the German Federal Ministry for the Environment (BMU)..

A1.26.2 Information on the use of community instruments and other national policies in the context of adaptation, water demand and management

Drought/scarcity measures under the common agricultural policy (CAP)
Spain identifies the following examples of actions eligible in the context of water scarcity and drought which, according to the 'strategic orientations for 2007–2013' include:

- modernisation of agricultural holdings (Art. 26);
- infrastructures for the agricultural and forest management development (Art. 28);
- meeting new standards based on community legislation (Art. 31);
- Natura 2000 payments and payments linked to the Water Framework Directive (Art. 38 and Art. 46);
- agro-environmental measures (Art. 39);
- first reforestation of agricultural land and non-agricultural land (Art. 43 and 45).

Use of structural and cohesion funds
Spain identifies that a number of specific related actions have been selected that have positive secondary environmental effects (reforestation, desalination, sewage treatment improvements etc.).

Under Axis 3 structural funds these include:

- water supply to population and sectoral activities;
- improvement of existing infrastructures, water supply to population and sewage treatment activities;
- waste-water treatment;

Table A1.26 Water resource adaptation status in Spain

Adaptation measure	Implemented	Planned	Effective/necessary (but not planned yet)	Not relevant/ necessary
Flood protection				
Technical flood protection	X	X		
Natural retention of flood water		X	X	
Restriction of settlement/building development in risk areas	X	X		
Standards for building development	X	X		
Improving forecasting and information	X	X		
Improving insurance schemes against flood damage				
Others, please specify:				
Drought/low flow protection				
Technical measures to increase supply	X	X		
Increasing efficiency of water use	X	X		
Economic instruments		X		
Restriction of water uses		X		
Landscape planning measures to improve water balance		X	X	
Improving forecasting, monitoring, information	X	X		
Improving insurance schemes against drought damage	X	X		
Others, please specify:				
Coastal zones				
Reinforce or heighten existing coastal protection infrastructure			X	
Retreat strategies, e.g. managed realignment of dams		X	X	
Others, please specify:				
General adaptation measures				
Awareness raising or information campaigns	X	X	X	
Others, please specify:				

- environmental activities on coasts;
- protection and regeneration of natural areas;
- environmental actions derived from landscape conservation and agricultural economy;
- monitoring and enforcement and environmental pollution reduction;
- regeneration of soils;
- derived environmental actions from landscape conservation and agricultural economy.

Axis (7):

- agricultural water resources management;
- support infrastructures development and improvement;
- agricultural water resources management: SEIASAS (National Society of Agricultural Infrastructures) actions.

Cohesion Funds for the 2000–2006 period include:

- water supply (dams, desalination plants, etc.);
- sewage and treatment (treatment plants, sub-littoral outflow, etc.);
- several environmental actions and projects.

Funds will not be available in Spain after 2010.

LIFE funding
During 2000–2006 period different projects have been developed related to:

- improvement in management of irrigated areas;
- improved water management including water use reduction;

- reduction of pollution in surface waters;
- treatment and recycling of saline waters from mining and industrial activities.

EU solidarity fund
There are no funds for issues related to water scarcity or droughts.

It is clear that while there are specific EU funds to address extreme phenomena such as floods, there are no equivalent instruments for droughts or scarcity.

Perceptions on the delivery of drought/scarcity measures and adaptation through the Water Framework Directive (WFD)
Spain is planning an initiative to assess climate change impacts on water resources as part of implementation of the WFD.

Spain believes that the WFD will establish long-term planning actions to avoid severe socio-economic and environmental impacts. However, it notes a lack of an approach or recommendations for addressing scarcity.

In terms of droughts Spain views the WFD as useful in securing a common approach to the problem and have all Member States recognize that drought events affect, or can affect to a certain degree in the near future, all countries. However, it notes that prolonged droughts are only mentioned in some articles (e.g. Art. 4, 6 and 11, 5), and often as a possible cause of not being able to meet good ecological status temporarily. No specific approach or measures are identified in the WFD on how to address such issues and take them into account in management. Spain notes that there is a need to identify strategies for how to apply the WFD while suffering water stress. It believes that the Water Scarcity and Drought group (WS&D), and more specifically the sub-activity of drought management plans, should help by exchanging information to ease the process. The lack of supply guarantee when an area suffers from scarcity also needs to be taken into account, since it directly affects aquatic ecosystems when urban supply is prioritised.

Water pricing measures implemented
The existing water pricing system in Spain includes charges for the services provided by the River Basin Authorities (regulation and transportation mainly) to irrigation associations, municipal services and industrial users and these in turn charge for this and their own distribution and treatment services to the final users.

Urban tariffs to domestic and industrial users are mainly 3 block tariffs (in major cities there could be 5 blocks) to penalise excessive usage; Industrial tariffs discriminate bigger users both in the fixed and variable charges.

The Water Law allows river basin authorities (RBAs) to vary charges to create incentives for water saving; increasingly irrigation associations are establishing charges by volume and penalisation for excessive use where water is scarce.

Other national policies
Drought river-basin plans are currently being developed to determine emergency protocols when facing drought and scarcity episodes. These plans are including, for example, specific measures to be taken into account for urban supply, and defining priorities in water uses.

Recent emergency legislation includes the use of market instruments and investments for improving the technical efficiency of the irrigation networks. These should be approved by the 2006 update, within the Hydrological National Plan Law, and applied by all River Basins and Autonomous Communities.

The Ministry of Environment has launched a broad public awareness campaign that promotes water saving and informs the public of the impacts of different domestic actions (http://www.mma.es/secciones/total/index.htm). A larger amount of information is periodically being provided through its website regarding hydrological uses, impacts and river basins status.

A1.27 Sweden

A1.27.1 Overview of issues and adaptation actions

The future climate according to the Rossby Centre scenarios will be both warmer and wetter, which means that run-off will increase in Sweden as a whole, by between 5 and 24 % towards the end of the 21st century depending on the scenario chosen. However, there are great regional differences. The greatest increases will occur in the mountainous regions of north-western Sweden, while south-eastern Sweden can anticipate substantially reduced availability of water. The seasonal distribution of run-off is also affected and it is generally the case that run-off during the autumn and winter increases. In northern Sweden the spring flow will occur 2–4 weeks earlier than today and at the same time decrease, except in the far north, where it will be approximately the same. In southern Sweden

the spring flow will almost completely disappear and run-off during the summer months will decrease substantially. Higher average run-off during the autumn and winter suggests that run-off during this period may become more extreme, with an increased risk of flooding. However, no comprehensive survey of how future climate change may affect extreme water flows has yet been compiled.

Under the prevailing climate, Sweden has good water resources in terms of both quality and availability for the production of drinking water and for hydropower. However, in some regions of southern and principally south-eastern Sweden, including the islands of Öland and Gotland in the Baltic Sea, there has been insufficient availability of water during the summer months in dry years. Dry years are also noticeable for the production of hydropower.

The level of the Baltic Sea is obviously affected by the sea level in the Kattegat. In addition, there are effects caused by wind changes. As far as Sweden is concerned, it is also necessary to consider land uplifting and land subsidence which is in progress. The effect of wind changes produces the widest variation in modelled rises in the Baltic Sea. Regional warming also entails a sharp reduction in the period of time during the year when the Baltic Sea is covered with ice.

The expected decrease in summer inflow in southern and south-eastern Sweden combined with increased temperature in Swedish lakes may have negative consequences for both the supply and quality of drinking water. In those parts of the country where flow is expected to increase, there is an increased risk of contaminants and toxins being dispersed as floods upstream of aquifers carry pollutants into lakes and watercourses.

If the frequency of extreme precipitation increases in a future climate, it will have direct repercussions for surface water systems. Under-dimensioning of these systems is already leading to great damage

Table A1.27 Water resource adaptation status in Sweden

Adaptation measure	Implemented	Planned	Effective/necessary (but not planned yet)	Not relevant/ necessary
Flood protection				
Technical flood protection	X		X	
Natural retention of flood water			X	X
Restriction of settlement/building development in risk areas		X	X	
Standards for building development			X	
Improving forecasting and information		X		
Improving insurance schemes against flood damage			X	
Others, please specify:				
Drought/low flow protection				
Technical measures to increase supply				X
Increasing efficiency of water use				X
Economic instruments				X
Restriction of water uses				X
Landscape planning measures to improve water balance				X
Improving forecasting, monitoring, information				X
Improving insurance schemes against drought damage				
Others, please specify:				
Coastal zones				
Reinforce or heighten existing coastal protection infrastructure			X	
Retreat strategies, e.g. managed realignment of dams			X	
Others, please specify:				
General adaptation measures				
Awareness raising or information campaigns			X	
Others, please specify:				

and high costs for insurance companies and individuals today. An increased frequency of floods increases the risk of wastewater treatment plants being overwhelmed and of surface water polluting aquifers, with direct consequences for water supply. In conjunction with floods, environmentally hazardous substances may also come into circulation when industrial sites and landfills are affected. The greatest threat to water quality is altered odour and taste problems, the presence of toxic algae and increased dispersal of harmful substances in flooded watercourses.

The fact that summers in southern Sweden are expected to become drier, combined with a change in sea surface level, increases the risk of intrusion of saltwater into aquifers and sewer networks.

In terms of adaptation, there is no national strategy yet in Sweden but a government inquiry was initiated in the summer of 2005, one of the tasks of which is to present proposals for how society can become more robust so that it can face up to future climate change. As there is no national strategy as yet, there are wide differences in the way in which the issue of adaptation has been dealt with by those affected in society. Some have not yet paid any attention to the issue, while others have made relatively great progress.

There are a few examples of specific measures that are either planned or have already been implemented. A start has been made in some municipalities on taking measures at the local level in physical planning and the built environment. This principally involves re-assessing high flow rates or water levels, with direct reference to the issue of climate change. Limits have been set for the location of buildings, and heights have been established for minimum floor level and levels for the capacity of sewer systems.

Other measures being implemented are primarily motivated by threats from the prevailing climate. The county administrative boards in the Mälaren valley, for example, have collaborated on plans to expand provisions for discharge from Lake Mälaren to prevent flooding. The need for increased discharge is a consequence of present-day climate variations, but can be expected to increase with a changed climate. The lowest point in Sweden is at Kristianstad, 2.4 m below sea level. To eliminate the risk of the town being flooded, the local authority is working to analyse the threat posed and take measures, for example to expand enclosure within embankments and improve the existing embankments around low-lying areas. In several other counties and municipalities, efforts aimed at reducing the risk of flooding have also been initiated.

Concerning hydropower, since new guidelines for design flows for dam installations were drawn up by the 'Flow Committee' in 1990, a nationwide analysis of the ability of the Swedish hydropower system to cope with high flows has been in progress. This analysis has led to reconstruction in several cases. Account is taken of new risks which climate change entails in this review activity in a number of cases. In practice, it means a further increase in safety margins in reconstruction work, where technically possible and economically feasible.

No measures have yet been taken in other sectors, although some vulnerability to climate change has been identified in several cases.

When addressing flooding, Sweden has identified the importance of not relying only on technical flood protection (e.g. raising dykes, enlarging reservoirs, upgrading drainage systems etc.). It has identified that other measures to promote natural retention of flood water (e.g. floodplain restoration, change of land use) are also part of the solution.

Higher run-off and increased intensity of floods may increase soil erosion and leakage of nutrients, organic matter and harmful substances. An increased load of these substances may decrease water quality and affect biodiversity and human health.

The government inquiry on climate and vulnerability was initiated in summer 2005 to map the vulnerability of the Swedish society to climate change and the potential to adapt to it. The results of the investigation will presented in October 2007 and proposals made. The report will include a description of the economic consequences for different sectors. Most focus will be on infrastructure (i.e. roads, railways and telecommunication), buildings, energy and water supply, forestry, agriculture, human health and biodiversity.

A1.27.2 Summary of adaptation actions and status

A summary of actions and their implementation status is provided in Table A1.27, drawn from the questionnaires sent to EEA member countries by the EEA and the German Federal Ministry for the Environment (BMU).

A1.27.3 Information on the use of community instruments and other national policies in the context of adaptation, water demand and management

Perceptions on the delivery of adaptation through the Water Framework Directive (WFD)
The programmes of measures under the WFD have an important role both to prevent consequences of climate change and to take measures because of the consequences of climate change. However, these programmes of measures must be effective and could lead to hard restrictions (for example, the use of land) in order to be effective.

A1.28 Switzerland

A1.28.1 Overview of issues and adaptation actions

Switzerland's position on water resource management in the context of climate change is as follows:

- the expected hydrological changes are so large that they should be considered explicitly in long-term integrated river basin management. This includes policy fields such as spatial planning, environment and agriculture;
- the appropriate management response is to adopt the 'no regrets and flexibility' principle. Long-term plans should be flexible and adaptable. Anticipatory measures, which serve different goals should be undertaken in combination with already on-going activities, like reservation of sufficient room for the rivers in combination with ecological rehabilitation. 'Wait and verify' is not an appropriate strategy for sustainable river basin management;
- some of the derived impacts cannot be sufficiently quantified at present. Therefore future research should focus on integrated approaches, especially links between climate, hydrological and ecosystem models. Research should also aim at the evaluation of strategies to

Table A1.28 Water resource adaptation status in Switzerland

Adaptation measure	Implemented	Planned	Effective/necessary (but not planned yet)	Not relevant/ necessary
Flood protection				
Technical flood protection	X	X		
Natural retention of flood water	X	X		
Restriction of settlement/building development in risk areas		X		
Standards for building development				X
Improving forecasting and information	X	X		
Improving insurance schemes against flood damage	X			
Others, please specify:				
Drought/low flow protection				
Technical measures to increase supply	X			
Increasing efficiency of water use	X			
Economic instruments	X			
Restriction of water uses		X		
Landscape planning measures to improve water balance				X
Improving forecasting, monitoring, information			X	
Improving insurance schemes against drought damage				X
Others, please specify:				
Coastal zones				
Reinforce or heighten existing coastal protection infrastructure				
Retreat strategies, e.g. managed realignment of dams				
Others, please specify:				
General adaptation measures				
Awareness raising or information campaigns	X			
Others, please specify:				

sustain and improve development of the river and its basin in a changing environment;

- the river basin is the unit to address impacts and policy options in view of water resources management. In such an approach, international cooperation including free and unrestricted access to data and information is a pre-requisite.

These insights are reflected by national legislation in the areas of hydraulic engineering, water protection, spatial planning and agriculture. It is now possible to reconcile demands for adequate watercourse corridors, effective flood protection and the maintenance of water quality using such an integrated approach

Flooding issues
In Switzerland, two thirds of all communities have experienced flooding in the last 30 years. An integrated flood protection strategy has been developed. The cornerstones and objectives of this strategy are:

- analysis and documentation of the existing danger. Hazard maps serve as a basis for prevention measures;

- to safeguard the required space for flowing water;

- providing sufficient space for extreme quantities of run-off water simultaneously guarantees space for the ecological function of watercourses;

- minimisation of damage;

- maintenance of watercourses (and the existing safety conditions) as well as measures for spatial planning (preventing a rise in the potential for damage by keeping space free or restricting the use of space);

- emergency planning (forecasting, alerting and mobile measures etc.) to minimise the ever present residual risks.

The new strategy is currently being implemented by the cantonal authorities. Based on the legal framework, a handbook (FOWG 2001), guidelines (KOHS, 2004) and various examples of good practice (FOWG 2004) have been published. Additionally, training courses for civil engineers have been organized on topics such as debris flow modelling, flood protection design and quality assurance in flood management design.

Switzerland has also been involved in cooperative efforts to address transboundary issues. In close coordination with Germany and the Netherlands, the Flood Early Warning System for the River Rhine 'FEWS-Rhine' has been developed. This system enables the FOWG to issue flood forecasts and flood warnings for the River Rhine and its tributaries, and also for the big lakes in the Swiss part of the River Rhine basin. The forecasts from Switzerland are transferred into the FEWS of the warning centres further downstream for integration into their forecasting systems. For the River Rhône, which is heavily influenced by many reservoirs, diversions and power plants, a forecasting and flood management system known as MINERVE is being developed. The flood management model proposes an original solution for the reduction of flood damage. The objective of the proposed method is to reduce the peak flow by storing the water in the reservoirs of existing hydropower schemes in catchment areas. This can be a valuable solution for regions such as the Valais, where numerous major hydropower schemes exist.

A1.28.2 Summary of adaptation actions and status

A summary of actions and their implementation status is provided in Table A1.28, drawn from the questionnaires sent to EEA member countries by the EEA and the German Federal Ministry for the Environment (BMU).

A1.29 United Kingdom

A1.29.1 Overview of issues and adaptation actions

The United Kingdom is currently developing a climate change Adaptation Policy Framework (APF), which will set out in more detail the appropriate responsibilities and activities by a range of organisations in a sector by sector approach. This work contributes to the strategic outcome in the Five Year Strategy under its climate change and energy strategic priority on the 'United Kingdom successfully adapting to unavoidable climate change'.

The framework aims to provide a consistent approach to building adaptation into policies, a coherent way to identify cross-cutting risks and opportunities, and is intended to assist in prioritisation of action across Government.

This first stage, which was launched with a consultation period in November 2005, aims to capture the national picture of climate change

adaptation as it currently stands across the United Kingdom. It is focusing on priority sectors where climate change will have a significant impact, or where considerable coordination between Departments or with other bodies will be needed to make progress on adaptation. During stage two in 2007, a cross-government framework is being developed to identify priority areas and set out roles and responsibilities. Stage 3 will identify those areas where adaptation is not occurring and what incentives and assistance may be required to ensure that it is considered appropriately in future planning and development.

Water demand and supply

Both public institutions and private organisations in the water supply sector are taking climate change seriously, but efforts to respond are still at an early stage. The legislative framework appears to be in place for firms to adapt. The majority of adaptation outputs are in the form of building adaptive capacity and few companies have yet begun to implement adaptation actions. Legislation, such as the Water Act 2003 and the EU Water Directive at the national and international scale are important drivers of adaptation in this sector in the United Kingdom. Some companies are investing financial resources into infrastructure improvements (such as sewage services) driven in part by climate-related events, but more generally by UK and EU legislative requirements. This investment is a function of the high level of awareness of climate change in the water supply industry, and potentially high susceptibility.

Table A1.29a Water resource adaptation status in England and Wales

Adaptation measure	Implemented	Planned	Effective/necessary (but not planned yet)	Not relevant/ necessary
Flood protection				
Technical flood protection	X			
Natural retention of flood water	X			
Restriction of settlement/building development in risk areas	X (PPS25*)			
Standards for building development	X			
Improving forecasting and information	X (ongoing)			
Improving insurance schemes against flood damage				
Others, please specify:	X			
Drought/low flow protection				
Technical measures to increase supply	X	X		
Increasing efficiency of water use	X	X		
Economic instruments	X (abstraction licenses, meters)			
Restriction of water uses	X (levels of service)			
Landscape planning measures to improve water balance		X (Making Space for Water?)		
Improving forecasting, monitoring, information	X (ongoing)			
Improving insurance schemes against drought damage				
Others, please specify:	X (ongoing)			
Coastal zones				
Reinforce or heighten existing coastal protection infrastructure		X (London)		
Retreat strategies, e.g. managed realignment of dams	X (Humber)			
Others, please specify:				
General adaptation measures				
Awareness raising or information campaigns	X			
Others, please specify:				

* Planning policy statement 25 (guidelines for local authorities on spatial planning and flood risk).

Table A1.29b Water resource adaptation status in Scotland

Implemented	Planned	Effective/necessary (but not planned yet)	Not relevant/ necessary
Flood protection			
Technical flood protection	X	X	
Natural retention of flood water	X	X	
Restriction of settlement/building development in risk areas			X
Standards for building development	X		
Improving forecasting and information	X	X	
Improving insurance schemes against flood damage	?	X	
Others, please specify:			
Drought/low flow protection			
Technical measures to increase supply		X	X
Increasing efficiency of water use		X	
Economic instruments	X		
Restriction of water uses		X	
Landscape planning measures to improve water balance			X
Improving forecasting, monitoring, information	X	X	
Improving insurance schemes against drought damage			X?
Others, please specify:			
Coastal zones			
Reinforce or heighten existing coastal protection infrastructure	X	X	
Retreat strategies, e.g. managed realignment of dams			
Others, please specify:			
	?	X	
General adaptation measures			
Awareness raising or information campaigns	X?	X	
Others, please specify:			

Floods
There are many different kinds of adaptation outputs in this sector, ranging from planning policy guidance to flood risk maps and local activities. Adaptation is occurring both in terms of implementing adaptation actions and building adaptive capacity. Most of the examples of adaptation in this sector are planned, i.e. deliberately initiated in response to the need to adapt to the impacts of climate change. However, it is clear that there are many drivers of adaptation in the inland and coastal flooding management sector, aside from climate change. The United Kingdom's strategy 'Making Space for Water: Developing a New Government Strategy for Flood and Coastal Erosion and Risk Management in England' was reviewed in 2005 in light of drivers for change, including the latest predictions on climate change.

A1.29.2 Summary of adaptation actions and status

A summary of actions and their implementation status is provided in Tables A1.29a (England and Wales) and A1.29b (Scotland), drawn from the questionnaires sent to EEA member countries by the EEA and the German Federal Ministry for the Environment (BMU)..

A1.29.3 Information on the use of community instruments and other national policies in the context of adaptation, water demand and management

Perceptions on the delivery of drought/scarcity measures and adaptation through the Water Framework Directive (WFD)
The WFD will bring more focus on demand management and increased re-use/recycling. Existing planning tools focus on measures to reduce demand initially, to avoid additional abstraction.

The United Kingdom has identified that the WFD provides a number of opportunities to integrate climate change adaptation and advantages of the WFD including:

- option identification and appraisal could explicitly test sensitivity of POMs to climate change alongside other long term drivers such as land-use change;
- formal mechanism for cost-benefit analysis of POMs/adaptation measures;
- River Basin Management framework could facilitate greater coordination across sectors/ groups to realise integrated adaptation;
- shift of emphasis to catchment wide solutions to water quality problems (such as diffuse pollution that are climate sensitive);
- monitoring and risk assessment could better define range of natural variability and distinguish climate change impacts from other drivers;
- cyclical RBMP approach means that approach can be reviewed/amended in the light of latest evidence.

Water pricing measures implemented
Abstraction charges are levied on all licensed abstractors. Charges reflect environmental impacts such as use, location, seasonal impacts, etc. Tariffs therefore vary and consumer water price limits are periodically reviewed (every five years) according to the investments and issues that operate.

Other national policies
Chapter 3, Part 2 of the Water resources Act 1991 governs drought orders and permit powers while the Water Industry Act 1991 requires drought planning by water companies. The Water Industry Act will require long-term water resource planning which factors in the impacts of climate change by water companies (from April 2007), where this is currently undertaken voluntarily.

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