Water scarcity and desertification: Background note in view of the Europe 2020 MP Survey

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Executive Summary

Generally speaking, water resources are widely available in Europe as only a small fraction of the renewable freshwater resources, about 13%, is abstracted every year for the various uses. However, in many areas, demand may still exceed availability, due to the uneven distribution of freshwater resources and the overexploitation by many concurrent and increasingly conflicting uses, leading to *water scarcity* problems. These are particularly severe in southern Europe, but water scarcity has also been observed in other regions in recent years. In addition, vast areas in the European Union (EU) are prone to *drought*, a naturally occurring phenomenon that can be exacerbated by anthropogenic activities. These areas are mainly located in southern and eastern Europe but periods of drought have also occurred in northern areas during the winter months. The water exploitation index (WEI), which gives a broad measure of water stress, has generally decreased in most countries over the last 20 years but it remains high in many countries.

Energy production was the main user of water in the period 1998-2007, with a 45% share of total water abstracted, followed by agriculture with 22%, public water supply with 21%, and the manufacturing industry with 12%. The share between the different sectors varies considerably across Europe, with agriculture being the major water consumer in southern Europe, using over 50%.

Water scarcity and droughts have important impacts on population, ecosystems and economic activities. According to an estimate of the European Commission (EC), water scarcity has affected 11% of European citizens and 17% of the EU area, while the economic effects of droughts exceeded EUR 100 billion in the period 1976-2006.

This situation is exacerbated by climate change. Current trends in the availability of freshwater resources are expected to worsen in those European regions already experiencing water stress conditions, while in other parts of Europe the situation is likely to improve or remain stable. Projected changes in precipitation, river run-off and longer dry spells are also expected to increase the occurrence, frequency and impact of droughts, especially in the southern and central regions.

The main policy instruments addressing water scarcity and drought in the EU are the Water Framework Directive (WFD), adopted in 2000, and the EU Strategy on Water Scarcity and Drought, drafted in 2007. The WFD provides the common general framework for the management of water resources, establishing an innovative approach to water management and setting up ambitious policy goals, while the strategy on water scarcity and drought adopts an integrated approach based on a combination of options including: water pricing policies across all water uses, recovering the costs of water supply as well as social and environmental costs; better land use for planning and integration of water concerns into sectoral policies and when allocating Community funds; drought management plans; water-saving and water-efficiency measures and practices; and awareness-raising campaigns. The approach is based on the concept of ‘water hierarchy’, which implies that expansion of water supply should be considered only when all other demand-side measures have been exhausted.

A number of other EU policies have a bearing on water scarcity and drought. These include, among other things: environmental policies and measures (biodiversity, climate change, soil protection); sectoral policies regulating the main economic sectors that use water (Common Agricultural Policy - CAP, energy policy); and regional policy. Other instruments such as voluntary schemes (EMAS, ecolabelling), the Strategic Impact Assessment (SIA), and relevant EU financial instruments may have an impact on water-oriented policy action; there is also evidence that the effects of such action may be counteracted or hindered by a number of sectoral and environmental policy measures in place.

At the level of international cooperation, a number of initiatives and activities have been undertaken to help countries to achieve the Millennium Development Goals (MDGs). In the EU, Member States and the EC launched the EU Water Initiative (EUWI) in 2002, with the objective of helping mobilise and coordinate available human and financial resources to achieve the water-related MDGs in partner countries. In Europe, international cooperation in several International River Basin Districts (IRBDs) has already been taking place for a long time, for example in the Danube and Rhine river basins, and a number of international river basin commissions are already active. However, more work still has to be done and international cooperation is yet to be established in most of the designated IRBDs. Other relevant international initiatives include the activities undertaken under the UN Convention to Combat Desertification (UNCCD), in particular through the implementation of National Action Programmes (NAPs) to fight desertification and mitigate the effects of drought in ‘affected’ countries.

In general, approaches to water management have mainly been based on expanding water supplies and on sectoral measures that did not take into account, or mediate between, the different needs. Traditional approaches are proving inadequate for dealing with current water management challenges such as water scarcity and the complexity of actors and levels of governance involved, hence the promotion of an integrated approach to water resources in Europe. Effective water management requires: the implementation of a mixture of policy measures, aimed in particular at promoting a more efficient use of water; the involvement of different levels of governance; and the active participation of all actors.

In Europe, there is a great potential for savings in the different sectors. In the public water supply sector, the potential for reduction may account for up to 33% of current water use (up to 47% in households), achievable through the reduction of leakages in water supply networks, the introduction of water-saving devices and the use of more efficient household appliances. Water loss in water supply systems is reported to be significant in many areas, mainly due to the poor maintenance of water infrastructure. Some Member States have made efforts over the past 10-15 years to invest in prevention, detection and repair of leakages, leading to a considerable reduction of water loss.

On latest policy developments, some progress is being made in mainstreaming water quantity concerns within sectoral policies at the EU, national and local levels. This is expected to lead to improvements in water efficiency and promote water conservation in the coming years. Though the effectiveness of water pricing polices is still to be proven, due to the lack of data and the complexity and variation of measures put in place, water charging systems and water metering have been implemented for drinking water supplies in most Member States. More efforts are still needed in setting up charging systems and metering programmes for other uses, in particular agriculture. Very few policy instruments address water efficiency in buildings, with most of the initiatives having been implemented and managed at the regional level in areas facing water scarcity and drought.

In the EU, some progress is being registered in the development of national Drought Management Plans encompassing, for example, indicator systems, risk area mapping, warning systems or awareness-raising campaigns; however, the approaches used are still very diverse across Europe and several Member States are still obliged to take supply-side measures to overcome problems of water scarcity and drought. Some of these measures may require a great deal of energy, such as in desalination plants, or they may transfer the problem to other media: for example, the reuse of waste water in agriculture may lead to soil contamination and have an impact on public health. It is therefore important to assess the environmental impacts of alternatives on a case-by-case basis.

The implementation of the Water Information System for Europe (WISE) and the development of the prototype of the European Drought Observatory are developments expected to provide better information to both consumers and policymakers. Exchange of best practices needs to be further fostered.

1. Introduction

1.1 Background

Water scarcity and the occurrence of droughts are increasingly becoming a concern in Europe. At its meeting of 11 June 2010, the Environment Council recognised that '*water scarcity and drought are already a very serious problem in many European regions and the situation is expected to worsen as a consequence of climate change and, if not appropriately addressed, increasing water demand'*. The Council also stressed the need to '*promote tools and solutions for Member States to cope with water scarcity and hydrological extreme events, such as drought'*, inviting the EC '*to consider the right mix of measures and financial instruments needed to tackle water scarcity and drought events and to present relevant proposals if appropriate'*.

The EC is preparing a 'Blueprint to safeguard Europe's Water Resources', expected by 2012; it will comprise an analysis of the implementation of the EU Water Framework Directive, a review of the EU Strategy on Water Scarcity and Droughts, and a review of the vulnerability of environmental resources (water, biodiversity, soil) to climate change and anthropogenic pressures. In the context of the Europe 2020 Strategy and the flagship initiative 'Resource efficient Europe', a Commission proposal to be announced for 2011 is expected to list measures and actions to be taken to tackle water scarcity and drought.

1.2 Scope of the report

Water scarcity and droughts are becoming increasingly relevant for many areas in Europe, and regions and cities are involved in implementing measures to counteract their immediate effects on the economy and population in a sustainable development perspective. With this in mind, and with a view to contributing to the ongoing debate, in 2011 the Committee of the Regions (CoR) will address the subject of 'Water Scarcity and Desertification' by undertaking a survey to collect experiences and good practices, views and suggestions from EU local and regional authorities (LRAs). The aim of this report is to provide background information for the survey and for subsequent CoR activities such as policy conclusions and follow-up.

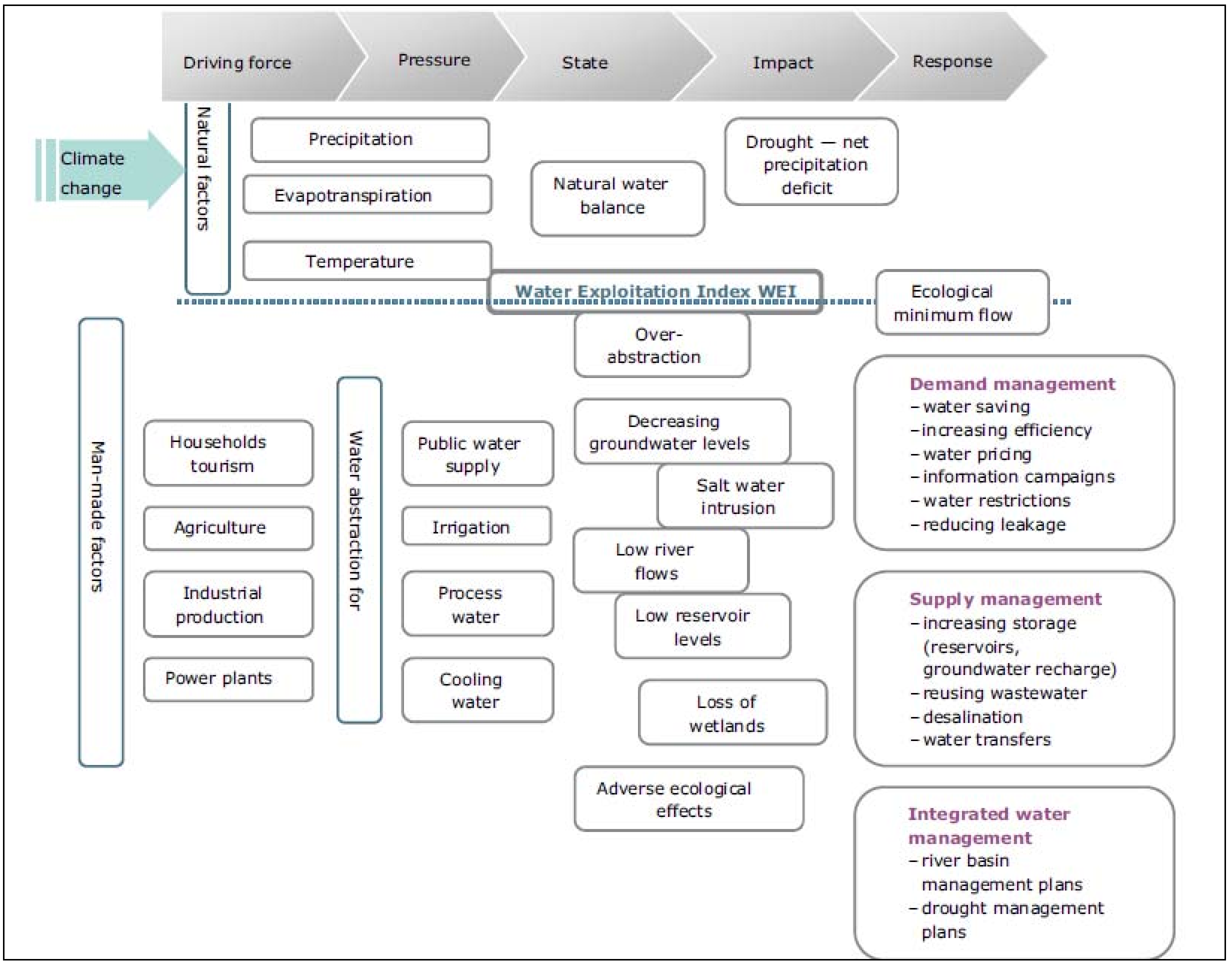
The report considers water scarcity and drought issues in Europe within the broader context of a coherent water management policy, looking at both demand and supply of water. Problems related to water quality and floods are only mentioned where they have direct implications on water scarcity, while land degradation and desertification aspects are briefly discussed as impacts of water scarcity and drought.

The report is structured into three main parts: an overview on state and trends in water scarcity and droughts in Europe (Part I); water policy responses (Part II); water management approaches and progress in the implementation of policy measures, with a focus on governance aspects, including the levels of government involved, their roles and possible relationship, and the role of multilevel governance (Part III).

1.3 Methodology

This report is based on the results of desk-work. The findings of publicly available studies and policy documents have been surveyed, compiled, analysed and summarised. Possibly conflicting views and policy responses have been highlighted and described where relevant. Whenever possible, published data and information have been processed and re-worked to best fit with the scope of the report. The state and trends in water scarcity and droughts have been analysed following the Driving forces, Pressures, State, Impacts and Responses (DPSIR) analytical framework for the management of water resources, as shown in Figure 1.

Figure 1 - The DPSIR framework applied to water resource management



Source: EEA (2009)

Boxes have been used throughout the report to draw attention to general aspects, key definitions, methodologies or specific issues that appeared to be particularly relevant for implementation at the local or regional level.

2. State and trends in water availability, demand and scarcity

2.1 Overview of water quantity problems in Europe

The current state is determined with respect to water scarcity (section 2.1.1) and droughts (section 2.1.2), along with driving forces and pressures, and the main environmental, social and economical impacts. Particular attention is given to the geographical and temporal dimensions of the problem, identifying main spatial patterns and trends, and highlighting differences across countries and regions. A brief overview of the issue at global level is also provided.

2.1.1 Water scarcity

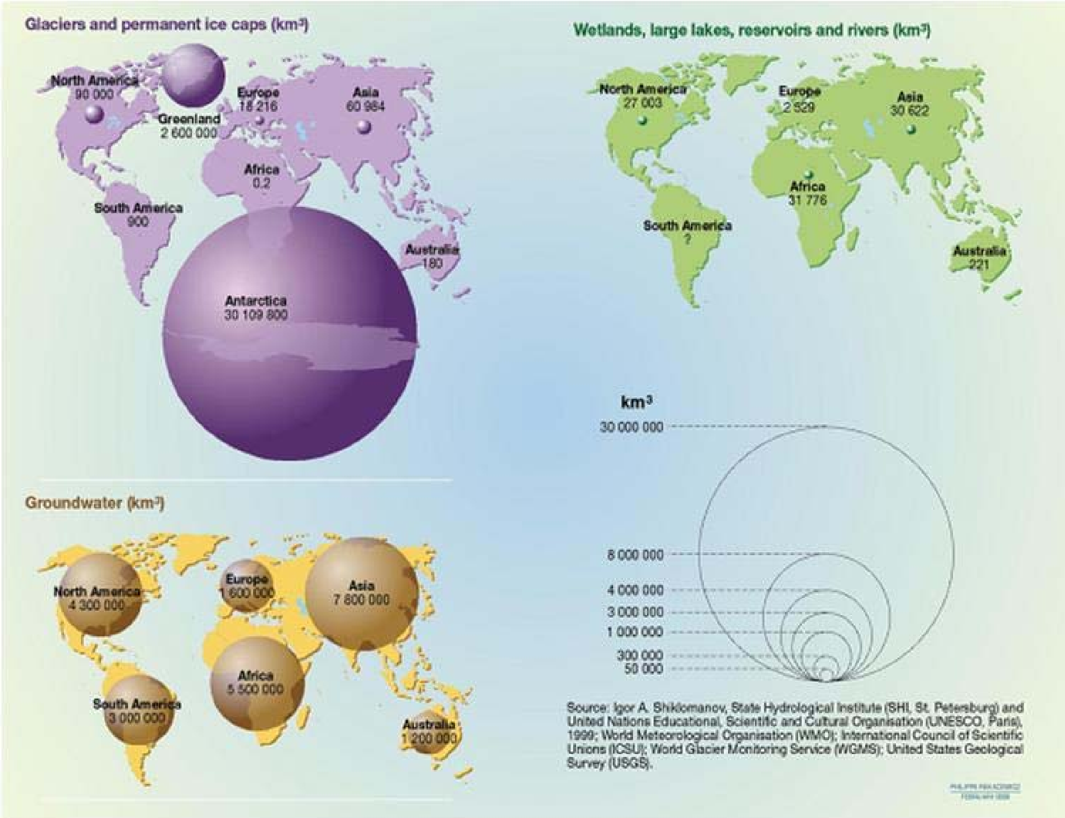
- ***State and trends***

Water availability

In absolute values[1], the largest volumes of water are located in Asia and South America (32% and 28%, respectively, of the total average global volume of 42,785 km^3/year). Renewable freshwater resources in Europe represent almost 7% of the total global volume, corresponding to 2,900 km^3/year, on average, equivalent to 4,230 m^3/year/person, i.e. well below the world average of 7,600 m^3/year/person. Groundwater is by far the most abundant source of freshwater available for use, representing 90% of the world's total readily available freshwater resources, followed by lakes, reservoirs, rivers and wetlands (Map 1). Although Europe's water resources are relatively small compared to other regions in the world, they are generally widely available since only a small fraction (about 13%) of renewable freshwater resources is abstracted every year for the various uses (EEA, 2009). This seems to suggest that, in general in Europe, the demand for water is met. However, the distribution of freshwater resources available for the various uses is uneven, due to the uneven distribution of people and economic activities, as well as to the spatial and temporal variability of the resources. In many areas, demand may actually exceed availability, due to overexploitation by many concurrent and increasingly conflicting uses, leading to water scarcity problems. This is especially true in southern Europe, but the problem has also been observed in northern Europe in recent years.

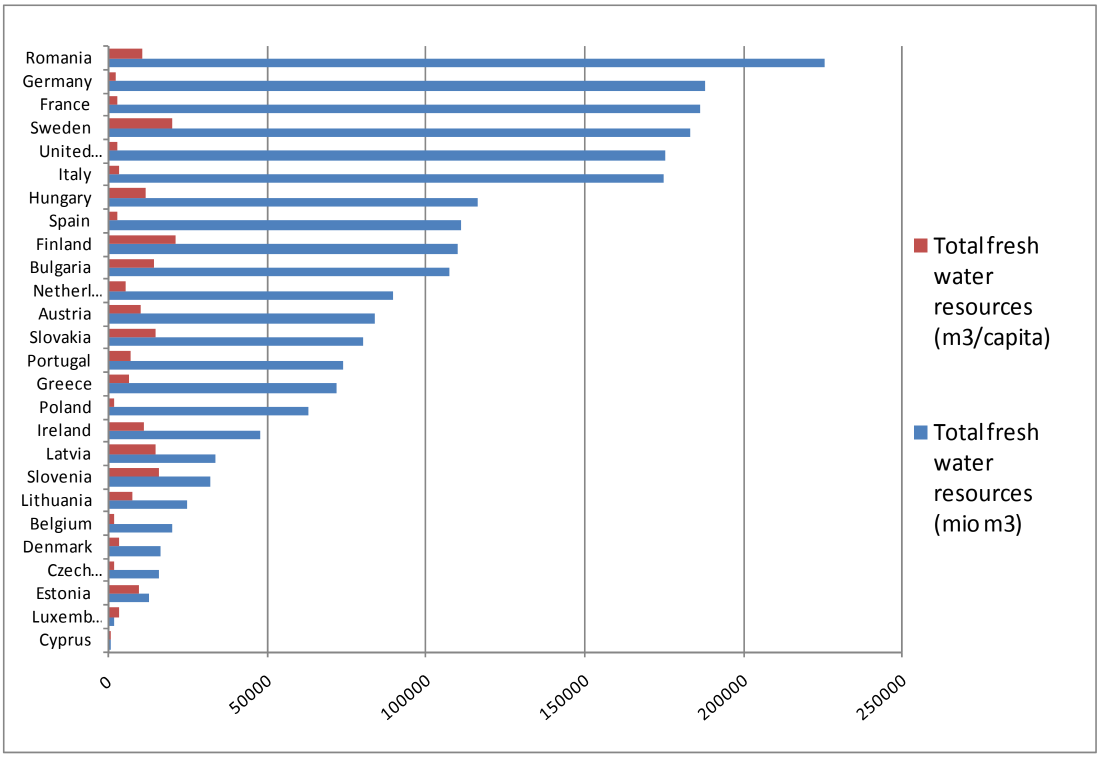
[1] All data on renewable freshwater resources at continental level are from UNESCO (1998).

Map 1 - Freshwater resources: volumes by continent



Source: Vital Water Graphics (UNEP, 2008)

Chart 1 – Total renewable freshwater resources in the EU



Source: based on Eurostat data (2010)

The distribution of freshwater resources varies greatly across Europe. According to Eurostat data, the total amount of freshwater resources available every year (long-term annual average) ranges from about 225,000 million m^3 in Romania to over 180,000 million m^3 in Germany, France and Sweden, and some 175,000 million m^3 in the UK and Italy. The 'water poorest' countries are Cyprus and Luxembourg (Chart 1). In terms of availability per capita, the lowest values relate to Cyprus and the more densely populated countries (Germany, Poland, Spain, the UK, France and Italy). The amount of water available is influenced by precipitation, evapotranspiration and river runoff.[2]

Water abstraction

In Europe, total water abstraction for the various uses has been estimated to be some 226 km^3/year, corresponding to about 440 m^3/per capita/year (EEA, 2010a). Abstraction rates vary across economic sectors, time and geographic location. In Europe as a whole, the main sectors abstracting water are energy production (mainly for cooling in power plants), agriculture (irrigation), public water supply (households, tourism and industry) and the manufacturing industry. On average, in the period 1998-2007, 21% of the total water abstracted was used for public water supply, 22% for irrigation, 12% for industry and 45% for energy production (EEA, 2010a). Although energy production is the sector with the highest abstraction rate, most of the water abstracted is returned to the system; on the other hand, only 30% of the water used in agriculture is returned, while the rest is used for crop growth or lost to evaporation. However, there are differences across Europe: for example, in absolute terms, abstraction for energy, the manufacturing industry and public water supply is higher in western Europe, while agriculture is the major water user in southern Europe, accounting for over 50% of the total water abstracted (EEA, 2010a).

Water sources

Surface water (i.e. the water available within rivers and lakes) accounts for over 80% of all water abstracted. It is virtually the only source of water supply for

[2] In general, the main components of the water cycle include: (i) water storage in the oceans; (ii) transformation of water into water vapour through evaporation from the oceans, evapotranspiration (transpiration from plants and evaporation from the soil), and sublimation of ice and snow; (iii) accumulation of water vapour in the atmosphere and condensation into clouds; (iv) precipitation of cloud particles as rain or snow onto land or water surface; (v) circulation of water through surface runoff (precipitation runoff over the soil surface to the nearest stream) and streamflow (movement of water in a natural channel, e.g. a river); (vi) water storage in ice and snow (glaciers, icefields, snowfields); (vii) snowmelt runoff to streams (movement of water as surface runoff from snow and ice to surface water); (viii) freshwater storage (in streams, lakes, wetlands, reservoirs); (ix) infiltration (movement from land surface to soil or porous rock); (x) groundwater storage; (xi) groundwater discharge (movement of water out of the ground) and springs (concentrated ground water discharge at the ground surface). (adapted from USGS).

energy production and the main source for industrial and agricultural uses (over 75%). Conversely, groundwater is the main source for public water supplies (about 55% of all water abstracted). It should be noted that the abstraction of groundwater for agricultural use is likely to be underestimated, as it does not take account of abstraction from irregular or illegal wells (EEA, 2009).

Water stress

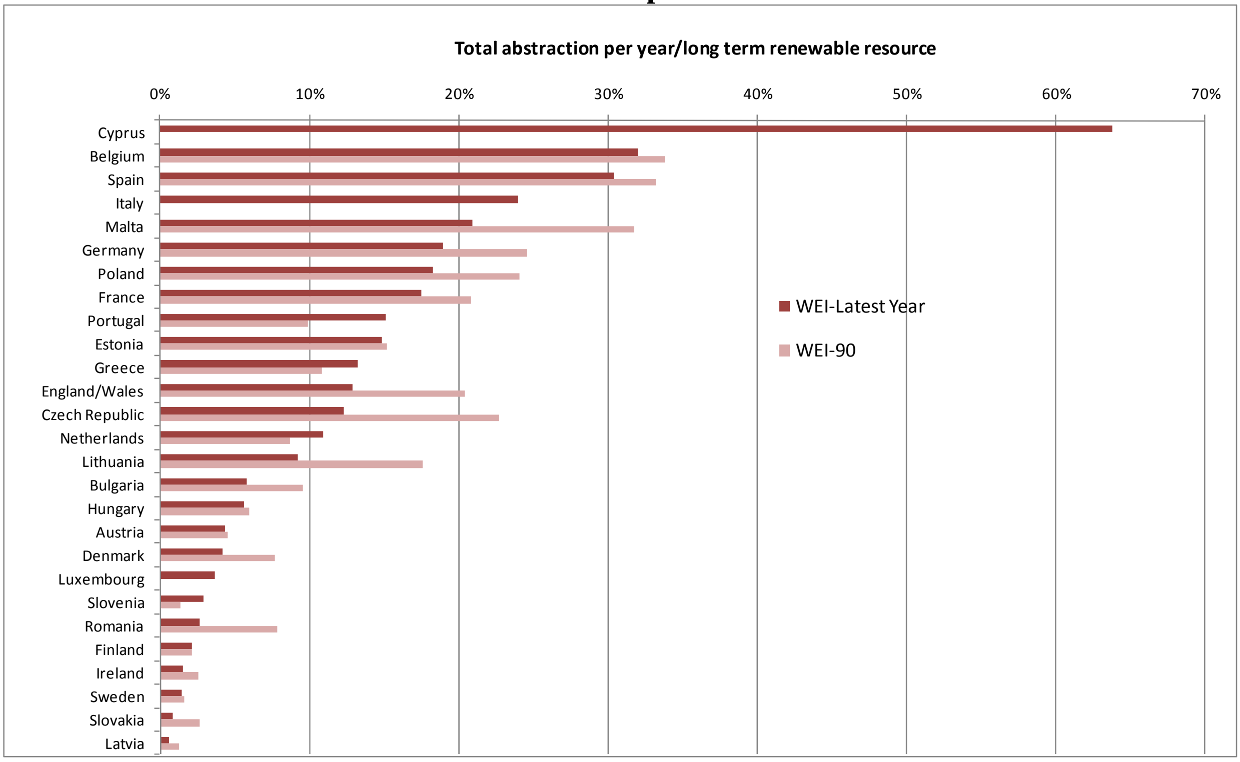
The water exploitation index (WEI) gives a broad measure of the pressures on freshwater resources (B.1). WEI has generally decreased in several countries over the period 1990-2007, but it remains high in Cyprus, Belgium, Spain, Italy and Malta (Chart 2), highlighting conditions of water stress or the unsustainable use of water resources and affecting about 113 million people. While in eastern Europe the reduction has been driven by economic and institutional changes, in western Europe the decrease was due to the implementation of water-saving and water efficiency measures. However, it should be mentioned that in Belgium, the high WEI is caused by high water abstraction for non-consumptive uses, such as cooling water, while most of the water abstracted in Spain, Italy and Malta is for consumptive uses, especially irrigation (EEA, 2010b). In four countries, namely the Netherlands, Greece, Finland, and Slovenia, the WEI actually increased in the same period. The WEI has also increased in Cyprus since 1998.

B.1 Water Exploitation Index (WEI)

The WEI represents the water removed from any freshwater source, either permanently or temporarily. Mine water and drainage water as well as water abstractions from precipitation are included, whereas water used for hydroelectricity generation (in situ use) is excluded. '*WEI is a measure of pressure or stress on freshwater resources. It is calculated annually as the ratio of total freshwater abstraction to the total renewable resource*' (Raskin *et al.*, (1997) quoted in EEA (2009). A water exploitation index of 20% (or more) indicates water stress; a water exploitation index of 40% (or more) indicates severe water stress.

The WEI indicates an average value, is calculated on a country basis, and does not take into account regional spatial variability. For example, in Portugal the national WEI is 15%, while the WEI in the most water-stressed river basins may be much higher (Sado River Basin 132%, Leca River Basin 82%) (EEA, 2010b). Moreover, regions with a WEI of less than 40% may experience severe water stress during droughts or low river-flow periods.

Chart 2 – Water Exploitation Index



Source: EEA data service, dataset Water Exploitation Index (August 2010)

- ***Drivers and pressures***

Water stress and water scarcity can be brought about by both natural and anthropogenic drivers. Climate change, with its effects on precipitation, river runoff and the occurrence of droughts, is the main natural cause of water scarcity, while anthropogenic drivers include the overexploitation of water resources for uses such as public water supply (including households, industry and tourism), energy production, agriculture, the manufacturing industry, and inland waterway transport. The EC has identified a number of policy-related underlying causes of the water scarcity problem in the EU (EC, 2007a). These include:

- Ineffective water pricing policies, which tend not to reflect the sensitivity of water resources at the local level and the effects of water abstraction on the environment.

- Land use planning, which may result in inadequate water allocation among economic sectors, causing imbalances between needs and the availability of the resource.

- Poor integration of water-related concerns into sectoral policies that affect water at all levels (from European to national, regional and local).

- Poor water management and the current high losses in the water distribution networks.

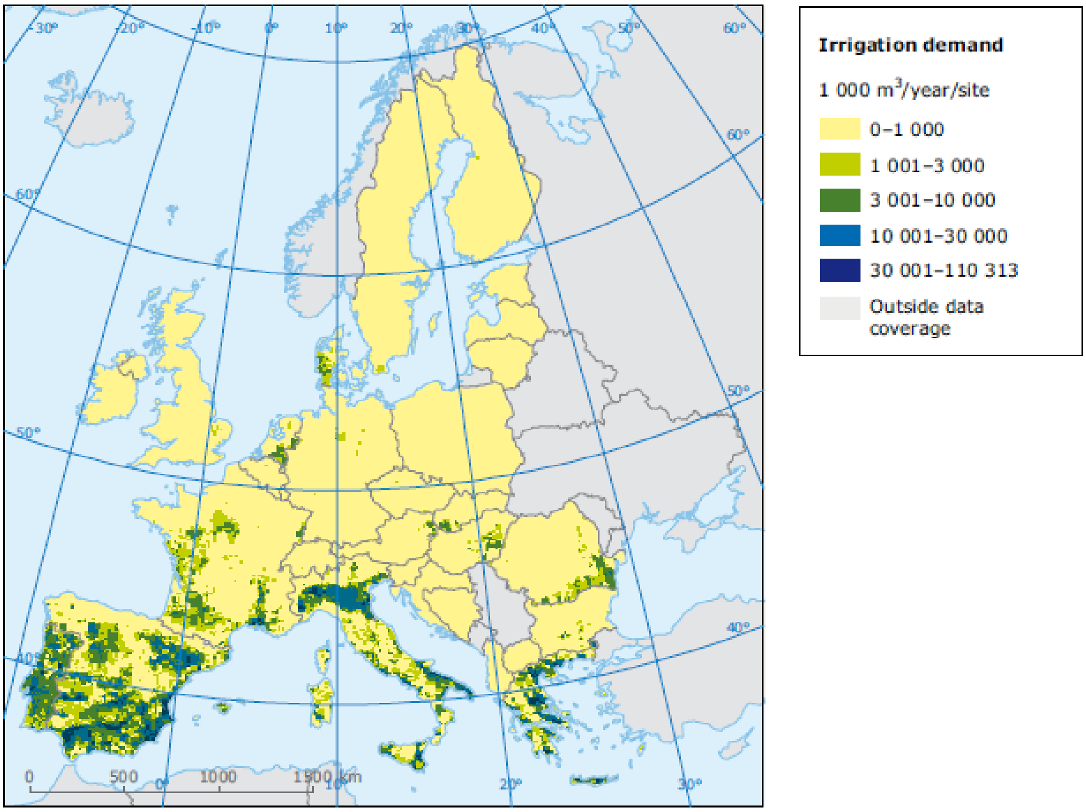
- Scarce information/awareness of the problem.

This section focuses on economic sectors as drivers of water scarcity. The impacts of climate change on water resources are analysed in section 2.2, while a more detailed discussion on policy-related aspects is provided in Part II.

Agriculture

Water abstraction for irrigation decreased by about 1% throughout Europe in the period between the early 1990s and 2007. A decrease of 88% was observed in eastern Europe, mainly due to the decline of agricultural activities in Bulgaria and Romania during the transition period. In southern Europe, there was a 2% decrease as opposed to an increase of about 22% in irrigable land, due to improvements in water efficiency (EEA 2010b, EEA 2010c). Finally, western Europe saw a 55% decrease, mainly driven by Denmark, Germany, the Netherlands and the UK. Estimates of irrigation water demand are shown in Map 2. Actual demand volumes would be higher due to losses in the irrigation system. These results confirm the importance of irrigated agriculture in southern Europe.

Map 2 - Average irrigation demand per site (10 x 10 km cell) (1,000 m^3/year/site over a simulation period 1995–2002)



Source: Wriedt *et al.* (2008)

Public water supply

In the period between the early 1990s and 2007, there was a marked decrease in water abstraction for public water supply in eastern Europe, with a reduction of 40%, while a consistent but less marked decrease took place in western Europe. This trend is more distinct in the UK, Germany, Poland, Bulgaria and Romania, where it was driven by the implementation of water-saving measures (Dworak T. *et al*., 2007), and, in the new EU Member States, by the introduction of higher water prices as a result of the establishment of new economic conditions (EEA, 2009). By contrast, the total amount of water abstracted for public water supply increased in southern Europe (12%) over the same period, due to changes in climate, with higher temperatures registered especially in the Mediterranean, and the expansion of tourism (EEA, 2009).

Manufacturing industry

Water abstracted for the manufacturing industry has decreased by 40% throughout Europe since the early 1990s. As for the other industry sectors, regional trends can be observed, with reduction rates varying from 10% in western Europe to 40% in southern Europe and up to 82% in eastern Europe, due to the transition to new, more water-efficient industrial plants. In France, the UK and Spain, for example, 30-40% of industrial plants have implemented water-saving technologies. At the same time, the reuse of water in industrial processes has increased (EEA, 2009).

Energy production

The total water abstracted for energy production in Europe decreased by about 10% on average in the period between the early 1990s and 2007. The reason for this is the replacement of older power plants and the introduction of more advanced technologies (EEA, 2009).

- ***Impacts***

Water scarcity and droughts have an important impact on population, ecosystems and economic activities. According to an estimate of the EC, water scarcity has affected 11% of European citizens and 17% of the territory, while the economic effects of droughts exceeded EUR 100 billion in the period 1976-2006 (EC, 2007c). This situation is exacerbated by climate change. Current negative trends in the availability of freshwater resources are expected to worsen due to the likely effects of projected climate changes on precipitation, river runoff and the occurrence of drought.

As water is vital for the survival and wellbeing of both populations and ecosystems, and is of crucial importance for all economic sectors, the establishment of water scarcity conditions may lead to a wide range of environmental, social and economic impacts.

Environmental impacts

Water scarcity has important impacts on natural resources and ecosystems, through the negative effects on biodiversity, water quality, soil resources, and the increased risk of forest fires. In particular, water scarcity may cause:

- Harm to terrestrial and aquatic ecosystems.

- Effects on groundwater: aquifer depletion due to seawater intrusion and over-pumping (lowered water table). The intrusion of seawater into coastal aquifers and its effects on water quality (in terms of salt water contamination) can lead to less water being available in a vicious circle (a map on ‘Salt water intrusions into groundwater in Europe (1999)’ may be viewed here); while the lowering of the water table can cause soil subsidence, geo-morphological impacts and damage to building structures).

- Effects on surface waters: increased concentrations of pollutants from various sources due to less dilution; lowered water levels in lakes; reduced river and impaired environmental flows[3]; fragmentation of water systems due to the construction of dams.

- Effects on wetlands: drying-up of vast areas, including the drying-up of peatlands, which, in turn, may result in the release to the atmosphere of the carbon stored in the soil.

- Impacts on soil: soil degradation and desertification (B.2). The sealing/encrusting of soil surface increases overland flow during rainfall, thereby increasing the concentrations of pollutants discharged into nearby watercourses.

More details on the impacts of water scarcity on the environment, as relating to the discussion of the impacts of climate change, are provided in section 2.2.

Social impacts

The social impacts of water scarcity include direct economic consequences for the general public due, for example, to increased water prices caused by the implementation of compensating measures (e.g. desalination units), and indirect effects on health, as the incidence of water-borne diseases may increase under conditions of water scarcity, as a result of the reduced dilution and increased concentrations of pathogens and contaminants in drinking water sources (WHO, 2010). In addition, although in Europe the majority of the population is connected to public water supplies, major differences can be observed between regions and income groups, as well as between rural and urban areas. In the EU15, the proportion of households in the lowest income group without proper sanitary installations is still about 2.5%; this number rises to over 30% in the EU10 (WHO, 2010).

Further social impacts may be caused by large projects for the construction of artificial reservoirs, dams and channels, which can often provoke social and political conflicts between planning authorities and the receiving basins (EC, 2007b).

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[3] Environmental flows are defined as '*the quantity, quality and timing of water flows needed to sustain ecosystems and the services they provide*'. EEA (2010c)

Economic impacts

The economic impacts of water scarcity refer to the direct impact on those sectors depending on water, such as agriculture, tourism, industry, energy production (especially hydropower), and transport (inland waterways). For example, there might be income losses in the agricultural sector due to deeper pumping or greater uncertainty about yields, or in the transport sector due to low river flows that hinder inland waterway transport.

B.2 Desertification

According to the final text of the UNCCD (UNCCD, 1994) desertification is '*…land degradation in arid, semi-arid and dry sub-humid areas resulting from various factors, including climatic variations and human activities*'. Changes in climate leading to prolonged droughts and more irregular precipitation, in combination with the unsustainable use of water and unsustainable agricultural practices can lead, in extreme cases, to desertification. Long, dry periods leave exposed soils vulnerable to erosion. Besides fires, droughts are often broken by intense storms that can wash away large amounts of soil, also because of low vegetation cover and poor soil conditions (low infiltration rates). According to the results of an assessment carried out by the EEA and based on a methodology developed within the Desertification Information System for the Mediterranean (DISMED), vulnerability to desertification and drought is lower in Europe than in neighbouring areas (EEA, 2008). However, according to available data, in southern, central and eastern Europe 8% of land, i.e. about 14 million hectares, shows very high and high sensitivity. The affected part increases to more than 40 million hectares if moderate sensitivities are also taken into account. The situation is most serious in southern Portugal, much of Spain, Sicily (south of Italy), south-eastern Greece, and the areas bordering the Black Sea in Bulgaria and Romania. Predicted changes in climate are expected to increase vulnerability in these regions. The map on '*Sensitivity to desertification and drought in Europe*' may be viewed here (EEA, 2008; DISMED project).

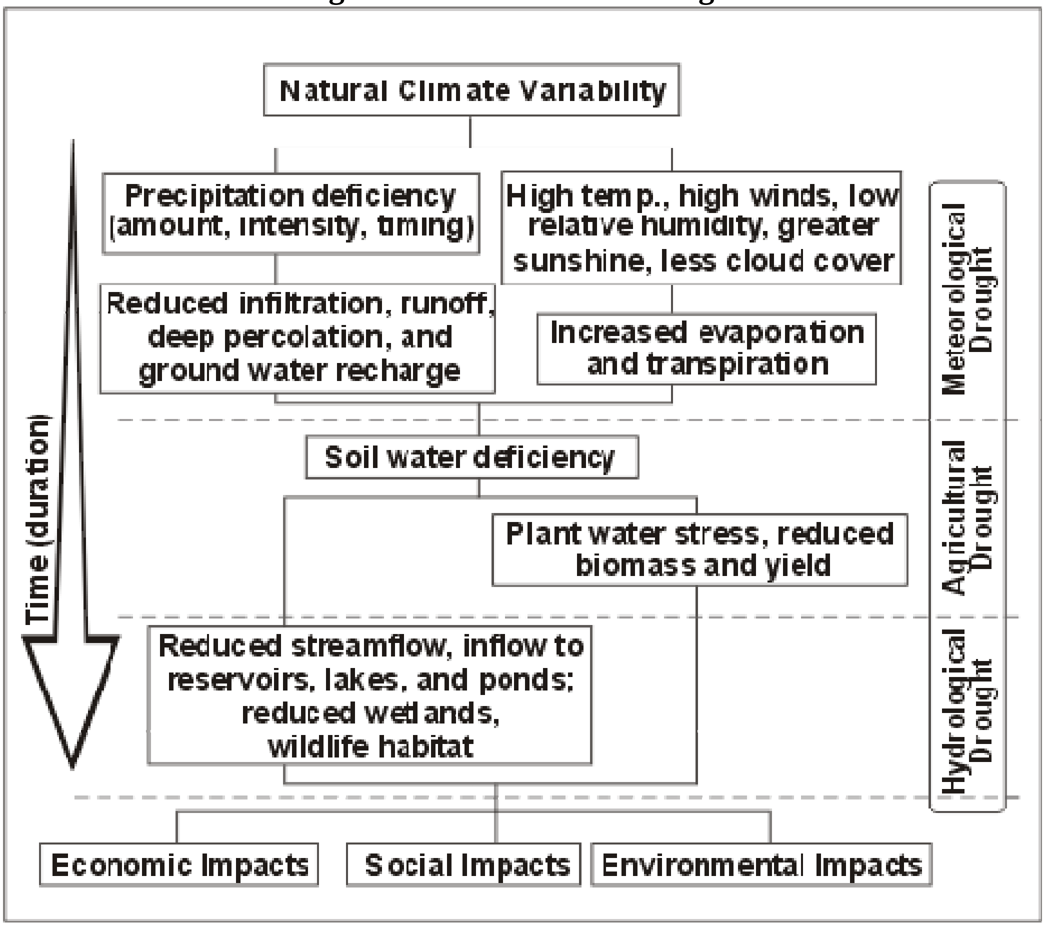
2.1.2 Droughts

Vast areas of the EU are prone to drought, a naturally occurring phenomenon that can be exacerbated by anthropogenic activities. Although mainly occurring in southern and eastern Europe, these events are also seen in northern Europe during winter.

- ***State and trends***

Drought is a temporary decrease in average water availability due to, for example, rainfall deficiency. In this sense it can be distinguished from water scarcity, which refers to long-term water imbalances. Nevertheless, the frequency and severity of droughts may worsen in regions under permanent water stress. On the other hand, droughts can lead to water scarcity due to the overexploitation of available freshwater resources (EC, 2007a). Causes of droughts are detailed in Figure 2; different types of drought can be identified[4]: 'meteorological drought', referring to deficiency in rainfall and duration of the dry spell; 'agricultural drought', referring to impacts on soil water retention and agricultural production; and 'hydrological drought', referring to impacts on groundwater and river flows.

Figure 2 - The causes of drought



Source: The US National Drought Mitigation Centre (NDMC)

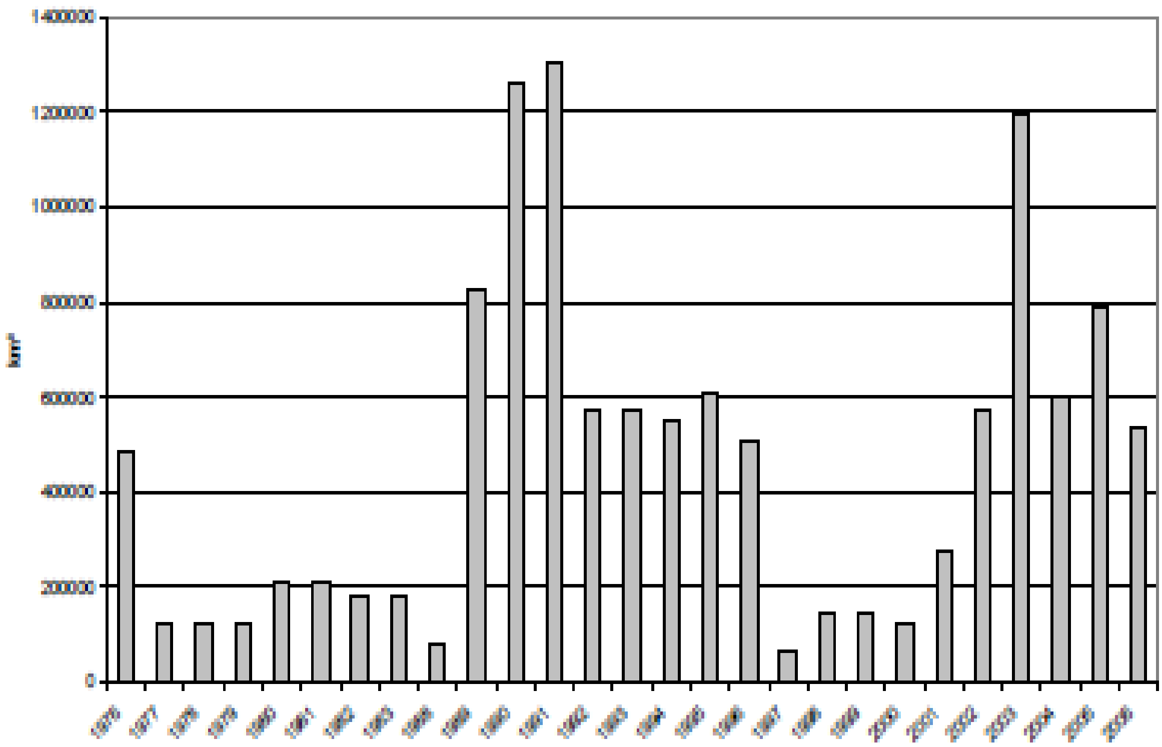
An assessment carried out by the EC in 2007, based on information collected from 13 Member States on the occurrence of droughts in the period 1976-2006, showed that severe drought events annually affected more than 800 million km^2

[4] Van Lanen A.J. *et al.* (2007)

or about 37% of the EU territory, and 100 million or 20% of EU population in 4 distinct years in the period from 1989 to 2003 (Figure 3). Moreover, a 6 to 13% increase in annual average of both affected area and population was observed between 1976-1990 and 1991-2006.

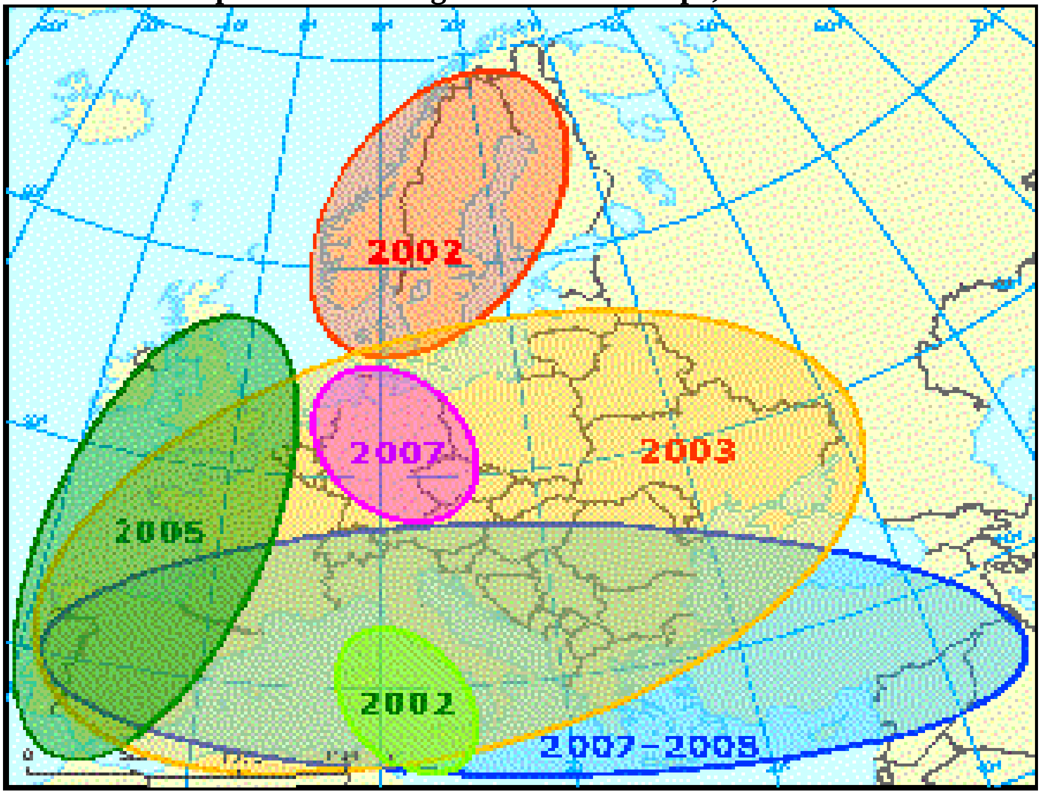
Droughts have occurred in all seasons, in the north as well the south of Europe, though with differing intensity and degrees of severity. Five countries (Italy, Portugal, Cyprus, Spain and France) have registered the highest frequencies over the whole period, with a total of 8 to 21 events per country. In the most recent years, large parts of Europe, especially in the south-east, have faced long periods of drought. For example, between 2004 and 2006, severe droughts occurred in the Iberian Peninsula, France and the southern part of the UK. In 2008, Cyprus suffered a fourth consecutive year of low rainfall and the drought situation became critical during the summer (Map 3).

Figure 3 - EU area affected by droughts (1976-2006)



Source: EC, 2007c

Map 3 - Main drought events in Europe, 2000–2009



Source: EEA (2010c)

- ***Drivers and pressures***

Drought is a natural phenomenon which can be exacerbated by a status of water scarcity resulting from water mismanagement or other anthropogenic causes. The primary cause is, however, a deficiency in rainfall, preventing groundwater or river recharge. High air temperatures and evapotranspiration, combined with a lack of rainfall, may aggravate the severity and duration of drought events. In contrast, winter droughts are caused by precipitation being stored as snow and ice, preventing the recharge of rivers or aquifers until air temperatures rise again and snow melts (EC, 2007c). Climate change, expected to affect the temporal and spatial pattern of precipitations, is therefore an important driving force.

- ***Impacts***

Droughts may have immediate and significant environmental, social and economic impacts, which may last well beyond the duration of the drought event itself. However, these impacts are often the result of a combination of concurrent factors, including permanent conditions of water scarcity. Droughts are, among other causes, responsible for forest fires, which may in turn lead to increased soil erosion and deficiency in water retention. Droughts also have important effects on sensitive areas and ecosystems, such as wetlands and mountain areas.

Social impacts of a drought include the restriction of water supplies over a given period and higher costs for additional supply and extra purification, which are often borne by public authorities. In Cyprus, for example, during the crisis caused by the 2008 drought, the government was forced to apply a 30% cut to water supply and import water from Greece by ship. The costs of the crisis amounted to 1.25% of Gross National Income, while EUR 7.6m was granted from the EU Solidarity Fund (EEA, 2010c). National, regional and local restrictions on water use may also result in loss of income for some economic activities, in particular tourism, energy production, especially hydropower, and inland waterway transport. Power plants need a minimum amount of water to operate and may actually be forced to stop if there is not enough water available. The agricultural sector can also be seriously affected, through income losses due to reduced production.

Table 1 – Estimated economic impact of droughts

Period	Total impact (million EUR)	Total impact a year
1976-1980	12,340	2,470
1981-1985	4,360	870
1986-1990	14,450	2,890
1991-1995	23,390	4,680
1996-2000	8,060	1,610
2001-2006	37,400	6,230
Total	100,000	

Source: EC (2007a)

Comprehensive estimates of the economic impact of drought, in particular their costs, are not available, due to gaps in data and problems of comparability at EU, national and river basin levels (EC, 2007a). The EC estimated the direct economic impact of drought events in the period 1976-2006 to be at least EUR 100 billion (Table 1). The annual costs of droughts were estimated to have doubled between 1976-1990 and 1991-2006, with an annual average of EUR 6.2 billion in the period 2002-2006. The annual costs are expected to continue to rise due to the likely increase in the occurrence of extreme weather events brought about by climate change (EC 2006a, EC 2007a).

2.2 The impact of climate change on water resources

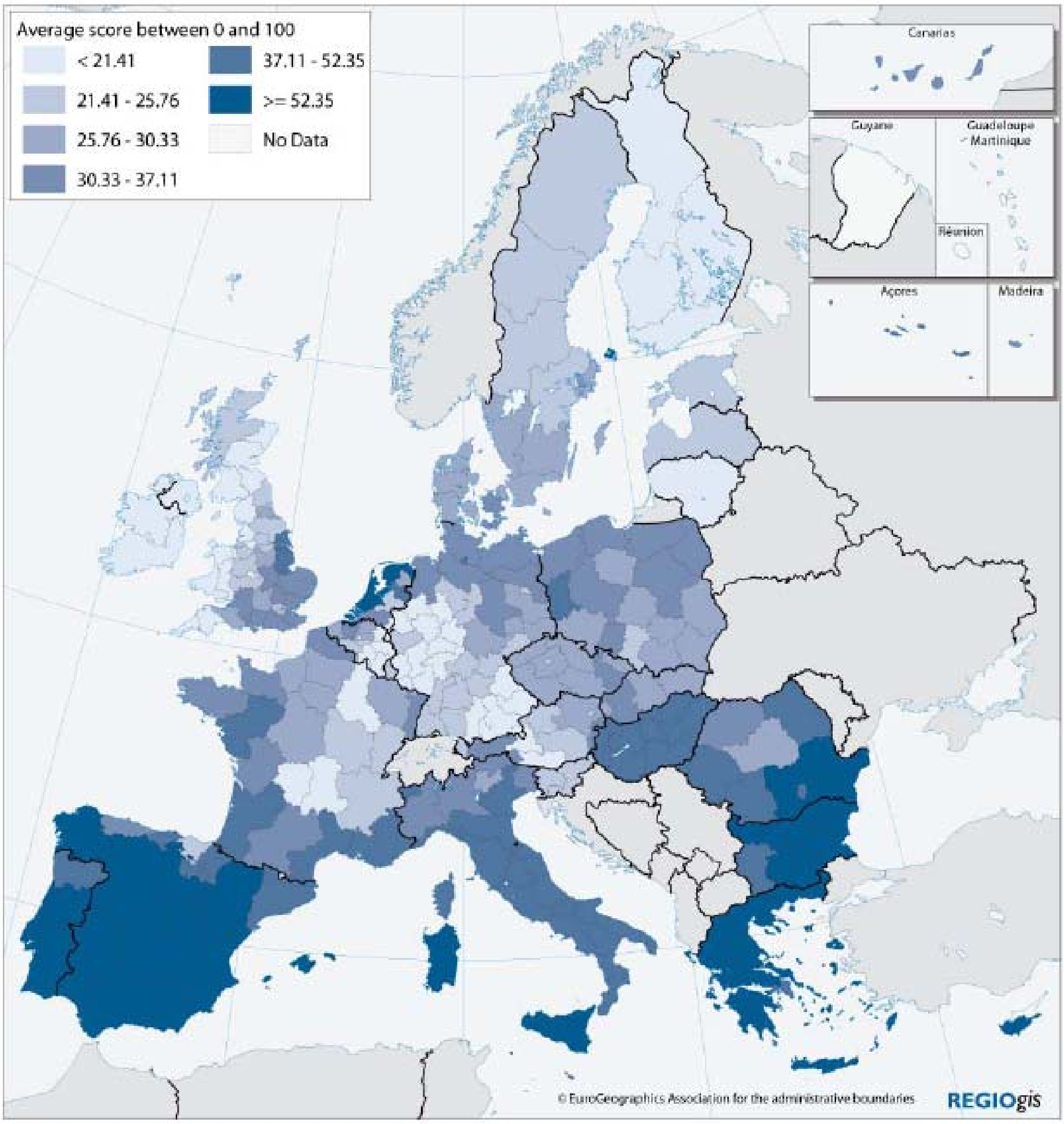
The analysis of the future situation of water scarcity and drought in Europe requires the consideration of some major aspects, in particular:

(a) future trends in water demand from the main economic sectors, including domestic, tourism, agriculture and the production of energy crops; and

(b) the impacts of climate change on the water cycle and the availability of water.

In Europe, likely rising demand for various water uses, especially in the agricultural sector, and reduced water availability, due to projected changes in climate, are expected to worsen the situation in areas already experiencing water stress conditions. The occurrence, frequency and impacts of droughts are also expected to increase, especially in southern and central regions (B.3). The situation will be compounded by projected changes in climate leading to amplified future impacts on water availability and ecosystems, and to impacts on population and economic sectors. B.4 reports on the main past and projected impacts of climate change in the main biogeographic regions of Europe.

B.3 Regional exposure to climate change over the medium term



Source: Eurostat, JRC, DG REGIO, 2008. Published in EC, 2008a.

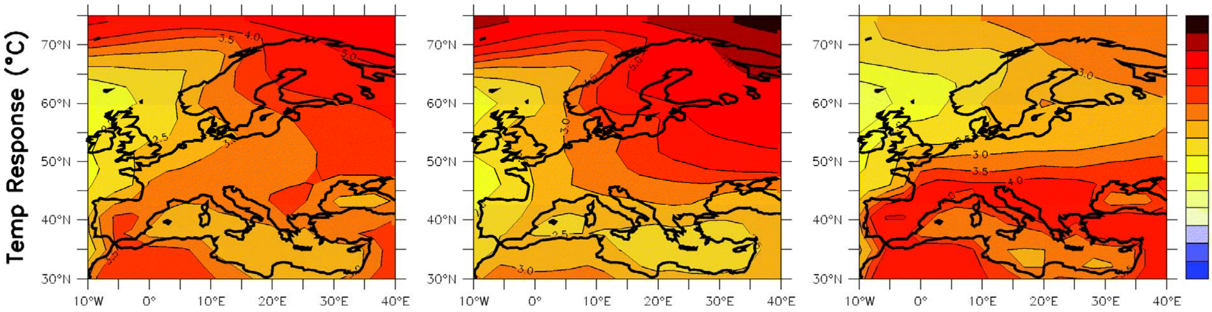
According to a study carried out by the EC, most regions are likely to be negatively affected by future impacts of changes in climate (EC, 2008a). The pressures from climate change are not evenly distributed. Regions under high pressure (dark blue in the map on the left side) are generally located in southern and eastern Europe, where about one third of the EU population, or 170 million people, live. The most affected areas include most of Spain, Italy, Greece, Bulgaria, Cyprus, Malta, Hungary and Romania, as well as the southern part of France. In these areas, climate change is projected to worsen existing conditions through declining precipitation and drought. The map represents the 'Climate Change Vulnerability Index', determined by: population affected by river floods; population in coastal areas below 5m; potential drought hazard; and vulnerability of agriculture, fisheries and tourism, taking into account temperature and precipitation changes.

2.2.1 Observed and projected changes in climate

Changing temperatures (past and future trends)

Global mean temperature has increased by 0.8^0 C with respect to pre-industrial levels. Europe has warmed more than the global average, especially in the Mediterranean, the north-eastern regions and in mountain areas. Further temperature increases of between 1.0 and 5.5^0 C are expected by the end of the century (Map 4). Moreover, more frequent and intense periods of extreme heat, such as hot summers, have occurred in the past 50 years and this trend is projected to continue (EEA-JRC-WHO, 2008).

Map 4 - Modelled change in mean temperature over Europe between 1980-1999 and 2080-2099

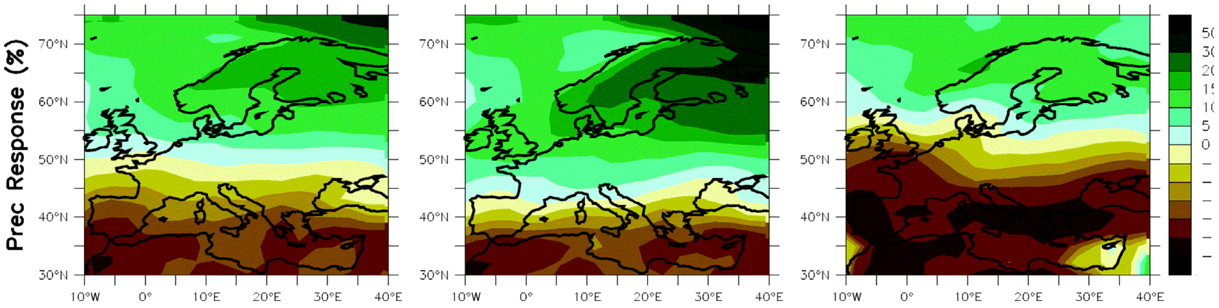


Note: Left: annual; middle: winter; right: summer changes in ^{o}C for the IPCC-SRES A1B emission scenario averaged over 21 models (MMD-A1B simulations). Source: published in EEA-JRC-WHO, 2008.

Changing precipitation patterns (past and future trends)

During the 20^{th} century, annual precipitation increased from 10 to 40% in northern Europe, while it decreased by up to 20% in southern Europe. The observed changes in precipitation have a high seasonal and regional variability (Map 5). The intensity of extreme precipitation events has increased in the past 50 years, and these events are expected to become more frequent. On the other hand, dry spells are projected to increase both in length and frequency, especially in southern Europe (EEA-JRC-WHO, 2008).

Map 5 - Modelled precipitation change between 1980-1999 and 2080-2099



Note: Left: annual; middle: winter; right: summer changes % for the IPCC-SRES A1B emission scenario averaged over 21 models (MMD-A1B simulations).
Source: published in EEA-JRC-WHO, 2008.

2.2.2 The influence of climate change on the water cycle

There is growing evidence, based both on observations and the results of models, of the vulnerability of water resources to changes in climate and the potential adverse impacts of climate change on the water cycle and the availability of freshwater resources (IPCC, 2007). This is because the water and climate systems are very closely interlinked through a number of connections and feedback cycles. In particular, increases in global mean temperature, such as those projected under current scenarios, are likely to affect the temporal and spatial distribution of freshwater resources through the changes in the temporal and spatial distribution of precipitation, and the melting of glaciers and snow deposits (EEA-JRC-WHO, 2008).

However, long-term alterations in the water cycle due to climate change are difficult to assess because of the limited hydrological measurements available as compared to climate records and the effects of other changes (land use, management practices, etc.) on the water system. More time may therefore be needed before statistically significant changes can be detected. This is especially the case for the effects of climate changes on droughts (and floods as well) with their relatively infrequent and random occurrence. Uncertainties are also introduced by differences of scale between climatic and hydrological models (EEA-JRC-WHO, 2008; Van Lanen, A.J. *et al.*, 2007; Flörke M., Alcamo J., 2004).

Changing river flows

In the 20th century, annual river flows increased in northern Europe, mainly during the winter season, and slightly decreased in southern Europe. This difference is projected to increase, although absolute changes are difficult to predict. In addition, major changes in seasonality are expected, with lower flows during summer and higher flows in winter. Reductions in river flows are also likely to occur during late summer and early autumn in areas where annual river flows will increase in absolute terms (EEA-JRC-WHO, 2008). In fact, projected temperature increases are likely to result in reduced precipitation in the form of snow during winter, with consequent reduced winter retention and higher winter runoff, earlier snow-melt and decreases in precipitation during summer.

Groundwater

Climate change is expected to have important effects on Europe's groundwater resources due to: rises in sea level; melting of permafrost and land ice; decline in groundwater recharge, especially in the southern regions; and higher river-flow excursions. On the other hand, rising groundwater levels may occur in regions with high precipitation, possibly causing damage to houses and infrastructure. Climate change will also affect groundwater quality. Groundwater temperature has already increased on average by 1° C since the 1970s (Stuyfzand *et al*., 2007). Further increases in temperature will raise the salinity of groundwater due to increased losses in evapotranspiration, increased soil CO_2 pressures and increased water-rock interaction. Furthermore, salt-water intrusion is expected to worsen in coastal areas due to the projected rise in sea level. Groundwater bodies will also become more vulnerable to pollution due to the reduced turnover times and the accelerated groundwater flow (EEA-JRC-WHO, 2008).

2.2.3 The effects of climate change on water availability

In Europe, the impacts of climate change on the water cycle are likely to intensify in the next decades, leading to major changes in annual and seasonal availability of freshwater resources, with a marked north-south gradient (see Maps 5 and 6 for current water availability and future trends). Water availability will generally increase in northern Europe, while the southern and south-eastern parts of the continent will be exposed to reductions in available water, and to more frequent and severe droughts. At the same time, river flows are expected to rise in many parts of Europe, due to more frequent cases of extreme precipitation, even in regions that are expected to become drier (EEA, 2005; EEA-JRC-WHO, 2008).

2.2.4 The effects of climate change on droughts

In many parts of Europe, climate change is expected to affect the frequency and occurrence of meteorological droughts due to increased temperatures, decreased summer precipitation and longer dry spells. However, quantitative analysis of these effects is currently not possible, as most studies on this area do not show clear trends in time and space (EEA-JRC-WHO, 2008; Van Lanen A.J. *et al.*, 2007).

B.4 Main impacts according to biogeographic regions of Europe

Arctic: decrease in Arctic sea ice coverage, Greenland ice sheet loss, higher risk of biodiversity loss. *North-western Europe*: increase in winter precipitation, increase in river flow, northward movement of freshwater species, higher risk of coastal flooding. *Northern Europe (boreal region)*: less snow, lake and river ice cover, northward movement of species, more energy from hydropower, lower energy consumption for heating, higher risk of damage by winter storms, increased river flows, higher forest growth, higher crop yields, more (summer) tourism. *Central and eastern Europe:* more temperature extremes, less summer precipitation, more river floods in winter, higher water temperature, higher crop yield variability, increased forest fire danger, lower forest stability. *Mountain areas:* high temperature increase, less glacier mass, less mountain permafrost, higher risk of rock falls, upwards shift of plants and animals, less ski tourism in winter, higher soil erosion risk, high risk of species extinction. *Coastal zones and regional seas*: sea-level rise, higher sea surface temperatures, northward movement of species, increase in phytoplankton biomass, higher risk for fish stocks. *Mediterranean region:* decrease in annual precipitation, decrease in annual river flow, increasing water demand for agriculture, lower crop yields, more forest fires, less energy from hydropower, more deaths in heat waves, more vector-borne diseases, less summer tourism, higher risk of biodiversity loss, higher risk of desertification.

Source: the information is extracted from a map published by EEA and available here.

2.3 Future trends in water availability and demand

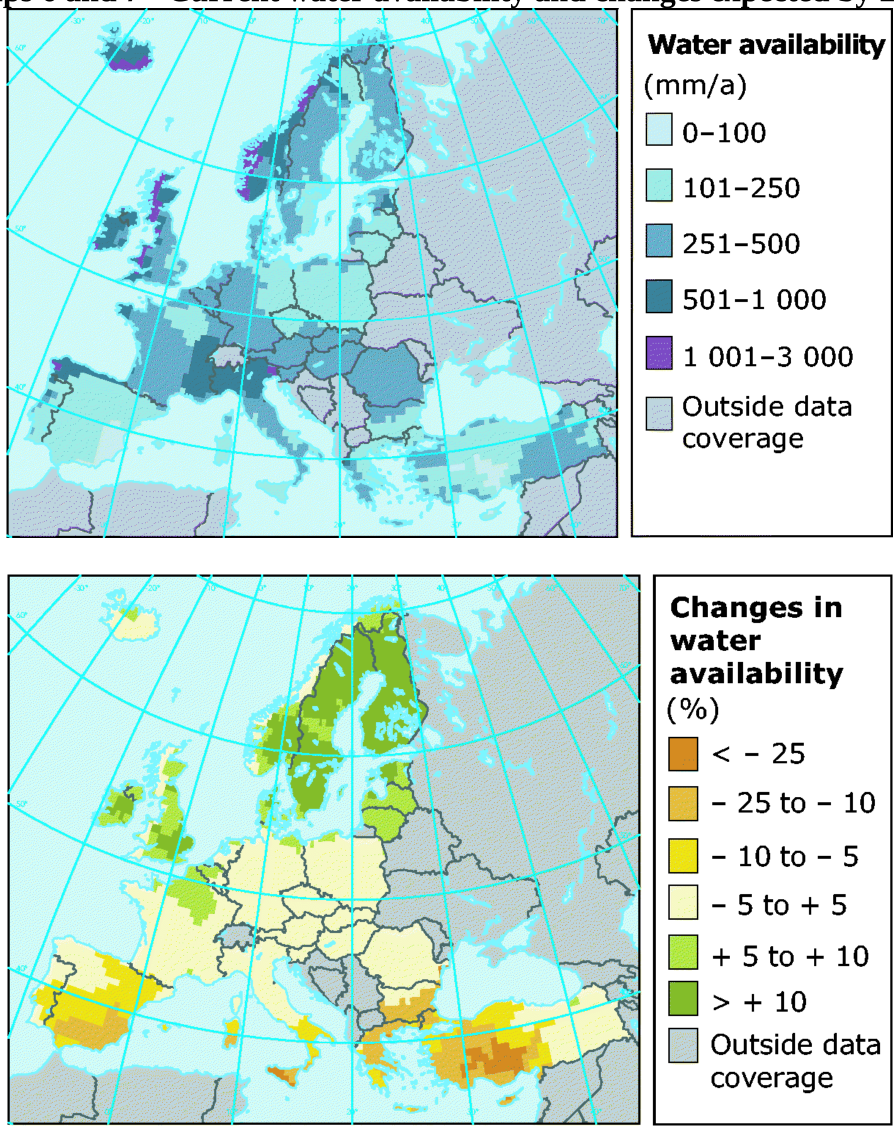
2.3.1 Water availability scenarios[5]

The projected changes in river flows and groundwater recharge are expected to vary between regions, following changing precipitation patterns. As a consequence, water availability[6] is also expected to vary across Europe. By 2030, under mid-range assumptions of changes in temperature and precipitation

[5] Based on EEA, 2005; Flörke M., Alcamo J. (2004). This work used the WaterGAP model (Water – Global Assessment and Prognosis) for modeling European water use and water availability.
[6] In this scenario, water availability is considered to be the total river discharge, combining surface runoff and groundwater recharge Flörke M., Alcamo J. (2004).

(baseline scenario)[7], water availability is expected to decline by 10% or even more from current levels in some river basins in southern and south-eastern Europe, especially in Greece, southern Italy and Spain (Maps 6 and 7). These changes are likely to become more evident in the longer term. On the other hand, changes in average water availability are expected to be relatively small in most of the rest of Europe, while increases of 10% or more in annual runoff are actually expected in some river basins in northern Europe, in large areas of Scandinavia and some parts of the UK (EEA, 2005). Seasonal variability is also expected, with less water being available during summer.

Maps 6 and 7 - Current water availability and changes expected by 2030

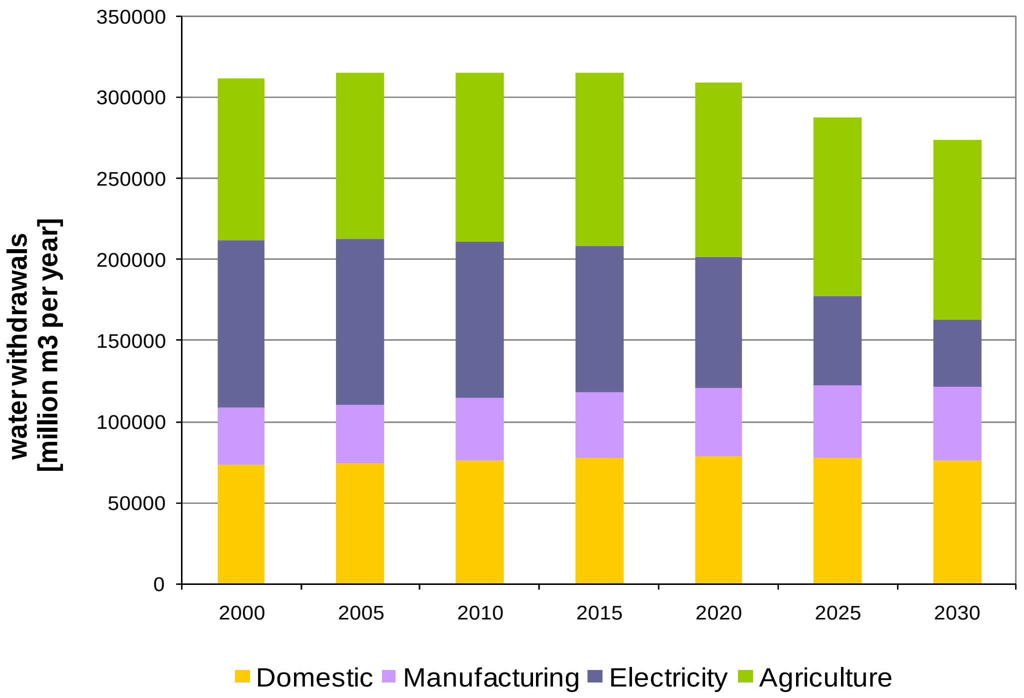


Source: Centre for Environmental Systems Research (University of Kassel, Germany), 2003-2004. Dataset: WaterGAP model. Published in EEA, 2005

[7] Baseline assumptions for key driving forces and related changes in precipitation and temperature: increase in global average temperature over pre-industrial levels of 1.3^{0}C by 2030 and 3.1^{0}C by 2100. The baseline scenario reflects the continuation of current demographic and socio-economic trends. For more details on the baseline scenario assumptions, the reference is Flörke M., Alcamo J. (2004).

2.3.2 Water demand scenarios and geopolitical implications[8]

Chart 3 - Water abstraction in Europe: outlook 2000-2030



Note: Data refer to EU27, plus Norway, Switzerland and Turkey. Source: EEA, 2005

In contrast with global trends that foresee a worsening of water stress conditions in many parts of the world, the demand for water is projected to remain stable or decrease in Europe. This trend is likely to be driven by a move towards more efficient water use across all sectors and by a limited increase in irrigated areas (EEA, 2010b). Under the baseline scenario, average water abstraction is projected to decrease in Europe by over 10% by 2030 (Chart 3). However, large regional differences are projected, with the exception of water abstracted for cooling of power plants, for which large decreases are expected all over Europe. Large differences are also expected in the relative contribution of the various sectors. The likely future trends for the various sectors are described below.

Agriculture

Estimates for future water abstraction are closely linked to the estimate of the future extent of the irrigated area. A 30% increase in water demand is expected in southern and south-eastern European countries by 2030, while water abstraction will remain at current levels in the rest of Europe. Energy crops are

[8] Based on EEA, 2005; Flörke M., Alcamo J. (2004).

an additional driver for change in water demand in the agricultural sector. In general, energy crops optimised for rapid growth consume more water than food crops. Current plans to increase the production of energy crops in the EU from 2 to up to 142 Mtoe[9] in the period 2003-2030 are expected to increase water demand and aggravate water stress conditions, especially in southern Europe during summer (Dworak *et al.*, 2007).

Energy production

Despite an almost doubling of thermal electricity production in the period 1990-2030, decreases of 50% or more in water demand by the energy sector are expected by 2030 in Europe. The reduction will be driven by the substitution of once-through systems with tower cooling systems in new power plants, requiring substantially less water to operate. Conversely, water consumed during the cooling process is expected to increase, as evaporation is twice as high in the new cooling systems as in traditional systems.

Public water supply

The future water demand in households is highly uncertain and will depend on many factors, including income and size of households (water use per person generally increases with income and decreases with household size); the age distribution of population (wide variations are observed between age groups); the development of tourism; the implementation of water pricing policies; and the uptake of new technologies, leading in general to more water-efficient domestic appliances (EEA, 2009; Flörke M., Alcamo J., 2004). On the other hand, water demand in households and in the tourism sector is likely to increase with climate change, as more water is expected to be consumed for personal hygiene or other uses such as the watering of gardens. Climate change and rising income are also likely to increase water use in leisure facilities (golf courses, aqua parks, swimming pools, artificial snow-making). In addition, water supply problems are becoming increasingly common in tourist resorts (EEA, 2010b).

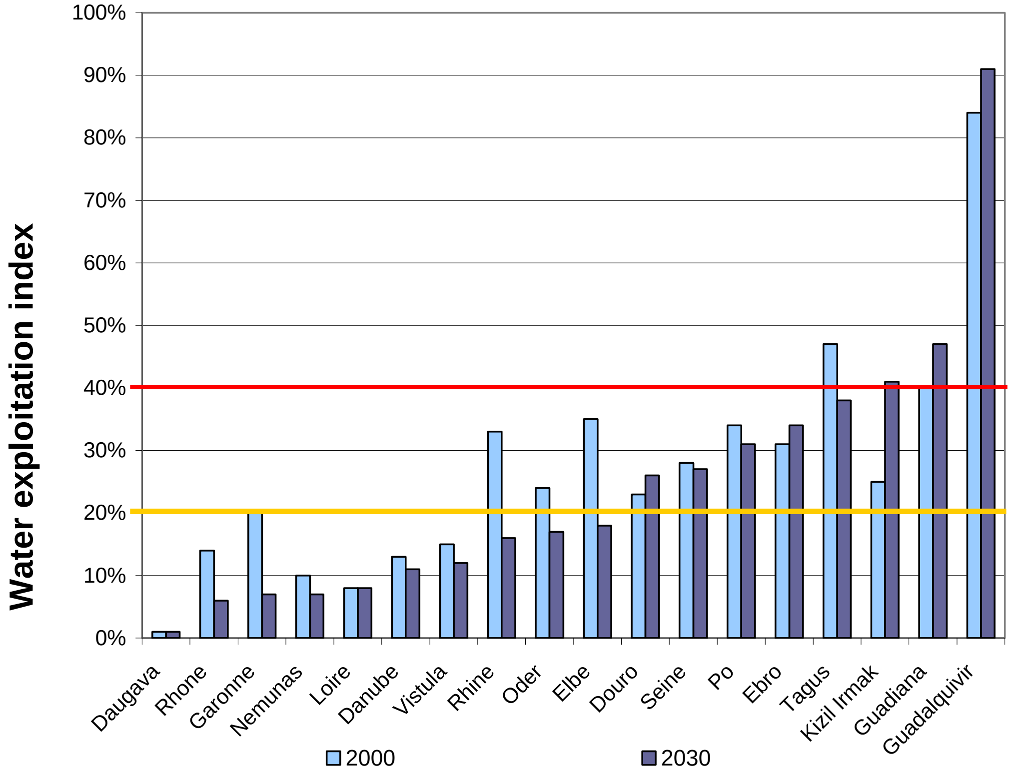
Manufacturing industry

An increase of over 20% in water abstraction is expected in most European countries. Water abstraction may even double in countries with fast-growing economies, where water use in manufacturing is currently low. There are, however, large uncertainties in water-use estimates for different industries, mainly linked to the extent of the uptake of new emerging and less water-consuming technologies and processes.

[9] Mtoe = million tonnes of oil equivalent

2.4 Future trends in water stress and frequency of droughts

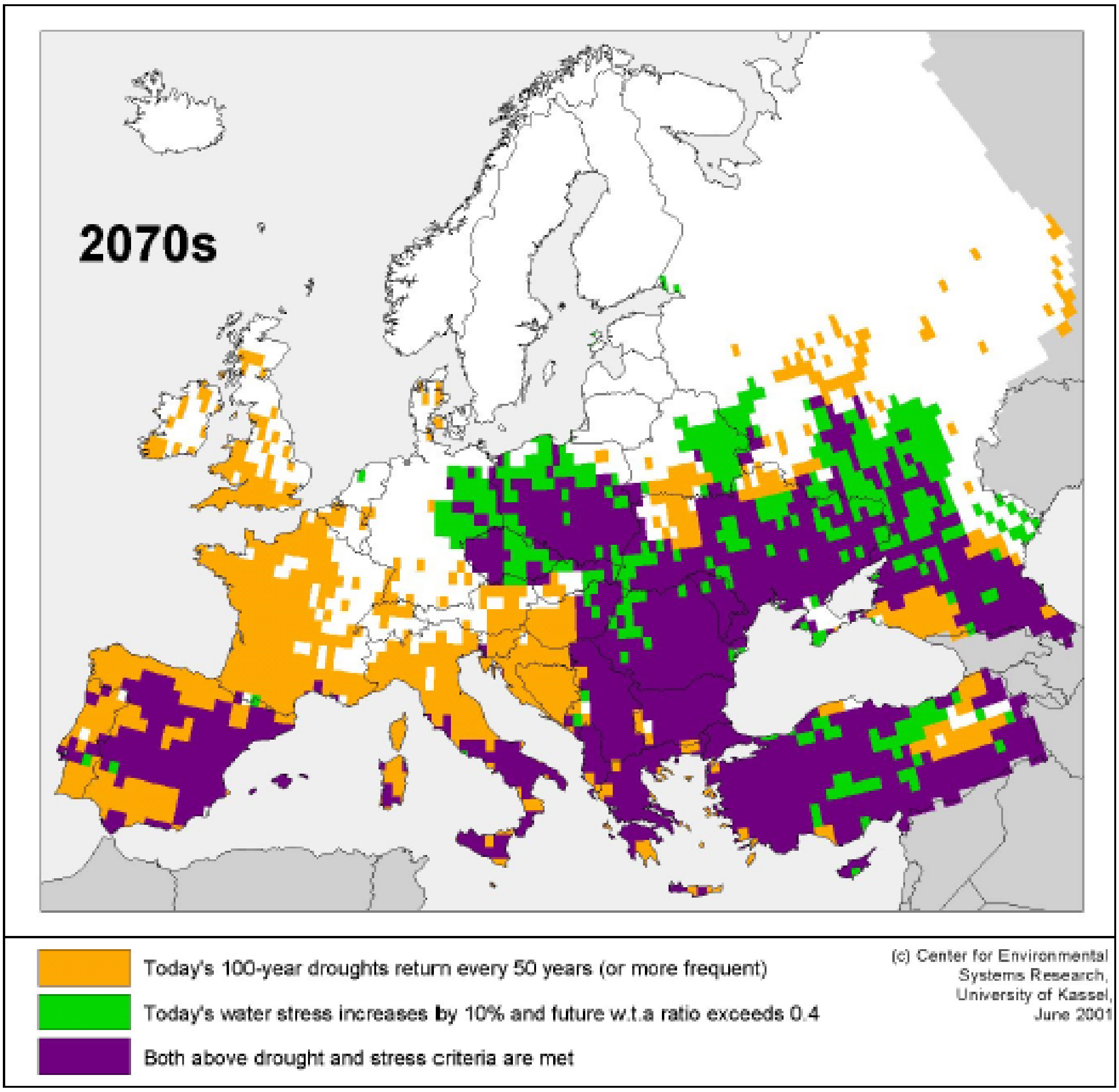
Chart 4 - Water stress in large European river basins: outlook 2000-2030



Note: WEI ≥ 20% (yellow line) indicates water stress; WEI ≥ 40% (red line) indicates severe water stress. Source: EEA, 2005

Chart 4 shows current modelled water stress conditions (year 2000) and projected water stress conditions (by 2030) in European river basins, under the baseline scenario. These results indicate that water stress will increase in several river basins in southern Europe. In particular, the Guadalquivir (Spain) and Guadiana (Spain and Portugal) basins are already experiencing, or will experience, severe water stress conditions by 2030. For example, more than 90% of the flow of the Guadalquivir is expected to be abstracted by 2030. Map 8 shows the results of a combined water stress and drought scenario: a major part of Europe is expected to experience severe impacts from water scarcity by 2070 as a consequence of either increased water demand from economic sectors (green shading in the map), decreased water supply due to the greater frequency of droughts (orange shading), or a combination of both (purple shading). It is noted that large parts of Europe, corresponding to about 25% of the total land area and located in particular in the south-east, are likely to become 'critical regions' in terms of both water stress and drought frequencies (Lehner B. *et al.*, 2001; EC, 2007a).

Map 8 - Critical regions with respect to water stress and frequency of droughts



Source: Lehner B. *et al.*, 2001. Data owners: Centre for Environmental Systems Research, University of Kassel.

3. Policy responses to tackle water scarcity and droughts

The overall objective of EU water policy is *'to ensure access to good quality water in sufficient quantity for all Europeans'*, securing at the same time *'the good status of all water bodies across Europe'* (EC, 2010b) and the preservation of aquatic ecosystems. This is in line with the operational objectives of the Renewed EU Strategy on Sustainable Development[10], which state the need to *'improve management and avoid overexploitation of renewable natural resources such as fisheries, biodiversity, forestry, water, air, soil and climate'*. More specifically, EU policies and actions aim at promoting *'sustainable water use based on a long-term protection of available water resources'* and at mitigating *'the effects of floods and droughts'*.

A number of policy instruments and measures have been put into place to achieve this objective, according to the provisions included in the Water Framework Directive (WFD) and the policy options identified in the EU Strategy on Water Scarcity and Drought; nevertheless, a number of other sectoral and environmental policy measures that are currently in place may counteract the effect of this water-oriented policy action and actually hinder the achievement of its objectives.

3.1 Overview of EU policy of relevance for water

3.1.1 EU water policy

The EU water policy framework is set in the 6th Environment Action Programme (EAP)[11], which states that EU action should focus, among other things, on:

- Ensuring a high level of protection of surface and ground water.

- Fully implementing existing legislation, in particular the WFD, with a view to achieving a good ecological, chemical and quantitative water status, and ensuring coherent and sustainable water management.

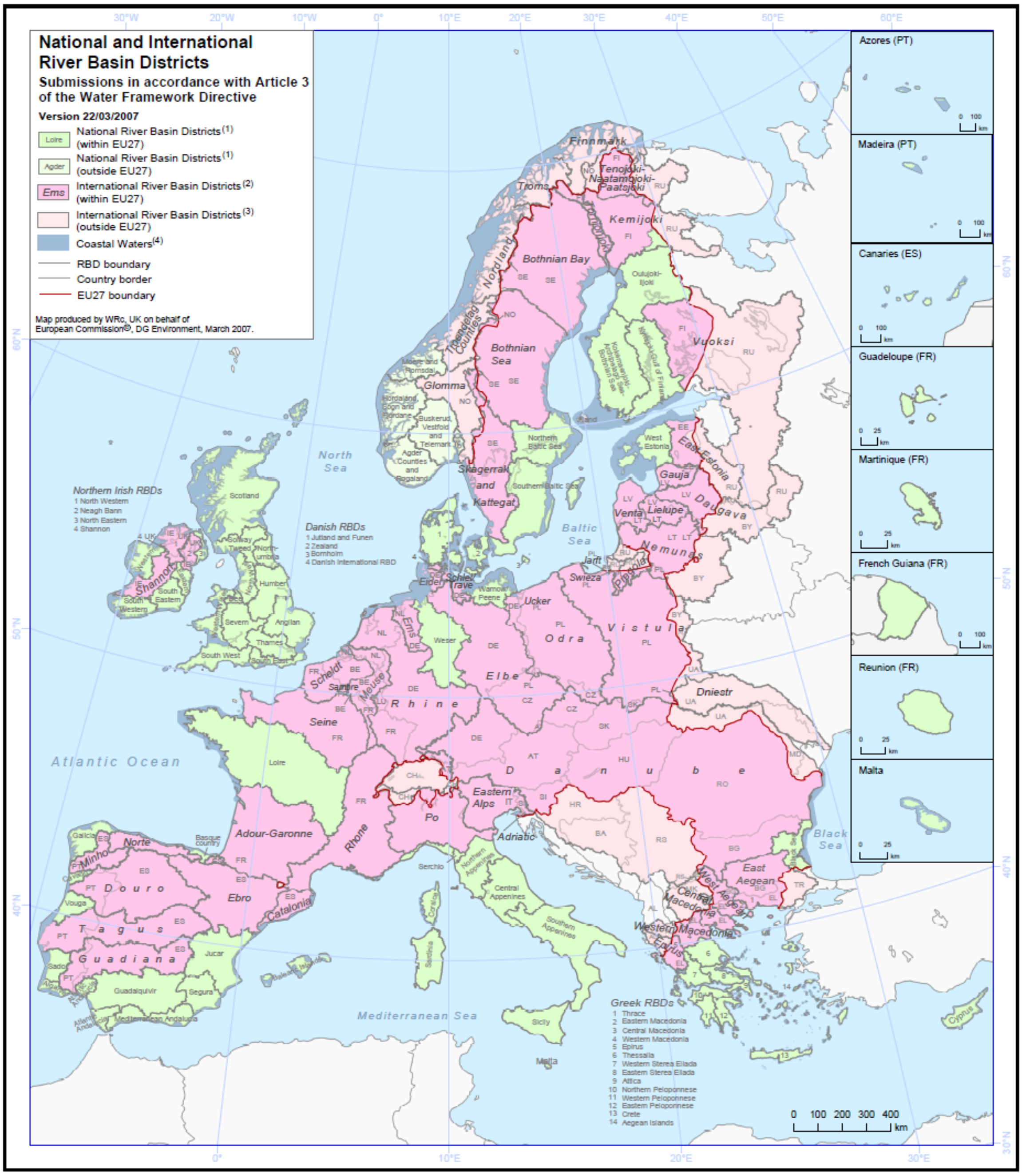
- Integrating the concepts and approaches regarding EU water policy set out in other Community policies (EC, 2002).

[10] COM (2005) 658 final, COM (2009) 400 final
[11] Decision No 1600/2002/EC

The Water Framework Directive

The WFD[12] provides the common general framework for the management of all water resources in the EU, including inland surface waters, groundwater, transitional and coastal waters, establishing an innovative approach for water management in the EU and setting up ambitious water policy goals (EC, 2000).

Map 9 - National and International River Basin Districts



Source: European Commission, DG Environment [website](#)

12 Directive 2000/60/EC

The Directive introduces the two main concepts of (i) good status, in the sense of good ecological, quantity and chemical status, which has to be ensured in all bodies of water by 2015; and (ii) integrated river basin management, implying the identification of river basins and the establishment of river basin management plans (RBMPs), which should integrate all measures aimed at the achievement of good status of bodies of water (Map 9). The management approach set out in the WFD aims at bringing together all water managers, water users and the public; involving different institutional levels in water management; ensuring wide public participation; and recognising the role of international cooperation, in view of the transboundary nature of water issues.

The WFD includes a number of specific measures of relevance for water scarcity and drought. In particular, it requires Member States to:

- Introduce water pricing policies by 2010 (Article 9, Annex III), following the principle of recovery of both environmental and resource costs of water services and the polluter-pays principle. This is meant to provide adequate incentives for the efficient use of water resources.

- Implement a programme of measures at river-basin level, including those aimed at promoting an efficient and sustainable water use (Article 11).

- Introduce systematic controls over the abstraction of fresh surface water and groundwater, including water abstraction registers and prior authorisation for the abstraction of water (Article 11).

- Draft detailed drought management plans or sub-plans as a supplement to RBMPs (Article 13).

The Member States and the EC agreed on a Common Implementation Strategy (CIS) for the WFD in order to address common implementation challenges and foster a common understanding and approach (EC, 2001b). In this context, cooperative work has produced a number of guidance documents, guidelines and other resources available to Member States, NGOs and other stakeholders.

EU action on water scarcity and drought

In 2007, following a request for action from the Environment Council in June 2006[13], the Commission adopted a Communication addressing the challenge of water scarcity and drought in the EU (EC, 2007b). The Communication proposes an integrated approach, based on a combination of options, to tackle

[13] COM (2007) 414 final.

water scarcity and droughts in the EU, and identifies a set of seven policy initiatives that have to be addressed in order to move towards a water-efficient and water-saving economy. This approach is based on the concept of 'water hierarchy' (see also point 4.1.1), which implies that expansion of water supply should be considered only when all other demand-side measures have been exhausted.[14] The seven main policy options identified include:

1. Putting the right price tag on water: introducing water pricing across all sectors, recovering the costs of water supply as well as environmental and resource costs.

2. Allocating water and water-related funding more efficiently, through improved land-use planning, and the introduction of measures for financing water efficiency.

3. Improving drought risk management, through the development of drought risk management plans; the establishment of an observatory and an early warning system on droughts; and the optimisation of the use of the EU Solidarity Fund and of the European Mechanism for Civil Protection.

4. Considering additional water supply infrastructure in areas where all prevention measures have been adopted and water demand still exceeds water availability, through alternatives such as: storage of surface or ground waters, water transfer, desalination or waste water reuse.

5. Fostering water-efficient technologies and practices, through, for example, the development of standards for water-using devices and the inclusion of water efficiency criteria in performance standards for buildings, among others.

6. Fostering the emergence of a water-saving culture in Europe, through awareness-raising initiatives and the extension of EU labelling schemes to promote water-efficient devices and water-friendly products.

7. Improve knowledge and data collection, through the establishment of a water scarcity and drought information system throughout Europe; and the expansion of research and technological development opportunities.

[14] Demand-side management refers to the '*Implementation of policies or measures which serve to control or influence the demand*' (EEA glossary), as opposed to supply-side management and strategies. The latter include '*alternatives based on generating new water sources generally through hydraulic works, groundwater development, desalination and recycling techniques...*' Smits S., 2005.

The implementation of the Communication is regularly monitored and assessed; the results are presented annually through follow-up reports. Within this report, progress in the implementation of EU water policy with respect to the different measures put in place is discussed in detail in Part III, Chapter 4.

A comprehensive policy review of the EU water policy is currently being prepared, following a request from the Environment Council in October 2007 (EC, 2010g). This review, expected by 2012, will contribute to the 'Blueprint for safeguarding European Waters', also scheduled for 2012, which will outline a comprehensive European Water Strategy. The Blueprint will also be based on an analysis of the implementation of the WFD and a review of the vulnerability of environmental resources such as water, biodiversity and soil to climate impacts and anthropogenic pressures (EC, 2010c).

3.1.2 Climate change mitigation and adaptation

The White Paper on adaptation to climate change (COM (2009) 147), presented by the EC in April 2009, sets out a common EU framework to reduce EU vulnerability to the impacts of climate change (EU adaptation framework); it integrates and reinforces the set of measures already put in place in a piecemeal fashion, setting the basis for further action (EC, 2009a). The paper recognises, in particular, that changes in climate will have important consequences on quality and availability of water resources, which in turn will affect many sectors that depend on water. It highlights the need '*to promote strategies which increase the resilience to climate change of health, property and the productive functions of land, inter alia by improving the management of water resources and ecosystems*'.

The EU adaptation framework follows a phased approach: phase 1 (2009-2012) focuses on the definition of a comprehensive EU adaptation strategy, to be implemented from 2013 onwards, and consisting of four pillars: (i) building up the knowledge base on the impacts of climate change; (ii) integration of adaptation concerns into relevant EU policy areas; (iii) establishment of a combination of policy instruments to ensure adaptation; and (iv) stepping up international cooperation on adaptation. In the area of water scarcity and drought, specific actions include:

- developing a Clearing House Mechanism on the impacts of climate change, vulnerability, and best practices on adaptation as well as indicators to better monitor impact and progress on adaptation;[15]

[15] The Clearing House Mechanism is expected to contribute to the Shared Environmental Information System (SEIS), i.e. an integrated and shared EU-wide environmental information system, and to rely also on geographical information provided by the Global Monitoring for Environment and Security (GMES).

- ensuring that measures for adaptation and water management are embedded into rural development programmes;

- developing guidelines, as well as guidance and exchange of best practices to ensure that climate change is taken into account in River Basin Management Plans;

- assessing the need for further measures to enhance water efficiency in agriculture, households and buildings; and

- exploring the potential for policies and measures to boost the capacity of ecosystems to store water.

In December 2009, as a follow-up to the White Paper, the board of water directors of EU Member States adopted a ‘guidance document’ on adaptation to climate change in water management. The document includes a section on water scarcity and drought, where the WFD and the river basin management plans are recognised to be ‘*the best mechanism through which to balance available water resources and demands, thus avoiding long-term water scarcity*’ (EC, 2009b).

3.1.3 EU sectoral policy and land planning

A number of other policies have an impact on water scarcity and drought issues. These include sectoral policies that regulate the main economic sectors using water, such as the Common Agricultural Policy (CAP), energy policy, and EU regional policy, as well as a number of other initiatives such as measures boosting water efficiency in buildings, and financial instruments.

Agriculture

Agriculture is one of the main water-using sectors in Europe, and the main sector in southern Europe. Historically, subsidies to farmers, while buffering the influence of global markets on agriculture, have led to greater water use and a shift from traditionally rain-fed to irrigated crops (EEA, 2009). In particular, CAP subsidies have supported the cultivation of crops such as rice and cotton, which require large amounts of water and often make use of inefficient irrigation techniques, such as flooding. Successive reforms of the CAP have progressively moved away from linking subsidies to production, through the introduction of agri-environmental schemes and support for more environmental-friendly and sustainable farming practices (EEA, 2009; IEEP, 2008; EC, 2007c). The decoupling of subsidies from production was introduced by the 2003 CAP reform together with the mechanism of cross-compliance, which calls on farmers receiving direct payments to respect environmental and other requirements at national and EU levels[16]. The CAP Health Check, agreed in 2008, has pushed decoupling even further by introducing a number of measures which '*will allow a better response to the new challenges and opportunities faced by European agriculture, including climate change, the need for better water management, the protection of biodiversity, and the production of green energy*'[17]. These include the requirement to respect authorisation procedures for using water for irrigation and the incorporation of water issues in the Farm Advisory System (FAS) (EEA, 2009; EC, 2010a). A handbook on advice to administrations about integrating water issues in FASs has recently been made available (Dworak T. *et al.*, 2009).

Energy

Although energy and water use are closely connected and energy production depends on the availability of water in many ways (B.5), EU energy policy does not specifically address this relationship (IEEP, 2008; EC, 2007c). Current policy measures may actually lead to an increase in water scarcity. For example, the national targets for the total share of renewable energy of 20% and a target of 10% renewable energy in transport by 2020[18] may actually lead to a large increase in the production of water-intensive energy crops and increased pressures on water resources, especially in water-scarce regions (EC, 2010a). A recent study concluded that strict implementation of the WFD may affect the capacity of southern European countries to increase national production of biomass (Dworak *et al.*, 2009); in these countries, the cultivation of bioenergy crops could account for 1.4% of total water abstraction. This figure could be reduced to 0.1% if stricter water abstraction measures are applied.

Tourism

Tourism is putting increasing pressure on water resources. In its Communication COM (2010) 352, setting out a European action framework for tourism, the EC recognises that among the challenges faced by the tourism sector are '*... climate change, the scarcity of water resources, pressure on biodiversity and the risks to the cultural heritage posed by mass tourism*'; therefore, '*tourism businesses need to reduce their use of drinking water where there is a risk of drought, and reduce their greenhouse gas emissions and environmental footprint*' (EC, 2010e). In this context, a number of actions are planned for promoting responsible management of resources, including a system of indicators for the

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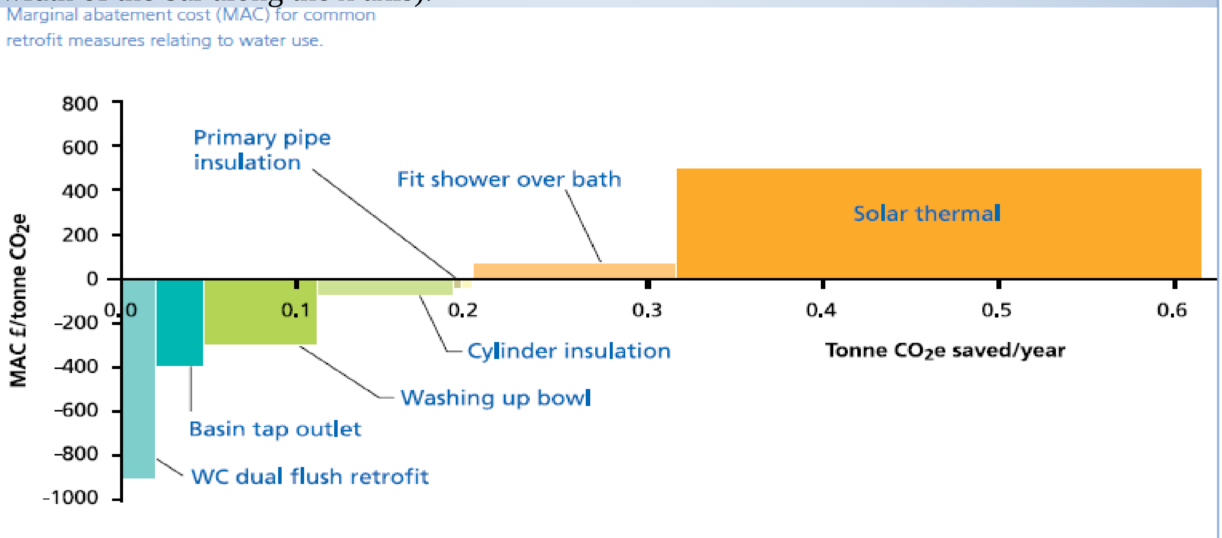
[16] European Commission, DG Agriculture Info sheet on cross-compliance
[17] European Commission, DG Agriculture web page on health check of the CAP
[18] Directive 2009/28/EC (Renewables Directive).

sustainable management of tourist destinations and the organisation of awareness-raising campaigns.

B.5 Energy use, carbon emissions and water

Energy use and water use are closely linked. Saving water would imply saving energy, thus reducing carbon emissions from all processes related to domestic water use. A recent study by the Environment Agency of England and Wales shows that the potential for savings is high. The study also evaluates the amount and distribution of CO_2 emissions for domestic water use and for all the related processes, i.e. water abstraction, treatment, distribution to households, treatment of sewage water and discharge back to the environment, in different types of dwelling (existing housing stock, new dwellings complying with current building regulations, 'Passivhaus' applying exemplary building standards). Findings show that CO_2 emissions associated with water use in households are mainly due to water use within the home (nearly 90%), and in particular for the production of hot water. The potential for CO_2 savings is estimated to be of 200 kg CO_2/person/year if a single measure, such as reduced shower time, is implemented; other measures are shown in the figure below, where those below the x axis save both money and CO_2 (the amount of CO_2 saved is represented by the width of the bar along the x axis).



Source: Environment Agency of England and Wales, 2009.

Soil protection

An EU thematic strategy for soil protection, including a proposal for a Soil Framework Directive, was presented by the EC in 2006 (COM (2006)231 final and COM (2006) 232 final) (EC, 2006b and 2006c), with the aim of maintaining soil functions, in particular its capacity to retain water and to filter contaminants. The protection of soil resources is expected to contribute to the protection of groundwater resources and minimise the impact of droughts (EC, 2010a). However, the Council has so far been unable to reach a qualified majority on the legislative proposal for a Soil Framework Directive.

Environmental Impact Assessment (EIA) and Strategic Environmental Assessment (SEA)

The EIA and SEA Directives[19] provide tools for evaluating the effects on water of those projects that are expected to have a considerable impact on the aquatic environment, as recommended by the board of EU water directors in the context of the CIS of the WFD (EC, 2009e). Most Member States reported full implementation of the two instruments (EC, 2007c).

3.1.4 EU financial instruments

Rural development funds

The rural development programmes funded by the European Agricultural Fund for Rural Development (EAFRD) offer the opportunity to introduce sustainable practices for water demand management (EC, 2007c). The funding of measures, such as water-saving technologies, leakage reduction, water reuse and soil protection, is on the increase (EC, 2010a). On the other hand, an analysis of agri-environmental measures introduced in the Member States in the period 2000-2006 and the results of a study undertaken for the EC in 2009 concluded that the measures included in the rural development programmes have only partially contributed to combating water scarcity and drought issues, and additional efforts are needed (EC, 2010a). In some cases, support was directed at the development of new water supply infrastructure, such as expanding irrigation networks and new reservoirs, rather than at the introduction of water-saving practices, and these may have actually contributed to water stress.

Structural and cohesion funds

The European Regional Development Fund (ERDF), the European Social Fund (ESF) and the Cohesion Fund (CF)[20] offer the opportunity to address water scarcity and drought, through the co-financing of capital-intensive investments in water infrastructure and support for initiatives aimed at complying with water legislation. The funding categories covered also comprise the management of water resources (reducing leakage rates, connecting to water supply, additional supply, and improving infrastructure), and disaster prevention. As in the case of rural development programmes, the activities supported through these funds over the period 2000-2006 rarely addressed water scarcity and drought. In some cases, specific funded measures supported the development of water supply infrastructure without '*demanding compliance with environmental requirements*

[19] Council Directive 85/337/EEC and Directive 2001/42/EC.
[20] These funds are the financial instruments of EU regional policy and contribute to its three objectives of: convergence; regional competitiveness and employment; and European territorial cooperation.

relating to water demand management as a prerequisite for funding' (EC, 2007c). The 2007-2013 programmes provide for significant investments in water infrastructure, amounting to a total of EUR 22 billion, of which EUR 8 million is earmarked for water management and distribution (EC, 2010a). In addition, the European Territorial Cooperation Programmes (formerly 'Interreg') are providing major support for transnational projects on water scarcity (EC, 2007c).

European Union Solidarity Fund

The EU Solidarity Fund (EUSF) provides funding for disaster relief. The fund intervenes in cases of major natural disasters with serious repercussions on living conditions, the natural environment or the economy. Assistance takes the form of a single global grant, with no co-financing required, and is intended to finance measures repairing non-insurable damage. Around EUR 1 billion is allocated every year. The fund has been used only once, by Cyprus during the 2008 drought crisis, to address water scarcity and drought issues (EEA, 2010b).

LIFE+

The financial instrument for the Environment, LIFE+, with a total budget of EUR 2,143 billion for the period 2007-2013, provides specific support for the development and implementation of EU environmental policy and legislation, in particular with regard to the 6th EAP objectives and related thematic strategies (EC, 2010b). Open to public bodies and NGOs, the fund can cover up to 75% of costs. Some 10% of the LIFE projects funded in the period 1992-2007 addressed water-related themes, although most of the projects dealt with water-quality issues, with only 20% addressing water scarcity and drought (EC, 2010b).

Community Mechanism for Civil Protection

The Community Mechanism for Civil Protection and the Civil Protection Financial Instrument are aimed at enhancing Community cooperation in the field of civil protection, and at facilitating prevention, adequate preparedness and effective response to disasters at the Community level. As of 2007, the mechanism had not been used to address water scarcity and drought issues (EC, 2007c).

Research funds

A number of projects on water scarcity and droughts have been funded under the EU Research Framework Programmes (FP). Recent projects have addressed, among other issues: new integrated approaches for the mitigation of water stress; the investigation of alternative water sources; the impact of climate change on drought; and the effectiveness of adaptation and mitigation measures related to changes in the water cycle.[21] The EC will also fund pilot projects for testing specially designed technologies, techniques or practices in four priority regions[22] affected by water scarcity and drought, as a follow-up to a request from the European Parliament (EC, 2010a; EC, 2010f). The projects will focus on techniques for the conservation of rainwater and surface water, alternative forms of irrigation, water-saving measures and less water-intensive crops.

3.1.5 Other initiatives

Water efficiency in buildings

There are currently no EU standards for water efficiency in buildings similar to that addressing energy efficiency (BIO Intelligence Service and Cranfield University, 2009a). Nevertheless, a number of policy instruments have relevance for the use of water in buildings. These include in particular:

- The Construction Products Directive (Directive 89/106/EEC), applying to products manufactured for permanent incorporation in construction works (EC, 1989), though it does not consider water efficiency as an essential requirement that buildings have to satisfy;

- The Energy Labelling Directive (Directive 92/75/EEC), aiming at influencing end-users to buy more resource-efficient appliances, in particular water-efficient appliances, including dishwashers, dryers and washing machines (EC, 1992);

- The Ecodesign Directive (Directive 2009/125/EC), aiming at improving the environmental performance of energy-using products, including water consumption, throughout their life cycle by setting a framework for requirements to be fulfilled in the design stage (EC, 2009c).

[21] The main research projects related to water scarcity and drought that have contributed to the development or identification of good practice are briefly presented at: http://ec.europa.eu/environment/water/quantity/good_practices.htm

[22] Eligible areas for the pilot projects are river basins located in countries affected by desertification according to the UNCCD, with priority given to the following four regions: Pinios River Basin (Greece); Cyprus (territory included in the EU acquis); Guadiana River Basin (Spain and Portugal); and Mures River Basin (Romania).

- The EU Eco-Management and Audit Scheme (EMAS) regulation (Regulation (EC) No 1221/2009), aiming at providing a management tool for companies and other organisations to evaluate, report and improve their environmental performance (EC, 2009d). The revised EMAS regulation includes a performance indicator on water use.

Eco-labelling

The EU Ecolabel (Regulation (EC) No 66/2010) is a voluntary environmental labelling system enabling consumers to recognise high quality eco-friendly products (EC, 2010d). The label may be awarded to products and services which have a lower environmental impact than other products in the same category. The Ecolabel schemes may apply to water-using products such as dishwashers and washing machines, but to date there is no product under these categories that has been awarded the Ecolabel. Other relevant categories of products include campsites and tourist accommodation services.

3.2 International cooperation on water

The World Summit on Sustainable Development and the Millennium Development Goals

The basis for international cooperation on water originates from the UN World Summit on Sustainable Development held in Rio in 1992 and the 2000 Millennium Declaration. The Millennium Development Goals (MDGs), outlined in the Millennium Declaration, set an ambitious international agenda for the eradication of poverty and the improvement of human conditions by 2015. Many MDGs are associated with access to water in adequate quantity and quality, including targets to reduce, by half, the proportion of people who do not have access to safe drinking water and basic sanitation by the year 2015 (UN, 2008). Reaching these will require the development of adequate water management strategies at the supra-national, national and local levels, promoting both equitable access and adequate supply of water.

UN-Water

A number of programmes and activities on water have been established in the MDG framework, including the UN-Water mechanism. UN-Water, composed of representatives of 28 UN organisations, was established in 2003, as a follow-up of the 2002 World Summit on Sustainable Development held in Johannesburg, with the aim of supporting countries in their water activities related to the MDGs. The World Water Assessment Programme, hosted by UNESCO, is the UN-Water flagship programme. Its activities include the preparation of the

World Water Development Report, a regularly updated assessment of the status of the world's freshwater resources.

The EU Water Initiative

The EU Water Initiative (EUWI) is a political initiative of the EU Member States and the EC, launched at the 2002 World Summit in Johannesburg. Its overall objective is to create *'the conditions for mobilising all available EU resources (human and financial), and to coordinate them to achieve the water-related Millennium Development Goals (MDGs) in partner countries'* (EUWI website). Its five specific objectives include: (i) reinforcing political commitment to action and innovation-oriented partnership; (ii) promoting water governance, capacity-building and awareness-raising; (iii) improving water management though multi-stakeholder dialogue and coordination; (iv) strengthening river basin approaches in national and transboundary waters; and (v) catalysing financial resources. EUWI operates through several working groups dealing with cross-cutting issues (research, finance) or with topics having a regional focus. Overall coordination is ensured by a Coordination Group which meets twice a year, and by an Annual Multi-Stakeholder Forum, while the secretariat is provided by the EC.

European official development assistance in the sector of water and sanitation more than doubled over the period 2002-2008, reaching a total of over USD 2.6 billion (nearly EUR 2 billion) in 2008.[23] Examples of successful EUWI cooperation activities include (EUWI, 2010):

- setting-up of country-level dialogues and assistance to relevant regional processes to improve water governance in Africa, the Mediterranean, and Eastern Europe, Caucasus and Central Asia (EECCA);
- contribution to the creation of the EU-ACP Water Facility for Africa, Caribbean and the Pacific;
- support for the establishment of the African Ministerial Council on Water, and the African Civil Society Network on Water and Sanitation (ANEW);
- build-up of capacity on financing and other water issues.

The ACP-EU Water Facility

[23] OECD Credit Reporting System reported in EUWI, 2010

The ACP-EU Water Facility was set up in 2004 with the objective of supporting projects providing water and basic sanitation, thus contributing to the MDGs and improving water management governance in ACP countries. A total of EUR 200 million from the 10th European Development Fund (EDF) has been earmarked under the new Water Facility for projects selected through two calls launched in February 2010. Under the first Water Facility, a budget of nearly EUR 500 million from the 9th EDF was allocated to 175 projects in 2004 and 2006 (ACP-EU Water Facility website).

International River Basin cooperation

More than half of the EU's land area lies within international river basins, i.e. river catchment areas crossing at least one national border. All EU Member States, with the exception of Cyprus and Malta, are concerned by at least one international river basin district (IRBD), which they share with one or more EU or neighbouring countries (see also Map 9) (EC, 2008b). The WFD calls for the creation of international districts for river basins, the setting-up of administrative structures and coordination of the related workload (Article 3); Member States are responsible for applying the directive in the IRBD portion in their territory and nominating a competent authority to administer the necessary work. Historically, cooperation in several IRBDs has already been going on for a long time, for example for the Danube and Rhine river basins, and a number of international river basin commissions are already active. However, more work still needs to be done and international cooperation has yet to be established in most of the designated IRBDs (B.6).

B.6 Disputes over transboundary waters

Despite a long tradition of cooperation on transboundary waters, several disputes have occurred between European countries, in particular on the management of shared water resources. Most disputes date back to the first decades of the twentieth century, but several have occurred even in the last two decades. The dispute between Portugal and Spain in the early 1990s on the 1993 Spanish water plan, which included plans to divert shared transboundary waters, was eventually resolved in 1998 with a bilateral convention and the setting-up of a joint commission. In 2002, a dispute broke out between Greece and the Former Yugoslav Republic of Macedonia (FYROM) on FYROM plans for Lake Dorjran, while there is still a dispute between Hungary and Slovakia over a 1977 bilateral agreement on a dam system, which was later abandoned by Hungary. Other disputes not fully resolved yet have occurred more recently in the Danube river basin (UNEP, 2009).

The Helsinki Convention

The Convention on the Protection and Use of Transboundary Watercourses and International Lakes (also known as the Helsinki Convention or the Water Convention) provides a legal framework to address transboundary waters in Europe, including surface and ground waters. The Convention was adopted in 1992 in Helsinki in the framework of the United Nations Economic Commission for Europe (UNECE) and entered into force in 1996. It includes supplementary Protocols on Water and Health (1999) and on Civil Liability (2003), and, as of January 2011, has been ratified by 38 UNECE countries and the EC. Its main aim is to *'strengthen local, national and regional measures within the UNECE region to protect and ensure the quantity, quality and sustainable use of transboundary water resources'* (UNECE, 2009a). Under the Convention, country Parties are required to prevent, control and reduce adverse impacts on the environment, human health and socio-economic conditions deriving from a change in the condition of transboundary waters caused by human activity. Countries are also obliged to jointly monitor and assess the state of their shared waters and the effectiveness of measures addressing transboundary impacts. In order to fulfil these duties, Parties are to conclude bilateral or multilateral agreements and create joint institutions, such as international river and lake commissions. Since 1992, the Convention has been influential in promoting cooperation on transboundary waters across Europe. In particular the principles of the Convention are reflected in many bilateral and multilateral agreements (UNEP, 2009).

Various activities are undertaken within the context of the Convention. The Convention secretariat takes part in the UN-Water mechanism, and supports the EUWI National Policy Dialogues on Integrated Water Resource Management in the EECCA countries. The Meeting of the Parties adopted Guidance on Water and Adaptation to Climate Change in November 2009 (UNECE, 2009b), providing recommendations on how to implement adaptation in water-related policy sectors addressing transboundary aspects. Other activities include the monitoring and assessment of transboundary waters. A first assessment of transboundary rivers, lakes and groundwater was prepared in 2007 (UNECE, 2007), and a second assessment is under way. An International Water Assessment Centre, located in Bratislava, assists the development of pilot projects on the different aspects of the Convention.

The UN Convention to Combat Desertification

The UN Convention to Combat Desertification (UNCCD) was adopted in Paris in 1994 and entered into force in 1996. As of December 2010, it had been ratified by 195 countries. The UNCCD promotes effective action to fight desertification and mitigate the effects of drought in affected countries by facilitating international partnerships and supporting the development of regional (supra-national), sub-regional and national action programmes (UNCCD, 1994). Its implementation criteria are detailed in five regional implementation annexes for Africa, Asia, Latin America and the Caribbean, the Northern Mediterranean, and Central and Eastern Europe. EU countries concerned are included in either the UNCCD Northern Mediterranean region (such as Italy) or the Central and Eastern European region (such as Romania). Affected country Parties are required to develop National Action Programmes (NAPs), detailing measures to combat desertification. As of December 2010, Greece, Italy, Portugal, Romania, and Spain had adopted their NAPs while others were still in the preparation phase (UNCCD website).

As of 2010, progress in the implementation of the Convention towards its strategic and operational objectives was to be regularly and systematically measured through a number of impact and performance indicators. The fourth reporting process is currently underway, involving both affected and developed country Parties and providing information on agreed performance indicators, financial flows and best practices for sustainable land management. In the context of UNCCD activities, a Drought Management Centre for South-Eastern Europe was established in Ljubljana, with the aim of helping Parties implement the UNCCD and strengthen their technical and scientific capacity for drought preparedness, monitoring and management.

The UNECE 'Environment for Europe' process

'Environment for Europe' (EfE) is a cooperative process involving the 56 UNECE countries, UN organisations, the EC and EU agencies, as well as NGOs, the private sector and other groups operating in the pan-European region. The process, together with its Ministerial Conference, provides a high-level platform for addressing environmental priorities across Europe. Its main aim is to harmonise environmental policy and improve Europe's environment, with a special focus on Southern Europe and the EECCA[24] countries. The first Ministerial Conference took place in Dobris Castle, near Prague, in June 1991, and has since been followed by five other conferences throughout which the EfE process has strengthened pan-European partnership and closer cooperation and has been a significant force for the adoption of regional multilateral environmental agreements, such as the Aarhus Convention[25] in 1998. Other achievements include the production of four pan-European assessments on the state of the environment, the introduction of a programme for Environmental

[24] Eastern Europe, Caucasus and Central Asia
[25] Convention on Access to Information, Public Participation in Decision-making and Access to Justice in Environmental Matters

Performance Reviews, and the adoption of several regional strategies (on biological and landscape diversity, education for sustainable development, environmental data collection and processing, among others).

Following a decision on reforming the process in 2007, activities will now focus on implementing national environmental policies, supporting the convergence of policies and approaches, and further encouraging cooperation with civil society, in particular the private sector. The 7th Conference will take place in Astana, Kazakhstan, in September 2011. ‘Sustainable management of water and water-related ecosystems’ will be addressed as a priority at the Conference, together with ‘Greening the environment: mainstreaming the environment and economic development’. Water topics will include policies to protect aquatic ecosystems, linkages between human health and water, adapting water management to extreme weather events and climate change, and cooperation in transboundary basins (UNECE, 2011). The discussion will be supported by, inter alia, two papers identifying key issues and challenges, proposing possible measures in the two priority areas of water and the green economy; the second report on transboundary waters that is being prepared in the framework of the Helsinki Convention; and a critical review of existing national and international environmental assessments on the two priority topics (the so-called ‘Assessment of Assessments’).

4. Policy implementation and the management of water resources

Water is becoming a scarce resource in many parts of Europe due to a variety of factors, starting with the increasing conflicts between different water needs, which may be exacerbated by local conditions and natural dynamics such as the effects of climate change. Conflicts on the use of water can take place at different levels; they may arise, for example, from the need to ensure enough water for human activities and for ecosystems; and for public and private use, taking into account the various economic sectors. In river basins, conflicts may also occur between upstream and downstream users, and among different communities, or as a consequence of the temporal variability of water resources (e.g. water uses in agriculture and tourism are generally higher during summer when there is less water available). Although water is considered a renewable resource, a conflict may also arise between generations, as choices made today, for example on the location of new water infrastructure, may affect the availability of water in the future.

Water is both a social and an economic good. On the one hand, as water is essential for life and for all human activities, access to clean water in sufficient quantity must be ensured for all. On the other hand, failures encountered in meeting basic water needs worldwide in the past decades have demonstrated the need to consider water as an economic good and to use economic approaches in water management (UN, 1992). Integrated water resources management approaches have been proposed to balance social, environmental and economic concerns, and water-pricing policies have been put in place to recover the full costs of water. However, finding the right balance among major social, economic and environmental requirements has proved difficult.

The management of water resources implies many different tasks, involving many different actors, the main ones being[26]: (i) water allocation, '*to major user and uses, maintaining minimum levels for social and environmental use while addressing equity and development needs of society*'; (ii) river basin planning, '*incorporating stakeholder views on development and management priorities for the basin*'; (iii) stakeholder participation: *'as a basis for decision making that takes into account the best interests of society and the environment in the development and use of water resources in the basin'*; (iv) pollution control, '*using polluter pays principles and appropriate incentives to reduce most important pollution problems and minimize environmental and social impact*'; (v) monitoring, *'through effective monitoring systems that provide essential*

[26] The source of definitions is the Global Water Partnership

management information and identifying and responding to infringements of laws, regulations and permits'; (vi) economic and financial management, '*applying economic and financial tools for investment, cost recovery and behavior change to support the goals of equitable access and sustainable benefits to society from water use*'; (vii) information management, providing the '*data to make informed and transparent decisions and development and sustainable management of water resources in the basin*'.

Approaches to water management have primarily been based on expanding water supplies and on sectoral measures, without taking into account, or mediating between, the different needs. Traditional, top-down, approaches are proving to be inadequate in handling current challenges of water management (EEA, 2010a), in particular in the face of current water scarcity problems and the great variety of actors and levels of government involved. Water management gaps such as those identified by the OECD (B.7) have led to *'poor service and unsustainable resource use'* (GWP website). Recognising these shortcomings, EU water policy (in particular the WFD and the EU policy on water scarcity and drought) has promoted a more sustainable and integrated approach to water resources in Europe, based on some key principles: (i) water hierarchy and water efficiency; (ii) integrated water resource management, in particular Integrated River Basin Management; (iii) subsidiarity and multilevel governance; and (iv) public participation.

In particular, sustainable water management should reflect the multiplicity of uses and the transboundary nature of water. In order to do so, it should integrate the economic, social and environmental dimensions; be based on physical river basin boundaries; involve different institutional levels; ensure wide public participation; and provide the basis for international cooperation where relevant.

4.1 Key principles of EU water management

4.1.1 Water hierarchy: promoting water efficiency

The 2007 Communication on water scarcity introduced the concept of water hierarchy, to be applied for identifying measures to tackle water scarcity. The principle establishes that water demand measures should be considered first, while additional water supply infrastructure and alternative sources should only be taken into account when the potential for water efficiency has been exhausted (an example of the application of the principle is illustrated in Figure 4, where the horizontal line indicates the limit beyond which supply-side measures would be necessary). The costs and benefits of the various options, including their environmental impacts, should also be taken into account. The Communication also prioritised various water uses, by considering public water supply as having the '*overriding priority to ensure access to adequate water provision*' (EC, 2007b).

B.7 Water governance and water management gaps

…'Whatever their institutional context, countries face strong governance challenges in the water sector, such as the high degree of fragmentation of roles and responsibilities, or the lack of competence of some key actors, especially at subnational level.'

In the framework of the Horizontal Programme on Water (2009-2010), the OECD is implementing activities aimed at helping policymakers to address water governance challenges. These challenges refer to both horizontal gaps across ministries and agencies and vertical gaps across levels of government. **Horizontal gaps** relate to: the *policy framework* (different political agendas, visibility concerns and power rivalries across ministries and agencies at central level); (ii) unclear *allocation of roles and decisions* with overlapping of roles and responsibilities among government ministries; (iii) *capacities* (asymmetry of knowledge, enforcement capacity and technical expertise across ministries); *funding resources* (asymmetry of revenues and resources across ministries); *timeframe and strategic planning* (different schedules and deadlines occuring between ministries involved in water policies); lack of evaluation of governance practices. **Vertical gaps** relate to: *administrative competence* (i.e. geographical mismatch between hydrological and administrative boundaries); *information* (asymmetries of information between policy making and/or implementation authorities and between public and non-governmental actors); *policy* (sectoral fragmentation of water-related tasks across various authorities, constraining synergies and the exercise of political leadership and commitment); *capacities* (insufficient scientific, technical, and implementation capacity on the part of local water management actors with respect to the size and quality of the infrastructure and resources they must manage); *funding* (unstable or insufficient revenue undermining the effective implementation of water responsibilities at subnational level).
Source: OECD, 2009.

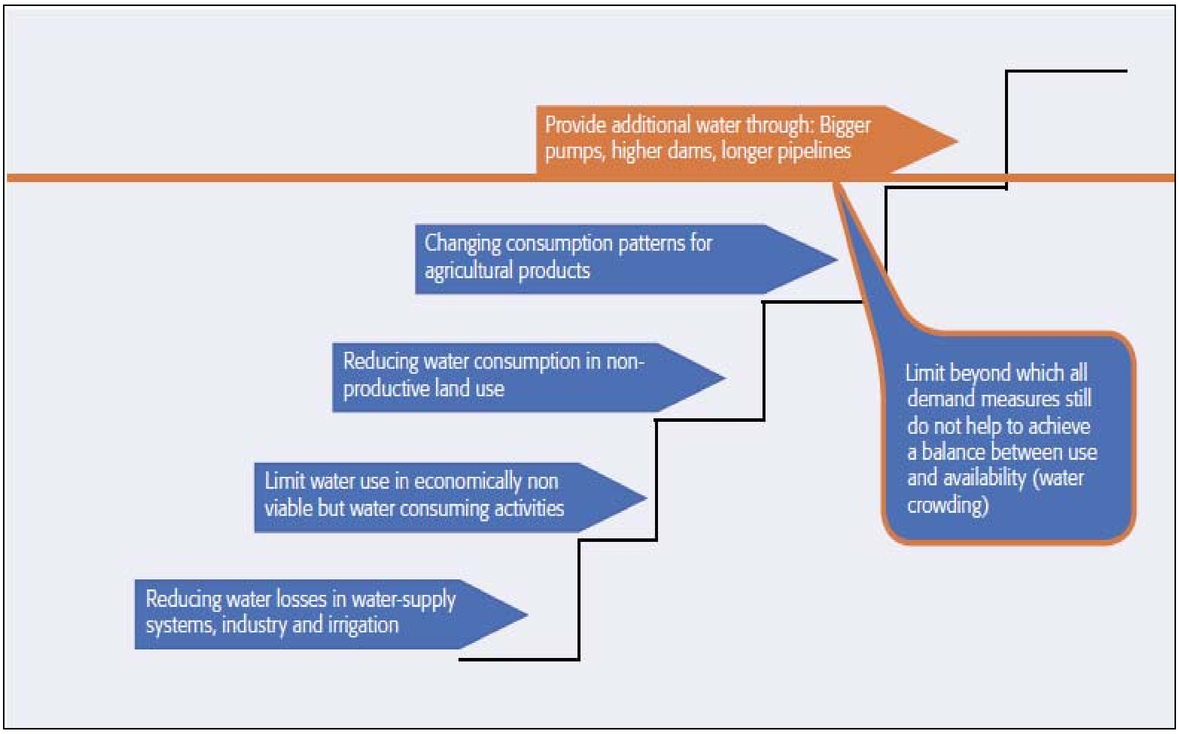
4.1.2 Integrated River Basin Management

Water management should reflect the multiplicity of uses and the transboundary nature of water. This requires the substitution of water management approaches addressing single sectors separately with the integrated management of water resources across all uses.[27] Water management should also be based on physical boundaries (hydrological planning), as waterflow does not follow administrative borders. The EU water policy considers the river basin as the most appropriate territorial level for water management, based on Integrated River Basin

[27] This approach is based on the concept of Integrated Water Resources Management (IWRM), which *'...is the coordinated development and management of water, land and related resources in order to maximise economic and social welfare without compromising the sustainability of ecosystems and the environment'* (source: Global Water Partnership).

Management (IRBM))[28]. IRBM takes into account the economic, social and environmental dimensions of water management as well as the interactions between the different sectoral uses.

Figure 4 - A hierarchy of measures: reduce, reuse and recycle



Source: Falkenmark, M. *et al.* (2007)

4.1.3 Subsidiarity and multi-level water governance

Water governance can be defined as '*...the political, social, economic and administrative systems that are in place, and which directly or indirectly affect the use, development and management of water resources and the delivery of water service at different levels of society* ' (UNDP-GWF website). In the EU context in particular, '*...multi-level governance means coordinated action by the Union, Member States and local and regional authorities, as well as socio-economic partners and NGOs, based on the principles of partnership and co-financing and aimed at drawing up and implementing European Union policies[...], a definition which implies responsibility being shared between the different tiers of government...*'(EP, 2010). Subsidiarity implies that policy issues should be handled at the lowest administrative level possible, closest to the citizen, while action should be taken at the EU level only if effective

[28] The WFD does not provide an explicit definition of IRBM. Based on the concept of IWRMs, the World Wide Fund For Nature has defined IRBM as *'the process of coordinating conservation, management and development of water, land and related resources across sectors within a given river basin, in order to maximise the economic and social benefits derived from water resources in an equitable manner while preserving and, where necessary, restoring freshwater ecosystems.'*

measures cannot be taken at local, regional or national level. Subsidiarity and multi-level governance are key principles of EU water policy.

4.1.4 Public participation

With the aim of improving the decision-making process, the WFD requires river basin management plans to be discussed among all relevant stakeholders, including local and regional authorities, local communities, water supply companies, and non-governmental organisations, encouraging their active involvement (Article 14 on Public information and consultation). This approach should enable the collection of information on possible local issues and specific needs existing at the river basin level, and support the planning of the different measures and the setting of priorities, thus ensuring a broad consensus for implementation. A specific document on public participation has been issued in the context of the CIS for the WFD. The document provides guidance to the competent authorities, i.e. the authorities designated as responsible for each river basin, on public participation, while recognising that *'no blueprint exists for public participation and that the public participation process should be organised and adapted to national, regional and local circumstances'* (EC, 2003).

4.2 Water management and progress in the implementation of water measures

Effective water management today requires the implementation of a mixture of measures, aimed in particular at promoting more efficient use of water. Demand-side measures might include devising drought management plans, promoting water-savings, increasing efficiency of water use through new technologies and changing processes in industry and agriculture, improving natural storage, improving irrigation technologies, optimising soil water use, reducing agricultural use, promoting waste water reuse, setting-up water banks and quota systems, establishing pricing policies, and conducting awareness campaigns. Supply-side measures might be directed at preserving the functioning of natural catchments and aquifers, recharging aquifers or improving efficiency in the use of existing water infrastructure.

4.2.1 Potential for savings in Europe across all water uses

The potential for savings in different sectors in Europe is summarised in Table 2 according to the results of a study carried out in 2007 for the EC (EC, 2007a; Ecologic, 2007). The study takes into account savings that can be achieved in all sectors through technical measures only, not considering major shifts in user behaviour or production patterns. Theoretically, savings range from 33% to 100%. Within the public sector or in households, they may be supported by the reduction of leakages in water-supply networks, the introduction of water-saving devices and/or the use of more efficient appliances. The tourism sector has the potential to significantly increase water-use efficiency by installing less water-consuming appliances similar to those available for households. More efficient irrigation techniques or rainwater harvesting for the irrigation of golf courses and leisure facilities could provide further savings. Improvements in irrigation technologies and infrastructure in the agricultural sector – including improvements in conveyance efficiency of irrigation systems, changes in irrigation practices, use of more drought-resistant crops, reuse of treated sewage water – could lead to potential water-savings of nearly 45% of the current volume of water abstracted for agricultural uses.

Technical measures implemented in the industrial sector[29] – including changes towards less water-demanding processes, higher recycling rates and the use of rainwater – could result in water-savings of between 15% and 90%.

[29] Water-intensive industries include mining and the production of paper and pulp, textile, leather (tanning), oil and gas, chemical, pharmaceutical, food, energy and metals.

Table 2 – EU water-saving potential by sector

Sector	Current water use	Saving potential	Water use in 2030 (baseline scenario)
Agriculture (EU27)	Around 65,898 million m³ for 11.7 million hectares equipped for irrigation	Estimated at 28,420 million m³ or 43% of today's total water abstraction. Most of the water-savings (98%) take place in southern Europe	73,608 million m³ per year (based on +11.3% increase for the period 2000-2030)
Households	Between 265l/p/d (Spain) and 85l/p/d (Lithuania) with an average of 150 l/p/d	Between 18% and 47% assuming an average consumption of 122 l/p/d (UN Sustainable Development Commission) and 80 l/p/d (UK Code for sustainable planning) respectively	
Public water supply (excluding households)	73,222 million m³ for EU 30 (563 million inhabitant in 2000) (*)	24,430 million m³ or 33% based on 87 m³/year	75,616 million m³ for EU 30 (587 million inhabitants) (*)
Industry	39,737 million m³/year (*)	43% of total water use (14,360 million m³) Based on the assumption that the sector has an average technical saving potential of 50% but that 25% of the sector have already achieved the maximum saving	56,943 million m³/year (95% increase) (*)
Energy production (electricity)	94,973 million m³/year (*)	Almost 100%, according to the technical specifications provided by the Electric Power Research Institute (2002)	30,816 million m³/year (*)
Tourism (EU 25)	490 million m³/year	38% or 188 million m³ litre/year	

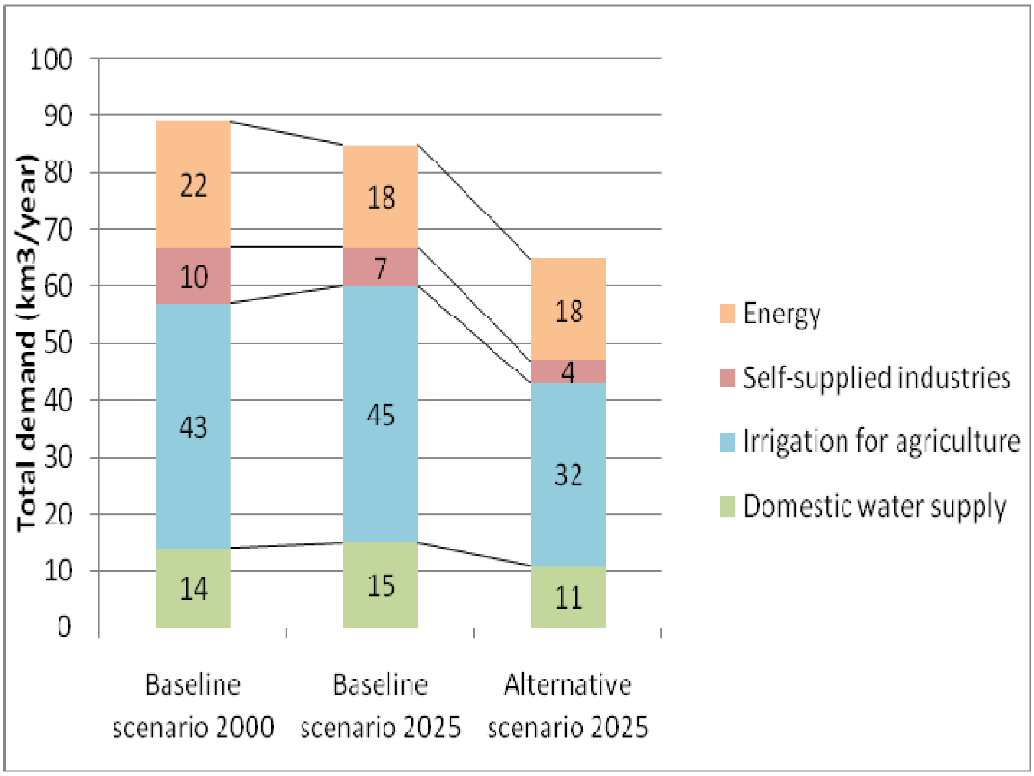
(*) Based on Flörke, M. Alcamo, J. (2004)

Source: adapted from EC, 2007a

The application of water-saving practices would be extremely relevant in areas prone to water scarcity and drought; according to the Plan Bleu, water-saving potential in the Northern Mediterranean could amount to some 20 km³/year in

2025, corresponding to about 25% of the total demand in 2000[30]. Most of the potential savings are estimated to be in the irrigation sector (Figure 5).

Figure 5 - Total demand, baseline and alternative scenarios, Northern Mediterranean



Source: Plan Bleu, 2005

4.2.2 Water pricing

The introduction of water pricing and charging systems in all sectors, aimed at recovering the costs of water supply as well as environmental and resources costs, is a key measure for promoting a water-saving culture and reducing water demand. The most common solutions to encourage water-savings are the application of progressive block tariffs[31], the application of penalties for excessive consumption, and discounts for water-savings (EC, 2010a).

While water charging systems have been implemented for drinking water supply in most Member States, more efforts have to be made in setting up charging systems for other uses. In the EU, water metering is being widely implemented in the context of domestic drinking water supply. There is evidence that the installation of meters has led to lower water consumption; in England and Wales, for example, water use in households equipped with water meters is

[30] Plan Bleu alternative scenario, estimates of water savings with respect to the 2000 baseline scenario. Sources: Plan Bleu (2005); European Commission (2007a).
[31] Block tariffs entail an increase in the volumetric or per unit charge in cases where a predefined consumption threshold is exceeded.

estimated to be 13% lower than water use in households without meters (EEA, 2009). Although some progress can be seen in the introduction of metering programmes in connection with other water uses, in particular agriculture, there is still ample room for improvement (EC, 2010a; EEA, 2010b).

Overall, a thorough evaluation of the effects of water pricing schemes is difficult due to lack of data, the complexity and wide variation of the measures being implemented across Europe; in some countries, water pricing has proved to be an effective tool for promoting water-savings (EEA 2009; EEA, 2010b) but in others water consumption has increased despite the introduction of charges recovering the full costs of water supply (EC, 2010a). For example, it has been reported that water pricing for agricultural use does not always lead to reduced abstraction in cases where the water bill is a small portion of the overall farm costs, alternative crops and techniques are not available and most of the charges consist of fixed costs (EEA, 2009).

A further major challenge is represented by illegal water abstraction. This is reported to be widespread in some areas in Europe, in particular from groundwater and for agricultural uses (EEA, 2009). Combating illegal abstraction would require monitoring and surveillance set-ups, and the enforcement of a system of fines.

4.2.3 Water efficiency and conservation measures

Economic development and the implementation of existing policies have had a significant impact on water resources at local level, especially in those areas more prone to water scarcity and droughts. Moving towards a more sustainable use of water requires taking into account the amount of water available at the local level in land-use planning and in the development of all economic activities (EC, 2007a). As a consequence of the implementation of the WFD, the EU strategy on water scarcity and drought, and the increasing awareness of water quantity issues, some progress is being made in integrating water quantity concerns within sectoral policies at the EU, national and local levels (EC, 2010a), but the implementation of RBMPs is reported to be lagging behind. Indeed, a recent study carried out by the European Environmental Bureau (EEB, 2010a), concludes that the implementation of the WFD is not meeting its objectives and a north-south divide is emerging. Moreover, few of the RBMPs have defined water-saving objectives and a ‘business as usual’ approach is still predominant. Water efficiency, demand management and drought planning is not being realised, and the integration of water quality, land use and water resources management is not progressing (EEB, 2010b).

Water efficiency in buildings

As shown in a study carried out for the EC, very few policy instruments address water efficiency in buildings (BIO Intelligence Service and Cranfield University, 2009a). Most of the measures have been taken in areas facing water scarcity and drought and appear to be managed primarily at the regional level. Instruments in place vary from incentives to regulatory and information mechanisms. Regulatory mechanisms include legislation requiring the use of devices or practices to improve water efficiency, such as building codes and planning guidelines; information mechanisms include measures aimed at increasing awareness and provide information to water users; incentives include subsidies and tax-related interventions aimed at changing user behaviour. Most of the existing schemes make use of either regulatory or information mechanisms, or a combination of both, which can be implemented as mandatory or voluntary measures. In general, mandatory measures are implemented in the most severely affected areas, while voluntary measures are taken at national or international level. A non-exhaustive list includes: rating tools (France, Germany and the UK); building codes at national or local level (Ireland, Italy, Spain and the UK); planning guidelines (France and Spain); and labelling schemes (Nordic Swan label in the Nordic countries).

The same study recognises that the measuring systems currently in place are unlikely to lead to consistent water-savings in most cases. A number of economic, technical and institutional barriers exist, but the main reason for the slow uptake of water efficiency measures in buildings remains the lack of awareness among users. More effort is required to achieve the existing saving potential in buildings; for example, the extension of the Ecodesign Directive to cover water-using devices could lead to a nearly 20% reduction of abstraction for public water supply in the EU, corresponding to over 3% reduction in annual total water abstraction.

Reduction of leakages

Water losses in water supply systems are reported to be significant in many areas in Europe, mainly due to poor maintenance of water infrastructure. The situation varies greatly across Europe (Ecologic, 2007; EEA, 2003; EEA, 2010a). In some countries, for example in Denmark and Germany, losses have been reduced to the lowest technically feasible level, with reported losses of less than 10%. In other countries, losses are considerably higher: around 20% for the Czech Republic, Spain, and England and Wales (EEA, 2010b) and nearly 25%, in 2008, in the historical network of the city of Rome (ACEA, 2010). In some countries, prevention, detection and repair of leakages over the past 10-15 years has led to considerable reductions in water loss - between 30% and 50% in the

Czech Republic, Denmark, Germany, Malta, the Netherlands, Spain and the UK (EEA, 2010b).

Whether the privatisation of water services results in better-maintained systems is still controversial (B.8).

4.2.4 Drought management plans

Effectively tackling water scarcity and drought requires moving away from ‘crisis response’ towards full ‘drought risk management’ (EC, 2007b). This entails the setting-up of comprehensive drought management plans (DMPs), the mapping of risk areas, the introduction of early warning systems, and the exchange of information and best practices, among other measures. The WFD requires the preparation of detailed drought management plans as a supplement to river basin management plans. Some progress is being registered in the Member States, for example in setting up indicator systems, mapping of risk areas, developing national DMPs, introducing warning systems or sectoral water-use restrictions, often in connection with awareness-raising campaigns. However, there are considerable differences across Europe (EC, 2010a).

In this context, a wider exchange of information and best practices would be beneficial. The Commission is planning to prepare general recommendations on methodologies for the mapping of droughts and the assessment of drought thresholds, while the European Drought Observatory has implemented a prototype for drought forecasting, detection and monitoring and is currently working on drought indicators (Observatory website). Moreover, the Drought Management Centre for South-Eastern Europe in Ljubljana, established in the context of the UNCCD, could play a role in the application of drought risk management tools.

B.8 The privatisation of water services

Following the application of economic approaches to water management, the transfer of responsibilities for the management of water services from the public to the private sector has been accelerating in the past decades. It has been estimated that the number of people served by private water services increased six-fold worldwide in the period 1990-2000. Privatisation has been supported by international financing institutions such as the World Bank and the International Monetary Fund, as well as by major multinational corporations. In the UK, the privatisation of water services took place in the late 1980s (UNDP, 2006). In Italy, privatisation was first introduced in 1999 at the regional and local level (municipality of Arezzo (Toscana), and Puglia region), while recent laws have promoted water privatisation on a national basis (Stampa, 2009; Ciervo M., 2010; Repubblica, 2011a). The privatisation of water services has raised significant concerns, sometimes facing strong opposition, partly due to the failure of several projects (Pacific Institute, 2002; UNDP, 2006; Massarutto A., 2008; Ciervo M., 2010). It is argued that private companies aim at maximising profits and implement top-down management approaches; additionally, in many cases privatisation has not resulted in water efficiency, better service, better infrastructure, or environmental benefits, nor has it resolved water scarcity problems as claimed or expected (Pacific Institute, 2002; UNDP, 2006; Ciervo, M. 2010). Although in some situations privatisation has proved beneficial, it is still a highly controversial issue. It Italy, for example, it is currently the subject of debate, as the Constitutional Court recently approved a referendum on the abrogation of some provisions of the national law on the privatisation of water services (Repubblica, 2011b).

4.2.5 Alternative water sources

The application of the water hierarchy principle implies that the expansion of water supply infrastructure (e.g. reservoirs, inter-basin transfers, new abstraction points) and the use of alternative water sources should be taken into account only after demand-side measures have been exhausted. Nevertheless, several EU countries are still obliged to take supply-side measures to overcome water scarcity and drought (EC, 2010a).

Alternative water sources include the accumulation and storing of rainwater (water harvesting), desalination of sea-water, and the reuse of greywater or treated waste water for non-drinking purposes such as agriculture, industry, gardens and leisure facilities. Some of these alternative sources may require a great deal more energy, for example desalination plants, or they may transfer the problem to other media. For example, the reuse of waste water in agriculture, for which there is a great potential, may lead to soil contamination and have an impact on public health. It is therefore crucial to assess the environmental impacts of alternatives on a case-by-case basis (Table 3). In particular, waste water could meet respectively 2% and 3.5% of the irrigation needs of the EU25 and the Mediterranean countries (EEA, 2010a; Angelakis A.N., Durham B., 2008).

Table 3 – Risks and benefits of alternative water supply sources

Alternative source	Description	Uptake	Advantages	Disadvantages
Desalination	Removal of dissolved minerals and mineral salts from saline water. Most used technology: reverse osmosis	Most common in coastal regions in southern Europe (e.g. Spain: over 700 million m^3/day), but being taking up in northern Europe	Can be used to supply drinking water	▪ Environmental and economic concerns about high energy use ▪ Local land use changes ▪ Brine disposal (e.g. impacts on water quality)
Rain harvesting	Collection, storage and use of rain water	Little information on uptake in EU27	Reduced urban storm-runoff	▪ Risks to health (water-borne diseases, skin irritation) ▪ Low uptake and high investment costs (recovery time: ca 25 years) ▪ Depending on seasonal rainfall distribution
Groundwater recharge	Recharge of aquifers through infiltration of rainwater, surface water or reclaimed water by natural infiltration or injection through a bore-hole	Most common in northern Europe	▪ Recharge of over exploited aquifers ▪ Prevention of saline water intrusion	Environmental risks mainly associated with reuse of waste water
Waste water reuse	Direct reuse of waste water (no dilution) Mixing of waste water with other water (as in ground water recharge)	Growing importance in southern European countries (e.g. Spain: 496 million m^3/yr in 2006; Italy: 233 million m^3/yr in 2000), but also used in other countries such as Germany, France and the UK	▪ Multi-sectoral use possible (but not for drinking use) ▪ Low, quickly recoverable capital costs ▪ Improvement of soil properties due to nutrients: decreased need for fertilisers if	▪ Health risks (water-borne diseases, skin irritation) ▪ Environmental risks (heavy metals, high nitrate loads, salt accumulation, acidification) ▪ Need for additional distribution systems ▪ Risk for groundwater contamination ▪ Low users' acceptance

			used in agriculture	▪ No EU legislation and standards

Source: extracted from the results of a study assessing four alternative water supply options in Europe (De Nocker L. *et al*., 2007)

Promoting the reuse of waste water would require the development of standards and the exchange of best practice. Mandatory standards for the reuse of waste water do not exist at EU level, while non-mandatory recommendations have been prepared by the Waste Water Reuse Working Group in the context of the Mediterranean-EU Water Initiative and the Joint Mediterranean EUWI/WFD Process (MED-EUWI, 2007; EC, 2010a).

4.2.6 Raising awareness and better information

Sustainable water management requires that relevant and reliable information is made available at the appropriate temporal and spatial scales to policymakers and the public. This would increase public awareness of water problems, and would facilitate the development, implementation and evaluation of policy measures (EEA, 2009). In this respect, there are large information gaps in terms of temporal and spatial scales and resolution of water-related data; information on the effects of climate change; quantification of socio-economic impacts of water scarcity and droughts; and effectiveness of policy measures.

Progress is being made to reduce these gaps. At European level, activities include the implementation of the Water Information System for Europe (WISE), gateway to water information in Europe hosted by the European Environment Agency (WISE portal) and the prototype of the European Drought Observatory, hosted by the Joint Research Centre. Other information tools have also been developed, for example in the context of the Euro-Mediterranean Partnership (EMWIS portal). Indicators such as 'virtual water' and the water footprint of a country[32] can be useful tools for improving awareness about water use.

[32] Virtual water describes the amount of water required to produce a particular good or service. The water footprint of a country is defined as the volume of water needed for the production of goods and services consumed by the country's population. Neither, however, provides an indication as to whether abstraction at source was done in a sustainable way or whether part of the water used was returned to the water system (EEA, 2009).

Appendix I – List of References

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