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WATER SCARCITY AND DROUGHTS

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EXECUTIVE SUMMARY

Water scarcity and droughts affect many parts of Europe. For example, all Mediterranean EU countries are already affected, being 130 million inhabitants or nearly 30% of the EU population. Climate change is predicted to make the existing problems worse in many regions. Thus it is important for the EU institutions, the Member States and individual stakeholders to adopt strategies and take action to manage such problems now and in the future. The European Parliament Environment, Public Health and Food Safety Committee (ENVI), therefore, requested this briefing specifically to consider the following questions:

1. Economic effects of water scarcity and droughts – regional differences and the link with Lisbon goals and meeting its targets.
2. Effects of water scarcity and droughts on ecosystems and public health.
3. Effects of climate change of water scarcity and droughts – regional differences, impacts on different sectors and adaptation strategies.
4. Water price policies in the Member States.
5. Integration of the issue into other policy areas.
6. Information availability for strategic decision making.
7. Research and technology development related to efficient water use – knowledge gaps and research for new technologies for industry/agriculture and private households.
8. EU institutional roles for decision making.
9. Situation in neighbouring countries/areas.

Significant economic effects can arise from the impact of water scarcity and droughts. Droughts are initially most likely to impact upon agricultural activity as irrigation is the first pressure to be tackled. However, power production can be affected if cooling water is restricted. The widespread drought of 2003 incurred damage costs to the EU economy of at least €8.7 billion. Over the past 30 years they put the total cost at €100 billion, and note a sharp upward trend such that the average cost has quadrupled over the same period. Assessing the longer-term economic impact of water scarcity is more difficult, not least because there are major efficiency savings that could be put in place which could off-set such impacts.

Water scarcity and droughts can have significant negative impacts on ecosystems through effects such as the drying of wetlands, concentration of pollutants affecting river biota, increasing risk of forest fires, etc. However, many of these impacts do not occur in isolation, but are influenced by other pressures, such as agriculture, and it is important to clarify precisely the nature of the specific impacts of water scarcity and droughts. There are limited impacts on health via water availability itself, although droughts are often accompanied by temperatures that do affect health. However, there can be significant social consequences.

Climate change presents a major threat in relation to water scarcity and droughts, particularly for the Mediterranean and Central and Eastern Europe, with predictions that both scarcity and droughts will increase and, therefore, water resource management decisions will become more difficult. Considerable uncertainties remain, however, not only in the extent and nature of likely impacts, but also in the potential efficacy of adaptation measures.

Water pricing is an important tool in reducing water use, although it has limitations in its ability to affect the behaviour of water consumers. Major advances have been made in making domestic water users pay more realistic prices for water and this has affected consumption in a number of countries. However, there are major differences in approach between Member States, such as in different size and types of rates and the extent of metering and thus comparability of data can be a problem. Agriculture is a major water user and water pricing can act as a major stimulus to reducing use.

However, pricing effects are highly variable, with some agricultural activities being barely able to cope with increased costs, while for others the costs are marginal to their profitability. Water pricing for industry is currently at a level that is unlikely to change behaviour given that water costs are small compared to overall production costs.

The EU has a range of policies relating to water scarcity and droughts. The primary water management policy is the 2000 Water Framework Directive. This contains the main EU legal provisions requiring assessment of water scarcity impacts and measures to tackle them. It is, therefore, important that River Basin Management Plans include a detailed analysis of water use and its impacts on availability and actions are identified within the programmes of measures required. These must also take account of future climate change impacts to help optimise the efficacy of measures adopted. Drought management plans could be included within this approach. However, other policies also need to be addressed, such as the Common Agricultural Policy. Some change might occur through the 2008 CAP Health Check, but more strategic change will be required. However, many policy areas are the competence of the Member States, such as those relating to land use planning, tourism and detailed aspects of rural development plans. It is likely that hard choices will need to be made.

While considerable information is available on water scarcity and droughts at an EU level, there are significant problems in many areas in obtaining detailed comparable pan-EU information, such as lack of river basin-based information (as opposed to information at Member State level) and the lack of common definitions of issues such as 'drought' across the Member States. The Commission has identified these problems and the development of the WISE information system will provide a platform for improved information. However, agreement is still needed on some fundamental data collection issues. Progress of this could be achieved through work under the Common Implementation Strategy.

Technology development has a major role to play in reducing water use by improving efficiency for domestic, industrial and agricultural users. There are a number of initiatives at EU level to support technology innovation in different sectors and considerable efficiency savings have been delivered. However, further development is required on issues such as small scale treatment and re-use, intelligent irrigation, etc. It is, therefore, important for EU and Member State policies and funding to recognise this.

Water scarcity issues are a major challenge to cohesive policy development and implementation by the EU institutions. The emphasis on the issue given by the Council, Parliament and DG Environment is very welcome. It is evident that different parts of the Commission services are involved in the debate on the issue. However, it remains to be seen how far policy change across the Commission services will reflect the seriousness of the issue and where trade-offs will arise.

The neighbouring countries to the EU also experience major water scarcity and drought problems. The EU Water Initiative is a major step forward in bringing together support on water management for these countries. Much of the support on infrastructure is related to water quality, while water resource issues are often addressed through policy and governance support. Thus it is important for the country dialogues/plans that are developed to evolve into specific actions on water scarcity and drought management which can form the focus on future EU funding.

1 INTRODUCTION AND BACKGROUND

Water scarcity and droughts affect many parts of Europe. For example, all Mediterranean EU countries are already affected, being 130 million inhabitants or nearly 30% of the EU population. In a recent survey, 13 Member States identified 33 river basins already affected by water scarcity. These were not limited to Southern Europe, but included basins in Belgium, Denmark Germany, Hungary and the UK. Across Europe agriculture is the major cause of water abstraction, but in parts of Northern Europe abstraction can be dominated by domestic and manufacturing sectors. Droughts have occurred with increasing frequency over the past 30 years. Severe events have affected more than 800,000 km² of the EU territory (37%) and 100 million inhabitants (20%) in four separate years since 1989. Five Southern Member States have suffered 8-21 drought events since 1976. These can have significant social and economic impacts as well as impacts on nature protection.

In March 2006 Member States called for EU action on drought events and water scarcity. In response the European Commission has conducted several analyses on this issue. This resulted, in July 2007, with a study on water-saving potential in the EU and a Communication (COM(2007)414) on 'Addressing the challenge of water scarcity and droughts in the European Union'. This summarised the main trends and concerns and identified a series of actions to be taken at EU and national level. The issue was a priority for the Portuguese Presidency, with conclusions on the issue being reached in the Environment Council in 2007 which welcomed the Communication and emphasised the importance of taking account of climate change and adapting policy areas such as agriculture.

At the European Parliament's Climate Change Temporary Committee's Fourth Thematic Session on 29 January 2008, MEPs and experts discussed the complex links between water issues and climate change. It was noted that significant choices will need to be made in adapting to climate change. Importantly, water policies will need to respond to the requirements of climate change and the issue of changing agricultural demands, including bio-fuel production, will need to be addressed. This requires policy development beyond water policy itself.

The European Parliament ENVI Committee requested this study concerning water scarcity and droughts specifically to consider the following questions:

1. Economic effects of water scarcity and droughts – regional differences and the link with Lisbon goals and meeting its targets.
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7. Research and technology development related to efficient water use – knowledge gaps and research for new technologies for industry/agriculture and private households.
8. EU institutional roles for decision making.
9. Situation in neighbouring countries/areas.

This study provides a brief overview of these key issues.

2 ECONOMIC EFFECTS OF WATER SCARCITY AND DROUGHTS

2.1 Geographical vulnerability to water scarcity and droughts

At the continental scale, Europe experiences rather a low level of water availability – only Australia and Oceania receive less (Shiklomanov, 1999). As against this, *on average*, Europe's population abstracts only 10% of the available water for human use (EEA, 2003a).

However this average conceals huge variations in both the level of precipitation and water availability, and in demand, from one region to another. Unfortunately, high demands for water frequently coincide with areas of low supply, leading to water stress. This occurs particularly in Southern Europe, though not exclusively so. The EEA (2007) reports that, around one-fifth of the EU's population lives in countries that are water-stressed.

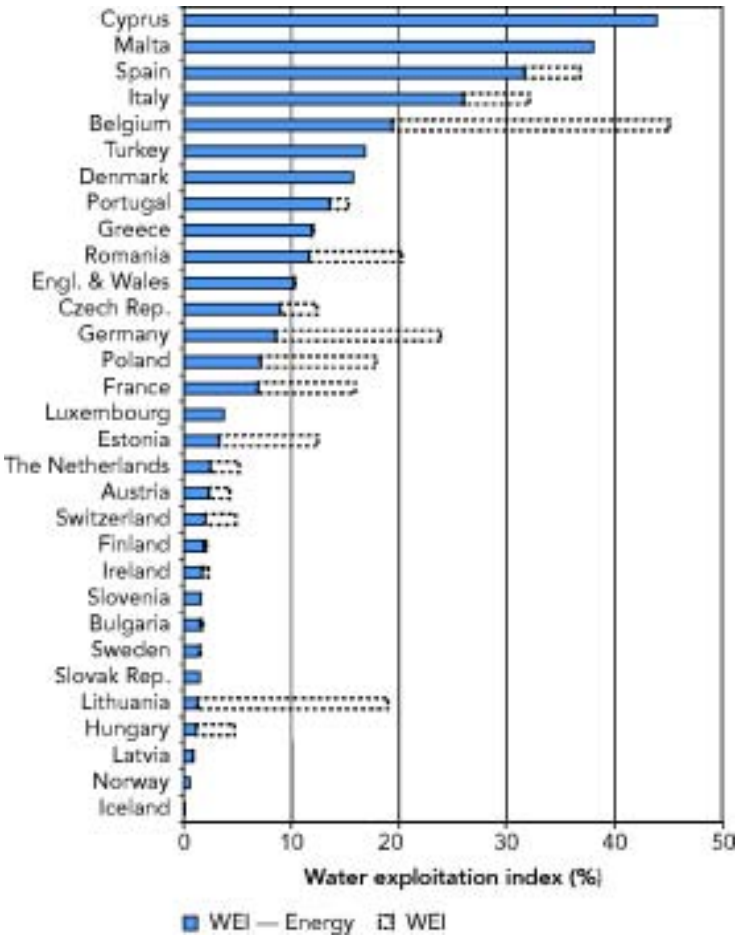

Figure 2.1: Water Exploitation Index of EU Member States (EEA, 2003)

Note: Solid bar shows WEI without water abstraction for energy; dotted bar is total abstraction

Figure 2.1 shows the Water Exploitation Index (WEI) of EU countries, and essentially expresses annual demand as a percentage of average available water resources. This shows that at least half of the Member States have quite low WEIs, but a significant minority have significant stress levels (i.e. >20%).

It also illustrates that new Member States, Cyprus and Malta have the most acute levels of water stress. Here low levels of rainfall combine with limited options for large scale storage of water, while on the demand side, tourism combines with highly-irrigated farming to push summer levels of demand to increasing heights. The Southern states (Spain, Italy, Portugal, Greece, Romania) all have high WEIs; but so too do some more Northerly states, e.g. Denmark, Germany, where moderate rainfall combines with high demands for industrial and domestic purposes.

2.2 Sectoral vulnerability to water scarcity and droughts

In sectoral terms, the three biggest water demand sectors are agriculture, industry and the domestic sector. These are addressed in turn in the sections that follow.

2.2.1 Agriculture

Agricultural demands for water vary enormously, but in countries with a high proportion of irrigated agriculture, this is typically the largest single demand source for water supplies. Eurostat estimates that, in the late 1990s, half of all water supplied in the South-West of Europe (France, Greece, Italy, Portugal and Spain) were used for agriculture; and even more so in Malta, Cyprus and Turkey. Also, reflecting higher temperatures, longer growing season and other factors, the South uses three times as much water per unit of land irrigated as do areas further north.

Furthermore, areas of land irrigated are continuing to grow. Amongst the EU15, irrigated areas in France, Greece and Italy have witnessed the fastest growth. Among the new and prospective members, Romania, Turkey and other parts of Southern and Eastern Europe are seeing rapid growth in the area under irrigation.

2.2.2 Industry

A significant number of industrial sectors make substantial demands on water for use in their various industrial processes. These include pulp and paper, leather, textiles, chemicals and metals industries.

By far the largest source of demand for water from industry, however, is for cooling in thermal power plants. This level in turn reflects the level of demand for electricity in other parts of the economy.

Water abstraction for electricity and other industries is now rising in most of the EU10, reflecting a general recovery of economic activities after the disruption of the early 1990s.

2.2.3 Domestic water use and tourism

Most water consumption in urban areas is for domestic use. This in turn is dominated by the demands of sanitation and personal hygiene (i.e. washing of persons, clothes and other property). The quantities devoted to drinking and cooking are only a few percent of the total, so these can easily be met in Europe even in times of water shortage.

Domestic water use levels vary substantially from country to country, reflecting variations in both efficiency and use patterns. Unfortunately, Spain has one of the highest level of domestic water use per capita of all the Member States at 265 litres per day, although with UK reported higher still at 343, driven by leakage from older distribution systems (European Water Association, 2005). In general terms, however, personal water use remains a small share of the total demand, especially in areas where irrigation agriculture is widely used.

Tourism is a substantial additional pressure on water demand, especially during the summer months and in coastal regions of Southern Europe, where it largely coincides with high demands for irrigation. Tourists can have particularly high demands on water for personal hygiene, swimming pools, etc., and can place severe pressure on both water supplies and sanitation in ecologically-sensitive areas.

2.3 Expected future developments and their impact

As described in greater detail in chapter 4, it is expected that climate change will lead to higher levels of precipitation in the areas of Europe that are already the wettest – i.e. Northern Europe and some mountainous areas – and a decrease in the South. Even the North, though, is expected to experience increased frequency of summer droughts.

This might bring some benefits to some parts of Northern Europe, for example increasing groundwater levels in some water-stressed regions such as parts of Denmark and South-East England, provided that the additional rainfall is in areas and at rates that allow it to be captured effectively or to replenish groundwaters naturally. However, in contrast, the worst effects of reduced rainfall will come in the drier areas of Southern Europe that are already the most water-stressed, and probably at the worst times of year (i.e. the summer growing and holiday season).

These effects are also likely to be exacerbated by positive feedback mechanisms caused by higher average temperatures and/or heat waves, for example:

- Crops (irrigated or otherwise) will need additional water to cope with the heat, leading to further demands for irrigation;
- Additional electricity demand for cooling buildings will in turn demand more water for cooling in thermal power stations, which can be problematic if water temperatures rise.

Thus it can be expected that both water scarcity and acute drought events will increase in extent, frequency and intensity as a result of climate change, and especially so in areas already suffering from water stress.

2.4 Likely economic impacts of drought

In acute episodes of drought, it is in most cases not possible or economic to transfer the very large quantities of water that would be needed to alleviate the drought. Also, droughts can be quite widespread so transfers from adjacent river basins may be infeasible. As a consequence, the main response is likely to be some form of rationing or selective cutting off of water supplies.

Some measures with limited economic consequences, e.g. banning watering of municipal or private gardens or washing of vehicles, are relatively common responses. These however have only limited effect in reducing demand, so more drastic measures may be needed.

In most cases it is very unlikely that the latter would include serious restrictions on use of water for domestic consumption, or probably even for electricity production. Normally cutting supplies to irrigation will be the first priority, possibly followed if needed by selective reduction in industrial abstractions. However, the extreme drought and heat wave of 2003 did cause disruption to power supplies in France, which is heavily dependent on nuclear power, but which was disrupted by loss of cooling water as river levels fell unusually low (UNEP, 2004).

Agricultural losses were also widespread in spite of higher than usual demands for water. Not only did crops fail, but those that matured often did so unusually early, and with low yields. For five of the countries worst affected, agricultural losses were estimated to run into hundreds of millions and up to around €5 billion each. The intense heat and drought also contributed to the very large areas of forest destroyed by fires.

Overall, the Commission calculates that the widespread drought of 2003 incurred damage costs to the EU economy of at least €8.7 billion. Over the past 30 years they put the total cost of droughts at €100 billion, and note a sharp upward trend such that the average cost has quadrupled over the same period.

2.5 Likely economic impacts of water scarcity and responses

In contrast to sudden droughts, structural water scarcity allows for a much wider and less disruptive range of responses, especially when scarcity translates into higher water prices. A number of positive responses to water scarcity are relatively easily available, and if the price of water rises or it becomes less readily available, then the economic incentives to adopt such measures increases. A recent report by Ecologic (2007) estimates that Europe is still wasting at least 20% of its water due to inefficiency.

Indeed, in much of Europe, total water abstraction has steadily declined through the 1990s and into the 2000s (EEA, 2007). This is not the case for Southern Europe, however.

2.5.1 Agriculture

The agriculture sector poses particular challenges in the face of increasing water stress. In much of Southern Europe, modern farming would be impossible without irrigation, while elsewhere it greatly increases the range of crops that can be grown. Therefore reducing the area under irrigation is not a popular option and would result in substantial economic losses for local farmers.

However, much agricultural irrigation is still profligate in its use of water – i.e. spraying crops from above rather than drip-feeding water to their roots, so there is considerable scope for improvement in the efficiency of delivery of water in many irrigated areas. Overall, Ecologic (2007) estimated that a 43% improvement in the efficiency of agricultural water use was possible, which is a very significant possibility given the disproportionate contribution of agriculture to water scarcity in the most water-stressed countries.

2.5.2 Industry

Owing to lack of data and the heterogeneous nature of the sector, Ecologic (2007) was unable to reach a firm estimate of the possible savings of water from industrial processes, but suggests that these are still substantial. However, it did identify major further savings in the power sector of 68-88%, where some modern plant requires no cooling water at all. Given the size and centralized nature of the sector, this appears to be a major opportunity.

Aside from hydro-electric power, increased use of renewable energy will also have the effect of reducing the overall water-intensity of electricity generation.

2.5.3 Domestic water use and tourism

EEA (2003a) notes the substantial water-efficiency gains from modern appliances from the 1970s to the 1990s, although these were in large measure offset by growing levels of ownership. Further significant improvements remain possible in a range of water-using appliances, including lavatories, showers and wet appliances. Ecologic estimated that around half of current domestic water supply could be saved by greater efficiency, primarily through improved appliances and reduced leakage of supply infrastructure.

Ownership levels can be expected to continue to grow in the poorer areas of Europe, although wealthier states are approaching saturation levels.

Tourism remains a problematic source of additional water demands, often in the most sensitive areas and seasons, but this is difficult to quantify separately. As against this, if higher temperatures and severe water stress limit the attractiveness of holidaying in Southern Europe, it is possible that some more tourism demand may be relocated to more northerly latitudes where water supplies are more plentiful.

2.5.4 Increasing water supply

As with electricity or other necessary utilities, it is often more attractive (politically if not economically) to increase water supplies rather than to seek to limit demand or to improve the efficiency of use. However, large scale plans to store more water (i.e. dams or reservoirs) or for mass transfer of water from wetter to drier areas (e.g. Spain's Hydrological Plan) tend to be very environmentally damaging as well as costly. Plans to improve efficiency of use or to manage demand, such as those outlined above, are likely to prove more cost-effective in many cases. The Commission's Communication makes clear that supply-side measures should be seen only as a last resort after the options for improved efficiency and demand management have been exhausted, but notes that national priorities are often the reverse of this.

One possible exception to this, although arguably an efficiency measure rather than truly a supply-side measure, is reduction of losses through leakage from supply and distribution infrastructure. The UK, for example, suffers from high leakage rates owing to its very old water networks. However, through high levels of investment and infrastructure renewal, leakage rates have been brought down from 30% and above in the mid-1990s to 23% in 2005/6 (Ofwat, 2006).

2.6 The EU policy response

The EEA (2007) stresses that, as outlined above, water use trends in Southern Europe are unsustainable. It therefore advocates a substantial increase in the efficiency of water use, especially in agriculture, in this region.

Although the Commission stresses that supply-side measures should be seen as a last resort, ironically storage and distribution capacity are the first items to be listed as possible recipients of funding from the current EU regional policy. Also, for example, a recent case study of Spain (Beaufoy et al, 2005) illustrates that EU funds still make a significant contribution towards extending areas under irrigation, and that this can actually undermine other stated policy objectives.

The Water Framework Directive was the first piece of EU legislation to address water quantity as well as quality, and requires that programmes of measures should ensure that a balance is achieved between water abstraction and the replenishment of supplies. The new Communication is a useful first step in identifying new priorities, including opportunities to modernise technologies and processes to achieve much more water-efficient economies. However more will need to be done to align funding mechanisms and national expectations to these new priorities.

3 EFFECTS OF FUTURE WATER SCARCITY AND DROUGHTS ON ECOSYSTEMS AND PUBLIC HEALTH

Developments such as population growth and economic growth (often leading to land use change and increased per capita water use), may increase the scarcity of water in several regions. In this chapter first the effects on ecosystems are described, then the effects on public health. The effect of climate change will be described in chapter 4.

3.1 Ecosystems

An ecosystem is an ecological community together with its environment, functioning as a unit. This might be as large as a tropical rainforest to as small as a backyard. The largest fundamental region of an ecosystem is a biome (Figure 3.1). In this briefing we focus on the following types of ecosystems: land ecosystems (forest, grassland and wetlands), freshwater ecosystems (rivers and lakes) and salt water ecosystems (deltas and the sea). These will be covered in general terms.

Assessments of water resources used to focus largely on the availability of water for unrestricted human use. Since the Dublin Statement (1992) on water and sustainable development, the importance of water for the environment and visa versa is given more attention. In order to provide for the sustainable utilisation of water resources, assessments must determine the extent to which a river's flow can be altered from its natural condition, while still maintaining the integrity or an acceptable level of degradation of the ecosystem. This is the environmental water requirement and is defined as the quality and quantity of water required by an (aquatic) ecosystem for the protection and maintenance of its structure, functioning, and dependent species (Smakhtin et al., 2004).

3.1.1 Ecosystem susceptible to water scarcity and droughts

For centuries humans have altered the natural conditions of rivers. This already has affected the capacity to sustain ecosystems and biodiversity (Covich et al, 1997; Poff et al, 2002). Ecosystems have an important role in the hydrological cycle as they have natural cleaning capacity and reduce the concentration of many (organic) pollutants in water. Ecosystems also help to reduce extremes in runoff through their capacity to store water.

Over recent decades developments have exerted pressure on freshwater systems. Droughts further affect already stressed water resources in many regions. Natural ecosystems are especially vulnerable to water scarcity and droughts, as they are already under pressure from human activities (e.g. fragmentation and fertilisation) and they can not react easily to the pressures. A managed system, like agriculture, has the ability to change crops if necessary. An ecosystem needs many years to adjust to a changed environment.

Periods of low flow result in water stress to ecosystems. Low flow also exacerbates water pollution such as nutrients, pesticides, herbicides, pathogens, etc., because there is less dilution. During periods of low flow, water temperature often rises, resulting in reduced oxygen concentrations. This negatively affects the self-purification capacity of rivers (Kundzewicz et al., 2007).

For terrestrial ecosystems, water scarcity is a long term pressure leading to deterioration of the ecosystem. A healthy ecosystem can cope with a period of drought and recuperate afterwards. An ecosystem which is already stressed will experience negative effects of droughts more profoundly and might not recover.

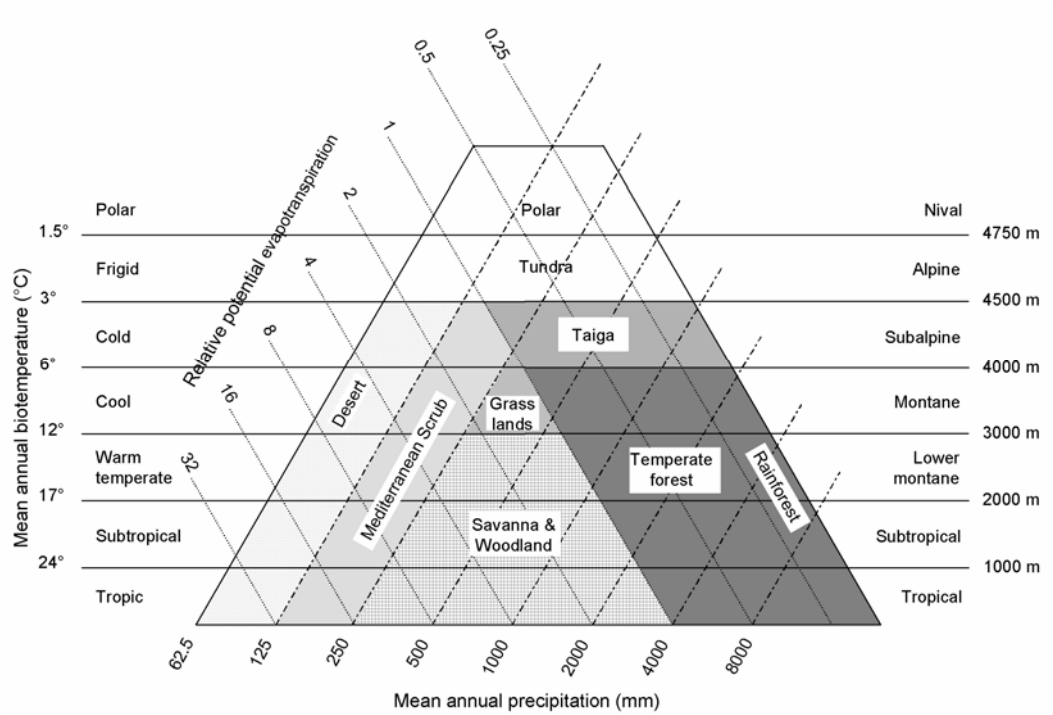

Figure 3.1: Classification of biome types based upon climatic classification of Holdridge (1947).

3.1.2 Specific ecosystems

Land

Changes in precipitation and draining of nature areas are the main drivers for water scarcity for terrestrial ecosystems. The effects of water scarcity on terrestrial ecosystems differ between the regions in the EU.

When precipitation decreases forest fires are expected to increase, because humidity in the soil will drop. A forest with low humidity is at risk of catching fire during periods of drought. This was the case during the record breaking forest fire year 2003 in the Mediterranean. This effect will be larger when the forest is already water stressed due to, for instance, groundwater extraction or draining. The impact of a period of drought on a forest ecosystem can be very large. For instance the drought which struck England in 1976 was still traceable in the condition of beech trees after two decades. The ecosystem has lost quality as result of the drought (Power et al., 1995). The recurring forest fires in the Mediterranean lead to increased soil erosion, threatening the fertility of the area.

In Mediterranean ecosystems effects of water scarcity will be large. Water availability is one of the most important limiting factors in this biotope already. If the circumstances change too much, vegetation will change into shrubland or grassland (see figure 3.2). The change in vegetation will affect the hydrological cycle. Trees evaporate more water than grass and shrubs, leading to increased humidity and precipitation in the region (Werth and Avissar, 2002). Forests also have a high infiltration capacity, compared to other vegetation. This helps prevent floods and enables a more regular flow in the basin.

Inland wetlands depend on external sources of water and are very vulnerable to changes in the water regime. Water scarcity will lead to warping and change of wetlands into grasslands, heathlands or forest, depending on local circumstances. Draining of peatlands has had the same effect in the past in large parts of North-West Europe. This will have a negative impact on the water resources because it reduces the capacity to regulate water flow more regular (Cooper and Arblaster, 2007).

Fresh water

Reduction in precipitation and increase in temperature influence the quantity and quality of fresh water resources. Fresh water ecosystems, like rivers and lakes, are affected by this. An example of the effects of a drought combined with a heat wave is the quality of the water in the river Rhine during the heat wave of 2003. Oxygen levels dropped dramatically and water temperatures above 30˚C were measured. Together with the occurrence of bacterial infectious diseases in the water, this led to an increase in death of many fish species. During the same period the quality of surface water deteriorated, all over Europe algal blooms occurred, reducing the oxygen content and also affecting animals living in the water.

Sea

Reduction of inflow fresh water might influence circumstances in the rivermouth; the salinity of the sea will increase. This effect is probably minimal. This effect may be important in estuaries where current species might have to migrate upstream because of the increased salinity.

3.2 Public health

The direct relation between water scarcity and public health is very weak in Europe. In Europe it is unlikely people will die because of a lack of (safe) drinking water. Other water uses will be stopped before water is no longer available for drinking, or drinking water will be transported to the area. Most effects on public health are caused by heat waves (EEA, 2004), as in 2003 when approximately 35,000 people died (Confalonieri et al., 2007). The main factor was the high temperature in combination with bad air quality leading to respiratory diseases. In cities the effect was even larger due to the urban heat effect, which caused higher temperatures than the surrounding areas (Arnfield, 2003). Water scarcity has not been mentioned as a major factor for the rise in deaths during the heat wave. Other factors like GDP, quality of health care, accessibility of health care, etc., have a larger effect on public health.

Indirect effects of water scarcity are more common. Water quality is influenced by the inflow of water. If a river has low flow because of overuse of the resource, but the same amount of pollutants is deposited in the river (from agriculture, sewage, etc.), the water quality will deteriorate. Contamination of drinking water is possible, again in combination with high temperatures. For areas where the main source of drinking water is the river or other surface water, this might lead to higher purification costs. Low flow in rivers near the sea also causes problems with salt intrusion. The quality of the water might become so low that it is no longer safe to swim in the water. In several countries this occurs during periods of drought which coincide with high temperatures leading to algal or bacterial blooms (blue-green alga, botulism, etc.).

Droughts will present risks in particular for coastal areas with high tourism activities in the summer, such as the East coast of Spain. An increased risk of contaminated surface water reaching groundwater through the opening of short circuits can be expected as a result of a lowered water table during times of drought, affecting the water resources (European Commission, 2007e).

Indirect effects of droughts on health are through forest fires. People are at risk of getting burned or breathing (toxic) smoke and ash, which negatively affects the respiratory system (European Commission, 2007e).

4 EFFECT OF CLIMATE CHANGE ON WATER SCARCITY AND DROUGHTS

4.1 How will climate change influence water scarcity and droughts in Europe?

Over the past century climate changes have been observed across Europe. Temperatures have risen by an average of 0.90 degrees Celsius. For the period 1077-2000 the warming trends were higher in Northern, Eastern and Central Europe and mountainous areas and less in the Mediterranean region. Precipitation has also changed. There has been an increase in winter precipitation in Western Europe and a decrease in annual precipitation in the Eastern part of the Mediterranean. For other parts of Europe no trend is visible (Alcamo et al., 2007).

Due to higher temperatures the atmosphere can hold more water and evaporation increases. The hydrological cycle will intensify the under influence of climate change. This leads to higher climate variability, with more intense precipitation and more droughts (Kundzewic et al., 2007). In Europe mean annual precipitation will increase in Northern, Central and Western Europe. However, seasonal variation will also change. Winter precipitation will increase and will shift partly from snow to rain in the mountains, due to rising temperatures, so that water is no longer stored in snow or ice. Summer precipitation will decrease and less melt water will come from the mountains. Together this will lead to higher runoff in winter and early spring and lower runoff in summer. In Southern Europe mean annual precipitation will decrease in all seasons. Both in Northern and Southern Europe periods of water scarcity will increase, especially during summer.

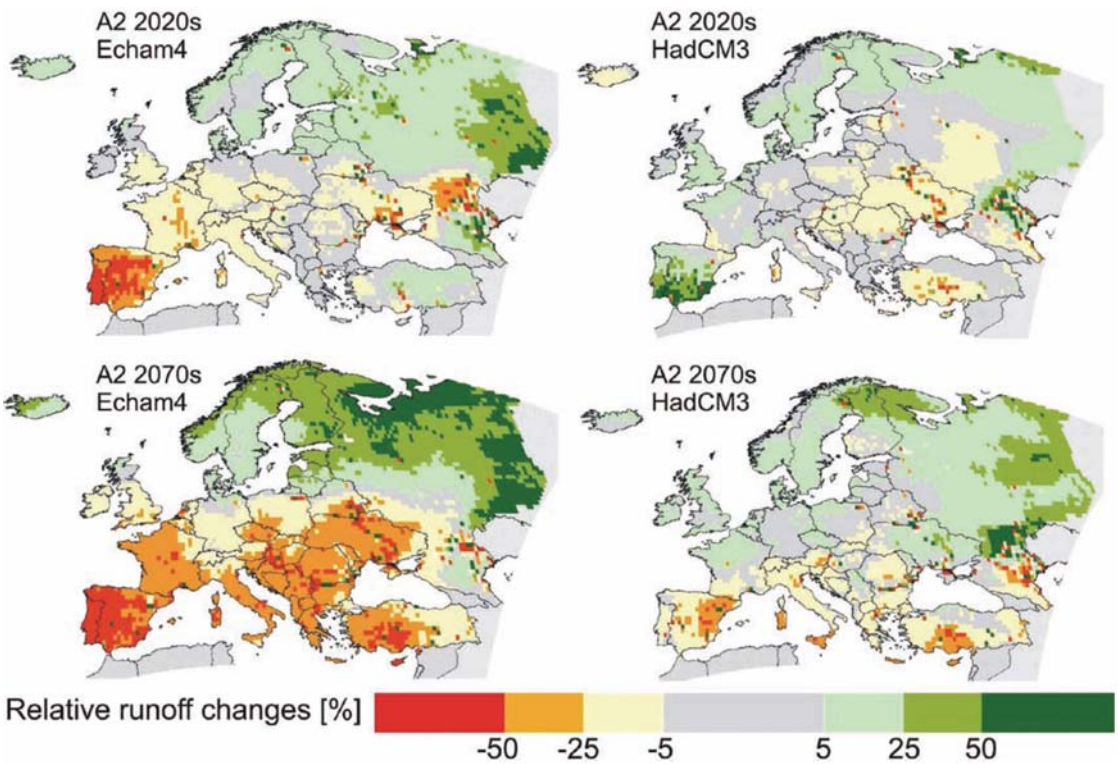

Figure 3.2: Change in annual river runoff between the 1961-1990 baseline period and two future time slices (2020s and 2070s) for the A2 scenarios (Alcamo et al., 2007).

An increase of 5 to 15% in average runoff in Western and Northern Europe is predicted for the 2020s and a decrease in average runoff between 0 to 20% is predicted for Central, Eastern and Mediterranean Europe for the 2020s (figure 3.2). The uneven distribution of water resources in Europe will become more pronounced under climate change. The regions with decreasing runoff are also the regions with an increased drought risk (Alcamo et al., 2007).

One can define the impact of climate change on water resources as another 'water user' (besides domestic, industrial and agricultural). The study of Alcamo et al. (2007) shows for Mediterranean countries water consumption by climate change in 2070 will be up to a half of total current water use to more than current water use. The latter means that effective water use will double if no measures are taken.

4.1.1 Ecosystems

The largest fundamental region of an ecosystem is a biome. The distribution of biomes depends, amongst other factors, on precipitation and temperature. Biomes are at locations where the circumstances fit their requirements. Changes in precipitation and/or temperature will cause a migration of the biome, when threshold values are exceeded. Figure 3.1 shows the distribution of the biomes based on latitude, temperature and precipitation.

Lengthening of the growing season due to a rise in temperature (Alcamo et al., 2007.) might result in problems with availability of water. The more days vegetation has leaves the more water it will use to grow, through an increase in total transpiration.

Besides changes in precipitation and a rise in temperature, other factors influence ecosystems and species. The occurrence of forest fires is expected to increase in the Mediterranean. When fires are more frequent, current species might be replaced by species that are more fire resistant or grow faster after a fire. This change in vegetation might lead to changes in the regional hydrology (see 1.1.2). Also the drained peatlands in Central Europe are at risk to experience more fires during dry years (IPCC, 2001).

Coastal wetlands will experience the effects of combined impacts. Due to lower inflow of fresh water and a rising sea level the coastal area will suffer from salinisation. In natural circumstances, wetlands will retreat. Due to human activities in the coastal zone, there is often no space for them to move to.

Water quality is affected in several ways by climate change. The most important are rises in water temperature and reduction in flow volumes. Water quality in particular relates to nutrients, oxygen levels, natural organic matter and hazardous substances contained in the water, as well as to its temperature. Both are influenced by climate change. In areas where flow will be reduced it will be difficult to maintain sufficient quantity and quality to sustain the ecosystems, without additional measures. Aquatic ecosystems will experience negative effects of these changes.

4.1.2 Public health

The deterioration of water quality due to temperature rise and flow reduction will indirectly influence public health, through bathing water and the quality of drinking water. See chapter 3.2 for a description of the effects.

4.2 Is it possible to identify winners and losers?

If the effects of climate change on Europe are only evaluated on water scarcity and droughts, some global remarks can be made. Some regions in Europe will benefit from climate change and some will be negatively affected (see figure 3.2). Northern and Western Europe are winners, as average precipitation will increase, although summer droughts will become more frequent. If adequate measures are taken, these regions may be able to cope with these changes. For Northern Europe the combination of higher temperatures and increase in precipitation will lead to less water scarcity and drought, so that more water is available for human use without limiting environmental flow. Not many people will benefit, because this area is not densely populated.

The Mediterranean area and Central Eastern Europe are negatively affected by climate change. Average precipitation will decrease and periods of drought will become more frequent. This will lead to a decrease in available water, causing more water scarce situations and droughts. These negative impacts will affect many people, because these areas are more densely populated, certainly when compared to Northern Europe.

4.3 What adaptation measures are necessary and available?

The IPCC uses the following definition for adaptation: adaptation is any adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities (IPCC, 2001). For water scarcity and droughts adaptation will be aimed at moderating the negative effects. To a large extent adaptation will take place at a decentralised level and in many cases it will be autonomous. Governments need to play a role in planned adaptation. Several possible government actions for adaptation are listed in Table 4.1.

Table 4.1: Examples of adaptation strategies and measures.

Adaptation strategy	Example of measure
Increase water use efficiency on basin level, (with special attention to transboundary rivers).	River basin management plans.
Increase water use efficiency on country level.	Water metering and pricing, leakage reduction, water reuse, etc.
Design of early warning systems for droughts.	Regulating and rationing water in times of drought. Provide safe drinking water to the vulnerable during heat waves.
Technical measures to enable more even supply.	Increase reservoir capacity, water transfer, etc.
Landscape planning measures improving the water balance.	Reforestation, change of land use, etc.

Relevant EU initiatives on adaptation are the Green Paper on adaptation, the Water Framework Directive and the Communication on water scarcity and droughts. Improved sustainable water use might also be achieved through other policy fields, like sustainable agriculture (EU Common Agricultural Policy).

Recent thinking about adaptation has developed from reactive disaster relief to more pro-active risk management, for instance early warning systems for heat waves or drought risk management plans have been developed (e.g. Spain and The Netherlands) (VWS, 2007).

National action plans on climate change have been developed in several countries, including adaptation options. These should cover the issues of water scarcity and droughts.

4.3.1 What is still unknown?

Some of the topics that are still largely unknown in relation to water scarcity, drought and climate change are: how to mainstream adaptation into current policies, climate change impacts on the regional scale, how ecosystems will react to changes in water availability in combination with rising temperatures, and the costs and benefits of adaptation measures.

There are large gaps in knowledge in relation to quantitative analysis that would help inform decision-makers by providing an argument for further work in this area. Research into the direct health effects from climate change is needed. Current information is probably insufficient to make detailed policy recommendations in relation to climate change and health.

4.3.2 Difficulties and pitfalls

Adaptation might be experienced as a new bureaucratic burden for Member States, on top of other Directives for which they have to report on many topics. Also the funding of adaptation measures is not clear yet, for example are only the additional costs to be paid?

There are difficulties in attributing health impacts to climate change, because health outcomes are influenced by a variety of social, economic, environmental, health system and individual factors.

4.4 Conclusions

The effect of current and future water scarcity and drought on public health is small compared to other factors of influence like GDP, quality of health care, accessibility of health care, etc. If climate change becomes more extreme in the second part of this century, water might start playing a more prominent role in public health, although the effect of extreme heat and air quality probably will be more important.

Ecosystems are susceptible to current water scarcity and future developments (economic growth, increase in per capita water use, climate change) and climate change is expected to increase the pressure on them. The main effects are not meeting environmental flows, increased vulnerability to fires, and deterioration of water quality. Most land ecosystems are affected by a decrease in precipitation, while fresh and salt water ecosystems are affected by reduced flow and water quality.

A good precautionary measure is to implement integrated water resources management and taking equally seriously the importance of all water users (domestic, environmental, agricultural and industrial). Part of this approach is the monitoring of the water quantity and quality. This will help to establish when water becomes scarce and additional measures need to be implemented.

5 WATER PRICE POLICIES IN THE MEMBER STATES

5.1 Water pricing in EU policy

Water is a scarce resource, the price of which is given by the cost of its abstraction and supply and the value of the resource itself. Failing to price it properly is a *de facto* subsidy which may lead to overexploitation. Proper pricing of water to end-users can improve price signals and encourage increased efficiency in water use (OECD, 2005).

The importance of water pricing in helping to control water use has increasingly been recognized in the EU, and in 2000 water pricing was included in the Water Framework Directive (WFD). Article 9 of the WFD (see full text in Annex 1) requires that Member States introduce by 2010 water pricing policies that encourage efficient use of water, in light of the polluter pays principle. The WFD also requires that the internal and external costs of water services (including environmental and resource costs) are borne adequately by all waster users – disaggregated into at least industry, households and agriculture. Member States will also have to report the steps they take to implement these provisions in their River Basin Management Plans by 2009.

The WFD also requires that, when establishing their water policy, Member States take into consideration social, environmental and economic effects, as well as the geographic and climatic conditions of the areas affected. Also, Member States are free to exempt certain water-use activities, if this does not compromise the Directives purposes and the reasons are reported in the River Basin Management Plans.

5.2 Examples from Member States practices

Quantifying the effects of water pricing at the European scale is complex due to the lack of reliable and comparable data, and the combined effects of other water demand measures. There are wide variations in water charges within individual countries and between different countries in Europe (EEA 2003a). Many cities in Mediterranean countries for instance have below average water prices, as well as in countries with abundant water supplies. Water prices instead are highest in Northern European cities, i.e. about 75-100% higher than the average (EEA, 2003b) (see Figure 5.1).

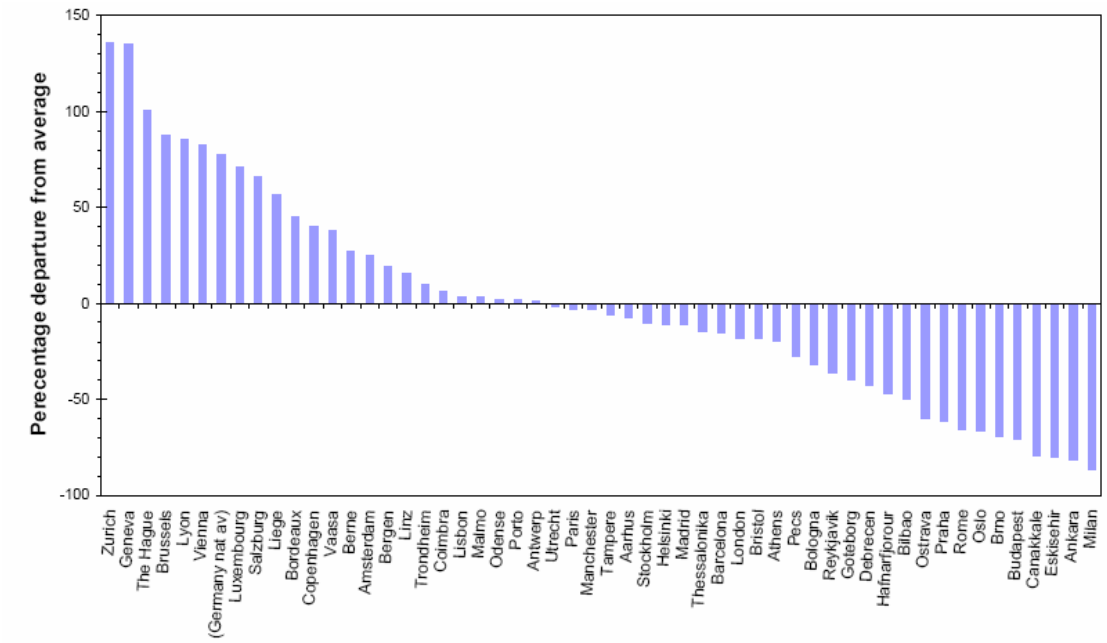

Figure 5.1: Percentage departure from average in water prices (Euro/m3) for major cities in 1996 (EEA, 2003)

In general there has been an overall trend towards higher water prices in real terms for the domestic sector throughout Europe in the 1990s (Figure 5.2).

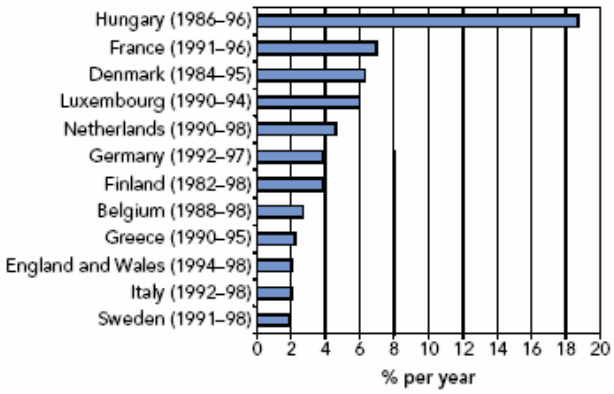

Figure 5.2: Domestic water use price: average increases in selected EU countries (OECD, 2001)

Note: Average household combined sewage and water bills - except for Germany and Luxembourg, where data are only to public water supply. The period over which the average price increase was calculated for each country is given in brackets.

The increase has been particularly marked in the pre-market economies of Central and Eastern Europe where, before 1990, it was common practice not to have full cost recovery and there was no control over water use. In the transition period subsidies have been removed, leading in some cases to significant decreases in water use. In Hungary, for example, households water prices increased 15-fold, and water use during the 1990s was reduced by about 50 % (EEA, 2007). A more detailed example for Czech Republic is provided in Box 5.1.

Box 5.1 Water pricing in Eastern Europe: an example from Czech Republic

After 1990 water pricing in the Czech Republic moved from covering only a fraction of the cost (the price of 1m^3 was only €0.02) to full cost recovery. Water prices gradually increased, and all houses have also been provided with metering to measure drinking water consumption. In 2004 the cost of 1m^3 of water was brought up to €0.71 (see Figure 5.3), corresponding to approximately 0.8% of household income, i.e. more than €50 per household per year (GKH, Ecolas and IEEP, 2007). The volume of water consumed in households decreased by about 40%, from 171 litres per day per capita in 1989 to 103 litres in 2002. In 2003 it was about 10% below the EU average. The reform also addressed the fees for withdrawal of surface and ground water, as well as the discharge of waste water. Between 1990 and 1999 water withdrawals decreased by 88% in agriculture, by 47% in industry and by 34% in public water mains (Naumann, 2003; UNDP, 2003).

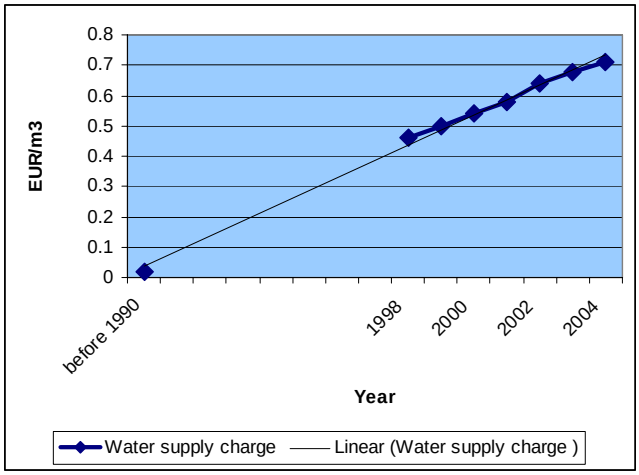

Figure 5.3: Water supply pricing in Czech Republic
Source: IEEP elaboration of GHK, Ecolas and IEEP (2007)

The size and method used for household water pricing varies considerably across countries. For instance, some use full cost recovery (e.g. the UK, see Box 5.2), while in other Member States costs are not entirely covered and hence subsidies still exist. Also, while some countries apply the same tariffs for all households, others differentiate prices according to the type of consumers (e.g. lower prices apply to persons receiving social assistance and pensioners). Some apply rising block systems (e.g. Malta), where water prices increase at higher levels of consumption.

In general, although increasing, water bills are still considered to represent a very small percentage of household income or of GDP per capita. In 1996 they were estimated to range from 0.2% (in Oslo) to 3.5% (in Bucharest) – while the World Bank considers that the cost of water services should not exceed 5% of household income (EEA, 2006).

Box 5.2 An example of full cost recovery: England and Wales

One way to assess a more efficient pricing of water is through the full cost recovery principle. This principle can require all the capital and operating costs of the provision of environmental goods and services to be fully recovered from the entity benefiting from the service (GKH, Ecolas and IEEP, 2007). In the case of water, users should pay for the full cost of water abstraction and supply infrastructure. In England and Wales, full-cost recovery has been applied since privatisation of the water industry in 1989, and led annual average household water bills to increase by about one-third - representing 1% of average household income. Domestic water consumption, however, continued to rise but stabilised at about 149 l/capita/day over the past few years. Water use by metered customers is about 10% less than non-metered customers, but meter penetration, although increasing, is still only about 13% (Ecologic, 2007).

In the industry sector, higher water prices are also leading to reduced water use through water-saving technology and re-use. In general, water pricing is considered though to have a low impact on industry competitiveness, as it usually represents a minimal part of industry production costs. An example for the Netherlands is provided in Box 5.3. Water prices hence appear to have a limited impact on water savings from industry, although they can be more effective if combined with other tools, e.g. if the revenues collected are used to support investments in water saving technologies.

Box 5.3 Water pricing in the industry sector: an example from the Netherlands

A groundwater tax was introduced in the Netherlands with the objectives to green the Dutch fiscal system and reduce groundwater use relative to surface water. The groundwater tax applies to both public water supply and direct abstraction. When the tax was first introduced, small and medium size enterprises faced a price increase of about 40% in comparison to public water supply prices. The increase reached 113% for industry with self-abstraction (Strosser and Speck, 2004). However, further investigation (ECOTEC, 2001) stressed that the groundwater tax revenue collected amounted to only 0.03% of total industrial turnover or 0.08% of the total added value of the sector. The impact on industrial competitiveness was therefore considered marginal.

5.3 Water pricing in the agriculture sector

Across Europe, agriculture is the activity responsible for most of water abstraction. Agriculture is still widely subsidised, and pays much lower prices than the other main sectors, particularly in Southern Europe. According to EEA data, 45% of total water abstraction in the EU is used for agriculture – followed by industry and energy generation (40%) and public water supply (15%). Abstraction for agriculture (see figure 5.4) is highest in arid regions, including the Mediterranean, Southern EECCA (Eastern Europe, Caucasus and Central Asia) and Turkey, where irrigation accounts for more than 60% of water use. The decrease of agricultural activities in EECCA and Central and Eastern European countries during the transition period though led to marked decreases in water use (EEA, 2007a).

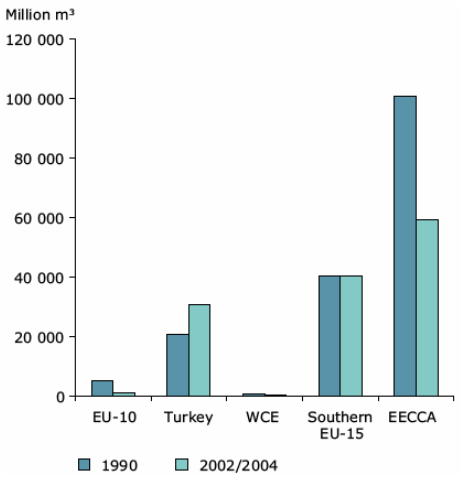

Figure 5.4: Water use for irrigation (EEA, 2007)

There are various means to charge for water in agriculture. In some countries, the distribution of water is not charged. In other countries, different methodologies are followed. The OECD (1999) identified a number of water pricing typologies:

- By land area: fees are based on the size of the irrigated area; in some cases, different rates are applied to different crops (e.g. on the basis of crops' water requirements), irrigation methods or season.
- Metered: fees account for the volume of water used (i.e. a fixed unitary rate is applied to each cubic meter of water used) or time.
- Dual pricing method: usage fees are charged by annual fixed facilities expenses and unit water usage.
- Method by use (or block rate pricing): different pricing methods are applied for different uses.
- Improved charged method: fees are levied against agricultural land based on the increase in land value to the supply of irrigation water.
- Incentive metered method: extra fees are charged for exceeding a given volume of water and incentives are provided for conserving a given volume.
- Passive water intake method: pricing permits a balance in overall water supply and demand in an irrigation district; farming families use the water freely according to their needs. Average pricing per unit is charged for the total water usage rights per family and, if water is conserved, rebates are paid.
- Water market method: pricing is set by voluntary payments for marginal water volume units of farming families.

The most common water pricing mechanisms in Europe are the two part tariff (combining a flat rate and a unitary volumetric rate) and the tariff based on the irrigated area. Water pricing is also often coupled with other water management instruments, e.g. quotas such as in Italy, France, Spain and UK (Ecologic, 2007).

The effectiveness of water pricing in reducing agriculture water use may depend on the type of method used. For instance, a number of studies (Rodríguez Díaz, 2004 and Hernández and Llamas, 2001) have shown that volumetric systems lead to lower water consumption than flat rate pricing. In addition, the existence of appropriate water-metering is also an important factor – especially in the case of volumetric pricing. But, while domestic and industrial supplies are now metered in most countries, irrigation supplies are still metered only in a few. Moreover, price elasticity of water demand plays also a crucial role. Increases of water prices in fact may not always provide the right incentive to enhance water use efficiency if the price elasticity of demand is very low. This happens for instance when the total water bill accounts for only a small proportion of farmers' total production costs, when alternative crops or irrigation practices are not available or when the bulk of total water charges consist of fixed costs (Ecologic, 2007). Some examples for Southern Europe are provided in Box 5.4.

Box 5.4 Water pricing in agriculture: examples in Southern Europe

Water pricing will have different impacts depending upon specific characteristics of each farming type. For less favoured areas, such as the Duero River (Spain), where irrigation is mostly based on sugar beet, any price increase implies a substantial reduction in total irrigated areas, farm income and employment. When price is above this crop's productivity irrigation is abandoned.

On the other hand, for high-value crops the water demand is usually much more rigid due to the high profitability of the crops cultivated. This is for instance the case of vegetable cultivation in Foggia (Italy), where excellent marketing channels for high-valued fruits and vegetables as well as drip technologies exist, and there is almost no possibility of water saving. Increasing the price of water would have almost no effect in terms of diminishing water use and would merely deflate farmers' incomes.

In Guadalquivir (Spain) the situation is instead somewhere in the middle, with some crops dependent on subsidies and others under market competition. In this area, water demand is approaching that of the Foggia case, as an increasing part of demand (about 50%) is already under drip irrigation. Since drip irrigation is linked to high-value crops (fruits and vegetables), water demand is more rigid,' and increased water pricing is likely to lead only to decreased farmers' income, as significant water saving is already in effect (Berbel and Gutierrez, 2005).

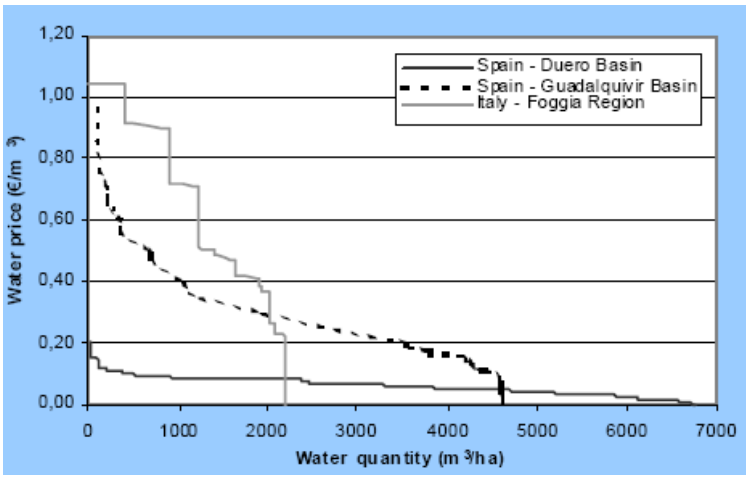

Figure 5.5 Water demand functions in three Southern Europe basins (Berbel and Gutierrez, 2005)

6 INFORMATION REQUIREMENTS FOR DECISION MAKING

In order to manage responses across Europe to water scarcity and droughts it is necessary to have sufficient information upon which to base decisions that will deliver effective solutions. To do this requires information on a wide variety of issues – not only detailed hydrological data, but also on changing pressures (such as irrigation) and responses to those pressures (such as technological change). It is without the scope of this briefing to provide detail on each of these issues. However, a 2007 Commission report (European Commission, 2007) on water scarcity and droughts makes a number of comments on data availability problems that inhibit EU-wide assessments. These include:

- On water availability data are only available at a national level, but it is necessary for information to be generated on a per capita basis at river basin level to reflect local and regional vulnerability.
- While Eurostat collates data on water use, in most countries there are no specific figures for water abstraction due to the tourism sector, so that this is included in statistics on domestic abstraction.
- There are significant gaps in data on water use by agriculture, particularly in taking account of unregulated water use, including use of private wells.
- There are very limited data on which to assess the volumes of water used by different industrial sectors and, therefore, to assess the efficiency of use related to production.
- Calculations of water exploitation indices (demand divided by availability) is undertaken by the EEA and Eurostat on a national basis, so that it is not possible to assess regional pressures.
- Expressing economic impacts through estimated financial costs is difficult as the costs of water scarcity mitigation measures are usually embedded into the costs of infrastructure provision so that the data describe only a part of the overall economic impacts.
- On estimating impacts there are many data lacking at EU, national and river basin levels so that it is difficult to give a comprehensive estimation of costs incurred at EU level.
- Member States use different methodologies to identify and describe drought events, such as different criteria to estimate duration and populations and areas affected. Thus to undertake European-wide assessment a common understanding is necessary.

The Commission report particularly highlights the need for detailed assessment of the water exploitation index at a river basin level. To do this the following methodological considerations need to be addressed:

- Geographical scale: national, regional, river basin – an indicator is required at least at river basin scale.
- Freshwater resources: agreement is required between hydrologic and statistic services to produce the most reliable available data. Also the concept of ‘exploitable’ freshwater must be considered rather than ‘freshwater resources’, which, therefore, takes account of technical and economic issues.
- For groundwater data must be present on an aquifer basis.

There are, therefore, problems in agreeing across Europe basic questions such as: what is a drought? What water is available? What resources are used by key sectors? What are the costs of water scarcity? This does not mean that there is insufficient information to reach conclusions, but that the information available needs to improve in order to enhance the ability of strategic decision making to target critical problems and solutions.

Information is collected at EU level through different processes, principally via the work of the EEA through the Eionet-Water process and by Eurostat and, in future, through a European Drought Observatory. The challenge of implementing the Water Framework Directive has led to the development of the information and data repository of WISE (Water Information System for Europe). Indeed COM(2007)414 considers that WISE 'provides the ideal platform to integrate and disseminate' information on the extent and impacts of water scarcity and droughts. However, it is important to note that while WISE will enhance pan-EU understanding of water issues, the information it contains depends upon the procedures in place to collect such information. The implementation of the Water Framework Directive will increase the range of data available. In particular it may help to overcome some of the problems identified above, such as the lack of information at a basin level. However, simply implementing the Directive is unlikely to address all of the above problems and it is necessary for the Commission to proceed with processes to enhance data availability. COM(2007)414 only states that there should be an annual assessment of scarcity and drought issues based on data provided to the Commission and the EEA and that the Global Monitoring for Environment and Security services should be exploited to assist in delivery of space-based data. However, such collation and analysis of information does not address the problems identified above. One possible approach is, although there is no standardised obligatory reporting requirement derived from a Directive for many of the issues identified, that it would be beneficial to examine the problems of data collection and comparability between Member States such as through a study by a working group under the Water Framework Directive Common Implementation Strategy. This could produce a series of recommendations for enhancing pan-EU analysis and river-basin based analysis.

7 INTEGRATION OF THE ISSUE INTO OTHER POLICY AREAS

In recognition of the acuteness of the water scarcity and drought challenges in Europe, on 18 July 2007, the European Commission adopted a Communication (COM(2007)414) addressing the challenge of water scarcity and droughts in the European Union. The Communication provides a fundamental and well-developed first set of policy options for future action, within the framework of EU water management principles, policies and objectives. Some other tools are already available with regard to water scarcity and droughts, for example the Water Framework Directive (WFD). Here after, the most important policies that are relevant to this issue are listed and described.

7.1 Water Framework Directive

The WFD sets a framework for the comprehensive management of water resources in the EU, within a common approach and with common objectives, principles and basic measures. It addresses inland surface waters, estuarine and coastal waters and groundwater. The fundamental objective of the Water Framework Directive is to maintain 'high status' of waters where it exists, preventing any deterioration in the existing status of waters and achieving at least 'good status' in relation to all waters by 2015. The WFD can help to address issues of water scarcity, through the implementation of the water management plans and associated programmes of measures. In particular, article 11 requires the implementation of a programme of measures taking into account quantity issues and measures to promote an efficient and sustainable water use. It also requires a systematic control over the abstraction of fresh surface water and groundwater. Furthermore, article 9 (see Annex 1) and annex III require Member States to take into account the principle of recovery of the costs of water services, including environmental and resource costs, in accordance in particular with the polluter pays principle. It requires Member States to ensure, at the latest by 2010, that water pricing policies provide adequate incentives for users to use water resources efficiently and that the various economic sectors contribute to the recovery of the costs of water services, including those relating to the environment and resources.

Regarding droughts, article 13.5 of the WFD requires River Basin Management Plans to be supplemented by the production of more detailed programmes and management plans to deal with drought issues. Therefore, progressing towards full implementation of the WFD is a priority in order to address mismanagement of water resources.

7.2 Land-use planning and water allocation between sectors

7.2.1 The Common Agricultural Policy (CAP)

Agriculture is one of the sectors that consume most water in Europe. Agri-environment schemes were introduced into the EU agricultural policy during the late 1980s as an instrument to support specific farming practices that help to protect the environment and maintain the countryside. With the CAP reform in 1992, the implementation of agri-environment programmes became compulsory for Member States in the framework of their rural development plans. The principle that farmers should comply with environmental protection requirements as a condition for benefiting from market support was incorporated into the Agenda 2000 reform. The 2003 CAP reform maintained the nature of the agri-environment schemes as being obligatory for Member States, whereas they remain optional for farmers. In particular, under rural development measures, the CAP provides support to investments for improving the state of irrigation infrastructures and allowing farmers to shift to improved irrigation techniques (e.g. drop irrigation) that require the abstraction of lower volumes of water.

Agri-environment schemes cover commitments to reduce irrigation volumes and adopt improved irrigation techniques (DG AGRI, 2008). Furthermore, the 2003 CAP reform puts greater emphasis on cross-compliance, which became compulsory. In the framework of this reinforced cross-compliance, the 2003 reform demanded the respect of requirements arising from the implementation of the groundwater Directive. Nevertheless, according to the in-depth assessment on water scarcity and droughts carried out by the Commission, agri-environmental measures set-up between 2000-2006 only partially, and sometimes not at all, contributed to addressing water scarcity and drought issues. Very few Member States have adopted specific agri-environmental measures aimed at addressing quantitative issues in the 2000-2006 programme (European Commission, 2007b).

The CAP reforms which began in 2003 contained a number of review clauses for the years 2007-2008. These are the basis of the so-called "Health Check of the CAP", which aims at streamlining and modernising the CAP. One of the questions to be assessed within the context of the Health Check is how to confront new challenges, including water management (European Commission, 2007a). For water management, the Commission will screen existing measures within Rural Development Plans, which will allow the identification of measures with the highest potential impact, and eventual needs to further strengthen them. An assessment of the impact of existing (and eventually new) relevant measures is also being carried out (European Commission, 2007b).

7.2.2 Energy policies

Water consumption and energy production are closely linked. Many forms of energy production depend on the availability of water (e.g. the production of electricity at hydropower sites, cooling methods of thermal power plants, etc). On the other hand, water demand also influences energy production and energy consumption. For example, hot water use in households for showers and baths as well as for washing clothes and dishes is a major driver of household energy consumption (European Commission, 2007b). In spite of this, it is observed that most recent energy policies (e.g. Directive 2005/89/EC on security of electricity supply, Directive 2006/32/EC on energy end-use efficiency and energy services, Directive 2003/30/EC on the promotion of the use of biofuels and other renewable fuels for transport, etc.) do not consider the current water situation and the interaction between water and energy consumption.

The EU's renewable energy roadmap has set binding targets for the share of biofuel (10%) and renewable energies (20%) in total fuel and energy consumption by 2020. The Commission’s Biomass Action Plan expects a potential increase of energy crops from agriculture from 2 Mtoe in 2003 to 102-142 Mtoe in 2030 (European Commission, 2005). One of the major concerns in relation to the increase of biofuels production is that it can create additional pressure on water resources, as bioenergy crops optimised for rapid growth generally consume more water than natural flora or many food crops. Currently, little information is available on how growing biomass for energy purpose will influence water demand in Europe. An assessment of the potential impact on agricultural markets from a 10% incorporation of biofuels by 2020 is already available, but it does not quantify nor asses in detail the potential impact of growing bioenergy crops on water resources. According to a new report by the US National Research Council (NRC) the demand for ethanol-based biofuels in the US has led to a boom in corn crops which could have detrimental effects on water quality and supply (NRC, 2007).

The report claims that as corn crops expand into dry states like Texas and replace crops such as cotton and soybeans, more irrigation is required and the NRC envisages that this could cause severe impacts on local drinking water supplies in areas where biomass production expands beyond current limits of irrigated agriculture. Furthermore, the conversion of plant material into ethanol is also a very water-demanding process. Producing a litre of ethanol fuel requires 3.5 times as much water, which may lead to increased pressures on water supply.

7.3 Water efficiency in buildings

Regarding the water use in buildings, the situation is as follows:

- Directive 92/75/EEC on the indication by labelling and standard product information of the consumption of energy and other resources by household appliances aims at promoting the use more resource-efficient appliances. This Directive applies to dishwashers, water heaters and hot-water storage appliances; dryers and washing machines.
- So far, water management and the introduction of water-efficiency appliances and systems are not included among the requirements of Directive 89/106/EEC on construction.
- The Eco-design Directive for energy-using products was adopted in 2005. It establishes a framework under which manufacturers of energy-using products will, at the design stage, be obliged to reduce energy consumption and other negative environmental impacts occurring throughout the product life cycle. The Directive's primary aim is to reduce energy use, and also enforces other environmental considerations including water use. Implementing measures are currently under consideration for several appliances like dishwashers and washing machines.

7.4 Climate change and adaptation

In June 2007, the European Commission adopted its first policy document on adapting to the impacts of climate change. This Green Paper 'Adaptation to climate change in Europe - options for EU action' refers to water scarcity and drought. To concentrate EU adaptation activities, the Green Paper sets out a four-action approach at Community level: planning process, economic stimuli, disaster risk management and knowledge information. Consideration of adaptation is provided in chapter 4.3.

7.5 Tourism

The tourism sector does not represent a key water use sector in Europe overall, but it can be very important in some regions: The situation in some regions might also become more significant in the future as tourism is a fast-growing sector, with an average growth rate of 2.2% between 2000-2005. Therefore, impacts on water resources in some areas (e.g. the Mediterranean) are significant. The Commission and the tourism stakeholders have recognised the impacts of tourism on the environment and are actively working on the elaboration of a European Agenda 21 for Tourism (COM(2006)134 on a renewed EU tourism policy). This document, which was expected by 2007, might recognise the need to reduce water consumption and to improve water management. However, it is important to note the limited scope for intervention at EU level on tourism policy, which is often driven by local or regional economic and planning processes and objectives.

7.6 EU financial instruments

7.6.1 Structural and cohesion funds

The expenditures related to quantitative issues under the 2000-2006 Programmes aimed mainly at setting up new water supply infrastructures. In the case of the programmes 2007-2008, the European Social Fund and the Cohesion Fund offer several possibilities to address the issue of water scarcity and drought (European Commission, 2007b).

7.6.2 LIFE

According to the in-depth assessment on water scarcity and droughts carried out by the Commission, Member States make little use of LIFE for addressing water scarcity and drought issues. It seems that most supported projects dealt with qualitative issues such as waste water treatments, diffuse and punctual pollutions. Spain is the only country where projects linked to water scarcity and droughts were supported by LIFE. Total costs of these projects came to €5.5 Million.

7.6.3 Other financial instruments

According to the same study, neither the European Union Solidarity Fund nor the Community Mechanism for Civil Protection are used by Member States to deal with water scarcity and drought issues.

8 RESEARCH AND TECHNOLOGY DEVELOPMENT RELATED TO EFFICIENT WATER USE

8.1 Potential for water savings in the European Union

According to a recent study commissioned by the European Commission (Ecologic 2007), there is a huge potential for water saving across Europe. This report shows that the sector that uses the most water is energy production, which represents 44% of the total water abstraction in Europe. This sector is followed by agriculture (24%), public water supply (17%) and industry (15%). The report analysed, for each of these sectors, the water saving potential and the technical measures that could contribute to meet those savings. The results suggest that:

- In the public water supply sector (including households, the public sector and small business), water savings of up to 50% could be achieved by reducing leakage in water supply networks, introducing water saving devices and using more efficient household appliances.
- Regarding agriculture, important water savings could be achieved with improvements in irrigation infrastructure and technologies. For example, improving the conveyance efficiency of irrigation systems could result in savings of 10% to 25%, improving application efficiency could save 15% to 60%, 30% saving is possible from changes in irrigation practices, up to 50% by using drought-resistant crops, and about 10% from the reuse of treated sewage effluent. The potential water savings from irrigation could amount to up to 43% of the current volume abstracted for agriculture.
- In industry, the introduction of technical measures such as changes in processes leading to less water demand, higher recycling rates or the use of rainwater, could lead to savings of between 15% and 90% with a global estimate of 43% of current water abstraction.
- The tourism sector also has a high reduction potential in certain areas of Europe. This sector could reduce its consumption by a maximum of 80%-90% through the application of technical measures such as the installation of newer appliances in guest rooms, cafeterias, kitchens, etc.

These results show significant possibilities for water saving by avoiding overexploitation, non-conventional water abstraction, and promoting integrated water saving measures. The acuteness of the water scarcity and drought challenges in Europe boosts the need for new technologies and new water management systems. Research and development of water saving techniques, prevention and reuse approaches, clean processes, end-of-pipe treatments, system design, IT-tools for management, monitoring and control systems, flood forecasting techniques, ecological engineering, and desalination, can help in harnessing the identified water saving potentials.

8.2 Research related to water saving in Europe

8.2.1 EU research priorities and programmes to support technological innovation

Research activities at the European, regional, and local levels have been supported by both public and private bodies. At the national level, the most important Ministries responsible for water related funding are Environment, Research, Agriculture, and Public Works/Housing/Transport. In some Member States, other important Ministries funding water research include those responsible for Trade and Industry and Education and Health. These Ministries also fund a range of environmental research programmes that sometimes indirectly relate to the aquatic environment.

In 1996, a Task Force on 'Environment-Water' was set up by the European Commission with the aim of identifying research priorities and promoting innovation in the field of sustainable use of water resources. The Environment-Water Task Force produced a final report that recommended 10 priority areas for EU collaborative research and technological development. Three of them were directed at water operators and in three particular management contexts at users: urban water systems, water in agriculture and water conservation in industry (European Commission, 1998). This initiative stimulated reflection and debate at EU level and led to increased funding of water research and demonstration under the Fourth Framework Programme, and the formulation of a Key Action on 'Sustainable Management and Quality of Water' in the Fifth Framework Programme (FP5).

Approximately €100 million were spent in research on different water technology areas under the framework of the FP5. More than 180 projects were funded under the FP5 key action 'Sustainable Management and Quality of Water', of which about 40% dealt with technologies. Water technology related topics in FP6 were spread across fewer priorities and in the beginning a smaller budget was allocated than in FP5. However, after the approval of the Environmental Technology Action Plan (ETAP) in 2004, more substantial actions on water technologies were introduced in the FP6 work programme for the 'Global change and ecosystems' priority (6.3) (DG Research, 2008). A non-exhaustive list of the most relevant FP6 projects can be found in Annex 2. For FP7, the following actions are foreseen (CORDIS, 2007):

- Innovative technologies and services for sustainable water use in industries.
- Improving observing systems for water.
- Climate change impacts and adaptation strategies in water policies.
- Investigating Europe's risk from droughts.
- Effectiveness of adaptation and mitigation measures related to changes of the hydrological cycle and its extremes.

In 2003, the EU ETAP Water Issue Group (ETAP, 2003) highlighted a series of priority technologies that are ready for use but that have a low uptake for several reasons including higher investment cost, lack of confidence, lack of management or technical skills to implement them or a poor knowledge of the appropriate design criteria. These include following:

- Membrane bioreactors for municipal waste water treatment which can allow increased volumes and loadings, which in turn result in better effluent quality. They also provide an effluent which is ready for re-use.
- Different water saving technologies have been developed for household application (low consumption tap and showers, low consumption toilet flushing, etc.). They could contribute to reducing consumption to less than 100 litres per capita per day.

- IT tools for controlling wastewater collection and treatment processes, which could facilitate the implementation of preventive measures to minimise under-performance, spills and overflows.
- IT tools for preventive rehabilitation of drinking water networks that could help to identify the portions of the network to be substituted and to optimise the choice of materials and techniques. This in turn could contribute to reducing leaks that cause water loss and contamination.
- Reed bed simplified wastewater treatment plants for small communities, which constitute a site-adapted solution that allows for more efficient waste water treatment.

Furthermore, the EU has financed different demonstration (e.g. LIFE and COST), technical assistance (e.g. PHARE and TACIS), and infrastructure (Structural Funds and Cohesion Funds) projects in the water sector in both the EU and outside. A list of demonstration projects funded by the LIFE framework is given in Annex 3. LIFE projects have addressed a wide range of important aspects of tackling water scarcity and droughts. This range is illustrated by the following, demonstrating advances on agriculture, technology, domestic and industrial consumption behaviour, etc.:

- The project 'Microfinishing' developed a new dry process of ceramic finishing which reduces water use to zero in an industry that was water intensive.
- The project 'Hagar' developed a new irrigation system calculating real-time water requirements of plants and avoiding unnecessary watering.
- The Dropawater project checked all water supply pipes in Ceuta and then implemented a 'Compact Pipe/Roll Down' technique to repair leaking pipes, which were sheathed in a new polyethylene pipe jacket. This reduced the daily water usage in Ceuta by nearly 3,000m³.
- The project 'Zaragoza, the Water-saving City' implemented a large information campaign on water saving in Zaragoza using a range of information and promotional tools. It doubled the number of households engaged in water-saving measures, enabling the saving of 1.2 billion litres of water in 1998. It also encouraged more than 140 companies to use market water-saving products.

There is also the IWRM-NET (No ERAC-CT-2005-026025) programme, which is a five year (2006-2010) European Research Area project (ERA-Net) funded by the European Commission. It aims at implementing new research activities at the national and regional levels related to Integrated Water Resource Management (IWRM) and giving the opportunity to research programme managers to inform their research activities.

8.3 Measures for technology promotion

Regulation is a major driver for the application of more advanced environmental technologies in the water sector. The Drinking Water Directive, the Urban Waste Water Treatment Directive and the Water Framework Directive require measures to extend water supply and sanitation systems and to bring water ecosystems to a high ecological and chemical standard. This in turn will require the introduction of new technologies to meet the new and more restrictive requirements. For example, the Urban Waste Water Treatment Directive was a major driver for the introduction of a new generation of biological nitrogen and phosphorus removal treatment plants. The Water Framework Directive is expected to contribute to the implementation of new river rehabilitation techniques, the diffusion of clean processes in industry, innovative agri-environmental techniques and better management practices.

The Integrated Pollution Prevention and Control Directive (IPPC) may also help to introduce water saving technologies, as it requires the application of Best Available Techniques (BAT) and best management practices in a series of industrial sectors. Nevertheless, while most of the BAT Reference Documents (the so-called BREFs) published by the Commission refer to BATs to reduce contamination to water, technologies and practices for water saving are covered poorly. To assist the licensing authorities and companies to determine BAT, the Commission organises an exchange of information between experts from the EU Member States, industry, and environmental organisations. This work is co-ordinated by the European IPPC Bureau of the Institute for Prospective Technology Studies at EU Joint Research Centre in Seville (Spain).

Since 2004, the ETAP covers a spectrum of actions to promote eco-innovation and the take-up of environmental technologies (ETAP, 2008). The 'Environmental Technology Action Plan' identified water supply and sanitation technologies as a potential topic to be supported through a European Technology Platform. The Water Supply and Sanitation Technology Platform (WSSTP) was set up in the same year (2004).

The overall objective of this technology platform is the definition of a Strategic Research Agenda and an Implementation Plan for sustainable innovative technologies to address the global challenges of ensuring safe and secure water supply for different uses and sanitation services, within the framework of integrated water resources management (WSSTP, 2008). This platform brings together researchers, public and private bodies and financing institutions with a shared interest in the particular technology sector. Thus, this Platform can help avoid and minimise fragmentation and duplication of research activities, previously identified as one of the main problems regarding research and technology development related to efficient water use. The WSSTP Strategic Research Agenda provides the main contribution of ideas for the 7th Research Framework Programme.

8.4 The implementation of water-saving technologies

8.4.1 Identified barriers

The broad application of water saving technologies, the shift towards wider water re-use both within industrial installations and from wastewater treatment plants, and the wider application of membrane technologies is sometimes held back mainly because they require high initial investments. The following are some of the most important barriers (COM(2006134 and European Commission, 2007a):

- Long time to pass innovative technologies from laboratory research to full scale implementation.
- Technological conservationism promoted by the traditional public procurement process for the construction of water works and supply networks. Tenders usually include traditional designs and well proven solutions. Open competition for design and construction is not frequent.
- The increasing re-use of treated wastewater and recovery of by-products of a wide range of properties, sources and applications (domestic, industrial, and agricultural) pose major challenges in terms of technology development and public acceptance.
- The lack of regulation or standards at the European or national scale could be an important barrier, such as in the case of wastewater re-use which reduces the credibility and confidence among stakeholders.
- Higher investment cost in comparison with traditional technologies such in the case of membrane bioreactors.

- New technologies in some cases are not well known and require new operational and maintenance skills.

8.4.2 Measures to bring technology into the market

In order to tackle the above mentioned barriers, the following measures could be considered:

- Development of common guidelines and new economic tools, as well as improved communication between stakeholders which could enable better wastewater reclamation and reuse (Bixio et al, 2006).
- To raise awareness on - and promote the uptake of - existing best practices and technologies among relevant stakeholders. Information developed will have to be highly practical and formatted according to the specific needs of the different target audiences, notably households, industry, public administration, hotels, and hospitals.
- Improve the linkage between the funding of demonstrative activities to research, such in the case of the LIFE instrument and the Research Framework programmes at the EU level.
- To provide incentives towards capital investments in new environmental technology and reduce taxation. Pricing policies should consider the incorporation of external costs in order to favour the introduction of new technologies that reduce water consumption.
- To take into consideration behavioural attitudes to water savings when designing measures for promoting waste water saving technologies for households. Recently British researchers analysed the different behavioural attitudes towards water saving in households in the United Kingdom. The authors identified four different types of individuals according to their behavioural characteristics. They conclude that it is necessary to recognise behavioural complexity in order to ensure that policies and initiatives for water conservation are effective (Gilg and Barr, 2006).
- To encourage the use of new technologies that provide environmental benefits in public tenders in a way that it is consistent with the requirements established in the legislation on public procurement.
- Introduction of a European Environmental Technology Verification and Certification System could help verify, though recognised and transparent protocols the performance of new environmental technologies. A recent report by JRC Institute for Prospective Technological Studies analyses the Environmental Technology Verification (ETV) concept and how it could be applied to Europe (IPTS, 2007). A generic model for a European ETV System (EETVS) is developed in this study based on all the gathered knowledge on existing ETV systems, similar European systems and the market survey results.

8.5 Knowledge gaps and research needs

There are still some issues that need further research and development in order to be able to achieve a sustainable use of water resources. According to an Agenda, published in 2006 (WSSTP Platform, 2006), the following aspects should be a priority for future research regarding efficient water use:

- Small scale local treatment and re-use systems that can reduce the reliance on long pipelines and other large infrastructure need to be developed.

- Tools for the detection and management of unaccounted for water (detectors, sensors, on-line models) have to be further developed and brought into operation, both in municipal and industrial water distribution networks, sewer systems and in agricultural irrigation systems. Viable solutions should be available before 2010 since many necessary elements already exist today.
- The development of water saving equipment and technologies, including equipment that does not use any water, should be encouraged. Also a complete closure of the water cycle and almost zero water use may be possible in some sectors.
- Intelligent irrigation systems and integrated water management methods have to be developed (before 2010) to enable water saving in agriculture as well as in urban landscape as well as methods to increase the water retaining capacity of the soil.
- A major long term challenge for research (until 2030) is to halt the over- exploitation of groundwater resources and to minimize pollution threats (e.g. by salinisation, diffusive agrichemicals, leakage from sewers). Research is necessary to integrate groundwater management concepts and to provide incentives to increase water harvesting and groundwater recharge.
- New innovative and integrated concepts for water distribution and re-use.

In general, more information is needed to reconcile the quantity and quality of available water resources with that of water actually needed. In agriculture, for example, there is a need for more accurate estimation of the water requirements of crops.

9 EU INSTITUTIONAL ROLES AND DECISION MAKING

To develop strategic approaches to tackle the problems of water scarcity and drought requires effective working relationships between different EU level institutions. This is a considerable challenge. The range of issues that need to be considered is considerable – environmental, agriculture, economic sectors, health, technology development, etc. Importantly, there is also a balance to be struck between assessment and action at a pan-EU level and assessment and action at national and river basin level. It is interesting, however, that the challenge of institutional co-operation is not addressed in detail in the Commission Communication (COM(2007)414).

There has been inter-institutional interaction in a number of areas addressed in this briefing. For example, DG ENV and DG AGRI are closely involved in assessing the interaction between agricultural activity and water impacts. DG ENV and DG ENTR collaborate on environmental technology development. Under the EU Water Initiative (see chapter 10.2) DGs DEV, ENV, RELEX, AIDCO and RTD are all partners. Each interaction is specific to a particular issue. The Commission has not proposed a grand strategic inter-institutional 'committee' on water scarcity and droughts. This is probably wise given that the range of issues to be addressed is large. What is best needed is accurate detailed assessments of the nature of water scarcity and drought, its impacts and possible solutions which can be fed into to discussions of various collaborative interactions.

It is also important for such interaction to bring together the representatives from the European Parliament and Council. This is needed to ensure effective co-ordination of decision making between the pan-EU and national/river basin level. Improving horizontal decision making at EU-level is not sufficient – the vertical links must also be strengthened.

The main challenge for the co-ordination at EU level, whether within the Commission services or between the institutions, is at the interface between policies. Working together to understand problems is easier than solving them. This is most obviously seen in relation to agricultural water use, where tackling the problem presents a major challenge to the CAP. The institutional issues that this raises concerning DG ENV, DG AGRI, the Parliament and Council are not new.

The identification of EU level actions relating to water scarcity and drought in COM(2007)414 is a new area of activity for the EU institutions. The complexities of different policy areas and the interaction between national and EU competence would suggest both the need for effective co-ordination and flexibility in such co-ordination as the different actors learn within this developing policy area.

However, it is important to stress the need for action by the Member States themselves, including bi/multilateral collaboration on transboundary issues. Thus the Impact Assessment accompanying the Commission Communication particularly emphasised the need for Member State action through regional and rural development policies. Where necessary, these will require co-ordination between neighbouring Member States.

10 SITUATION IN NEIGHBOURING COUNTRIES/AREAS

10.1 Introduction

EU neighbouring countries include those of South Eastern Europe, Turkey, EECCA (Eastern Europe, Caucasus and Central Asia) and the Mediterranean rim. Many of these countries suffer significant problems with water scarcity. These issues and trends include (EEA, 2007; UNECE, 2007):

- The water scarcity situation is highly heterogeneous across the countries covered.
- Changing water abstraction patterns, e.g. large increases in Turkey and some MEDA[1] countries, relatively constant in South Eastern Europe and reductions in EECCA.
- Significant water stress in much of the MEDA region, FYR Macedonia and parts of Central Asia and Southern Ukraine.
- Agriculture and energy remain the main water users.
- Abstraction for agriculture is highest in the most arid regions.
- Transboundary water courses under stress can result in up and downstream conflicts, for example Turkey has recently increased abstraction for irrigation by 37% in the Tigris and Euphrates basins and concerns are seen also in basins of the Amu Darya, Syr Darya, Ili and Samur rivers.
- Recent droughts (such as 2000 and 2001 in Central Asia) have been severe compared to historical records.
- There is concern that climate change impacts are already being felt in some cases.

The impact of water scarcity and droughts in neighbouring countries can be addressed through support initiatives from the EU itself and consideration can be given to whether activities in the EU affect water use in neighbouring countries. The former is now addressed within the 'umbrella' of the EU Water Initiative, while the latter can be considered through an examination of water footprints.

10.2 The EU Water Initiative

The EU Water Initiative (EUWI) was launched at the 2002 WSSD in Johannesburg. The EUWI has specific geographical components, including on the neighbouring EECCA and MEDA countries. The EUWI is not simply a process of the Commission or the other EU institutions, but is designed as a multi-stakeholder process to support improved water management, including providing better co-ordination of funding programmes from the individual Member States to recipient countries. The work of the EUWI can be considered in two contexts – that of improving water governance and co-ordination of specific water management projects.

In order to shape the financial strategy of the EUWI, a Financial Working Group (FWG) was formed, with representatives from the public, private and civil society with special expertise or interest in the financing of the water sector.

[1] MEDA Programme, Financial instrument of the EU for the implementation of the Euro-Mediterranean Partnership

The FWG has the following key objectives:

- To improve the efficiency and effectiveness of existing and future EU aid flows to water, including encouraging innovation, the development of institutional and regulatory frameworks and capacity building; and
- To enable the use of development funding as a catalyst to leverage other forms of finance, including donor, user and private finance, to improve access of the poor to water and sanitation services.

In its first three years the FWG evolved from having a supply sided focus to being country focused and with a demand led approach. However, a major constraint of the FWG, under the current approach, is the lack of funds to carry out all its activities. Thus it has developed a Medium Term Work Programme for 2006-08 to present all the activities that the FWG would like undertake in this period with their associated costs and current sources of funds. This helps to identify the funds required, identify funding gaps and seek new funding sources. In order to encourage other donors to contribute an agreement has been reached with the Global Water Partnership Organisation to establish and manage a dedicated FWG Funding Account which will be used to provide the funding needs of the FWG.

On specific water projects there has been little focus on water scarcity issues in the EECCA region. This is because there are major immediate concerns with the supply of clean drinking water and collection and disposal of waste water that have led to these interventions as priorities, as well as broader strategic discussion, such as on utility funding. However, action on water scarcity management can arise from actions to improve governance. The approach taken is to encourage basin management and to bring a wide range of stakeholders together to analyse issues through National Policy Dialogues. These have been trialled in Armenia and Moldova and preliminary assessments in Kyrgyzstan and Ukraine, the latter focusing on integrated water resource management in conditions of climate change.

In relation to MEDA countries, the EUWI has a specific Mediterranean Water Scarcity and Drought Working Group. This undertakes analysis, organises country dialogues and capacity building. The direction of delivering water objectives is through the context of integrated water resource management. It has a budget of around €1 million per year. The Secretariat is supported by Greece. Its aims are to:

- Reinforce political commitment to action and raise the profile of water and sanitation with view to poverty reduction.
- Promote better water governance arrangements including stronger partnerships between public and private sectors and local stakeholders and build institutional capacity.
- Improve co-ordination and co-operation moving towards sector wide approaches, assisting multi-stakeholder processes to reinforce partnerships for action.
- Develop regional and sub-regional co-operation by assisting in the application of integrated water resources management including transboundary waters to contribute to sustainable development and conflict prevention.
- Develop additional and innovative funding mechanisms and catalyze additional funding.

Links are established through a number of related programmes, such as those of the UNEP Global Environmental Fund. For example, a formal mechanism called the 'Joint Process between the Water Framework Directive and the MED EUWI' has been established. This aims at making Mediterranean non-EU partners benefit from the principles, approach and experience of the Water Framework Directive and to improve integrated water resources management in the region, including a specific thematic topic on water scarcity.

The MED Joint Process WFD/EUWI water scarcity drafting group published a policy document on 'water scarcity management in the context of the WFD'. This concluded that drought planning has to evolve to risk management. It requires the development of comprehensive, long-term drought preparedness policies and plans of action, based on the following principles:

- Reducing vulnerability and increasing resilience to drought.
- Prevention in order to reduce the risk and effects of uncertainty.
- Mitigation of the adverse impacts of the hazard.
- Proactive management. Developing actions planned in advance, involving modification of infrastructures, national laws and institutional agreements together with an improvement in public awareness.
- A drought management strategy should include sufficient capacity for contingency planning before the onset of drought. It entails effective information and early warning systems as well as effective networking and coordination between central, regional, and local authorities.

The MED EUWI focuses on the following sectoral and cross-cutting themes:

1. Water supply and sanitation, with emphasis on the poorest part of the societies.
2. Integrated water resources management, with emphasis on management of transboundary and national water bodies.
3. Water, food and environment interaction, with emphasis on fragile ecosystems.
4. Non-conventional water resources.
5. Transfer of technology, transfer of know how, capacity building and training.
6. Education.

These have been translated into objectives in the Activity Plan, such as support for sustainable water use in agriculture, improved knowledge transfer, etc. Long-term actions are focused on reducing the vulnerability of water supply systems to drought, improving the reliability of each system to meet future demands under drought conditions by a set of appropriate structural and institutional measures, such as water conservation and demand management, efficient use and resource protection, educational programmes, public information and awareness, research. Short-term actions are those relating to a specific drought event within an existing framework of infrastructures and management policies and comprise a contingency plan which aims to limit the adverse impacts on the economy, social life and environment.

However, even with water scarcity and drought being a major issue for MEDA countries, external support on water management has been predominantly on other issues. Thus work undertaken by the OECD (Bertuzzi, 2004) examined the relative contribution of external financing to support different water issues between 1996 and 2002. This found the following relative funding for different issues:

- Large water supply and sanitation systems 71%;
- Small water supply and sanitation systems 6%;
- Education/training on water supply and sanitation 0.1%;
- River development 2%;
- Water resources policy/administration 18%;
- Water resources protection 3%.

This illustrates the prior focus on water quality issues. Also where water resource issues are considered, the focus is on policy and administration. This is, however, not surprising given that agriculture is the major water user and major infrastructure projects that attract external funding are not always the right approach to tackling water use from agriculture. It is, however, to be expected that the greater strategic focus on water scarcity and drought within the EUWI on MEDA countries will lead to increased support in this area through strategic prioritisation.

10.3 Water footprints to reduce the impact of the EU

It is important to note that the impacts of activities in neighbouring and other countries are not simply determined by processes driven within those countries. They can also be driven by pressures from within the EU itself. Thus the goods and services imported to the EU result in water use in third countries and this could be an issue to be addressed in policy development. Examples include the water used to produce food and the production of biofuels.

One approach to assessing this impact is the concept of ‘water footprints’. The internal water footprint of a country is the volume of water used from domestic water resources to produce the goods and services consumed within that country. The external water footprint is the volume of water used in other countries to produce the goods and services consumed within a specified country.

There has been considerable research undertaken on defining water footprints. A major report, for example, was produced on this issue in 2004 (Hoekstra and Chapagain, 2004, 2007). Some data from this are presented in Annex 4. This demonstrates a wide range in the quantity of water used within selected Member States for industrial and agricultural production and in the external water footprint of those countries for these sectors.

The question arises as to whether such water footprint data could be used in driving policies. In the broadest sense these data can do this. They highlight some significant differences between countries that require more detailed assessment which could lead to a re-examination of individual policy areas. However, extreme caution should be given to any use of these data to affect trade policy, such as through the establishment of some form of ‘water use standard’ to reduce the water footprint of imported goods and services.

The water footprint does not examine the impact of the water use in the country of origin. Clearly water use for crops grown in highly water stressed countries is likely to have more impact than in those with plentiful water. Thus any attempt to set a water efficiency standard for production would need to examine the different water environments in each country (and potentially in different regions of countries). It is not clear that data are sufficiently available to deliver this. In any case there are significant problems with setting trade related standards.

Thus consideration of whether such standards could be set for biofuels has so far proved difficult. This is an issue that deserves further research, but it is premature to adopt any hard policy measures based on the information currently available. Indeed, adoption of policies in this area for trade external to the EU could result in uncomfortable questions relating to the water footprint of goods traded within the European Single Market, which would have enormous political sensitivities.

11 CONCLUSIONS AND RECOMMENDATIONS

Water scarcity and droughts are currently a major challenge to the EU. Climate change is predicted to make these problems worse in many regions. Thus it is important for the EU institutions, the Member States and individual stakeholders to adopt strategies and take action to manage such problems now and in the future.

Water scarcity and droughts can have significant economic effects. Droughts are most likely to impact upon agricultural activity and can effect industrial production if cooling water is restricted. The widespread drought of 2003 incurred damage costs to the EU economy of at least €8.7 billion. Over the past 30 years they put the total cost at €100 billion, and note a sharp upward trend such that the average cost has quadrupled over the same period. Assessing the longer-term economic impact of water scarcity is more difficult, not least because there are major efficiency savings that could be put in place which could off-set such impacts.

It is, therefore, recommended that:

- **More research is undertaken on the economic pressures that result from longer-term water scarcity issues.**
- **A more strategic approach is given to the relative assessment of the costs and benefits of improved water storage, water efficiency measures and the impact of scarcity to optimise policy choices.**

Water scarcity and droughts have a number of negative impacts on ecosystems, including drying of wetlands, concentration of pollutants affecting river biota, increasing risk of forest fires, etc. A number of these issues are influenced by other pressures, particularly human, and it is important to clarify precisely the nature of the impacts that are externally driven. There are limited impacts on health via water availability itself, although droughts are often accompanied by temperatures that do affect health. However, there can be significant social consequences.

It is, therefore, recommended that:

- **Detailed analysis is undertaken of the interaction of water scarcity and drought pressures with other pressures to identify the precise impacts on ecosystems.**
- **The consequences of water scarcity and drought for achievement of favourable conservation status of protected sites and species under EU law are identified and management options developed.**

Climate change presents a major threat in relation water scarcity and droughts, particularly for the Mediterranean and Central and Eastern Europe, making current problems worse and making water resource management decisions more difficult. Considerable uncertainties remain, however, not only in the extent and nature of likely impacts, but also in the potential efficacy of adaptation measures.

It is, therefore, recommended that:

- **Research is extended into the likely impacts of climate change on water resources with the aim to reduce uncertainty in the analysis.**
- **That all water resource policies take account of future climate change effects and do not only address current problems.**

Water pricing can have a major role to play in reducing water use. Major advances have been made in making domestic water users pay more realistic prices for water. However, there are major differences in approach between Member States, such as in different types of rates and the extent of metering. Agriculture is a major water user and water pricing can act as a major stimulus to reducing use. However, pricing effects are highly variable, with some agricultural activities being barely able to cope with increased costs, while for others the costs are marginal to their profitability.

It is, therefore, recommended that:

- **Common methodologies are applied across the EU to assess the effects of water pricing, particularly beyond the country scale, such as with respect to individual crops.**
- **That consideration is given to the implications of nature of water pricing policies in agriculture where demand is inelastic.**
- **Water pricing should take account of the generally small impact on the overall costs to industry.**
- **Water pricing for households must take account of affordability and consideration could be given to the efficacy of measures such as rising block tariffs.**

The EU has a range of policies relating to water scarcity and droughts. The primary water management policy is the Water Framework Directive. It is essential that River Basin Management Plans include a detailed analysis of water use and its impacts on availability and actions are identified within the programmes of measures required. These must also take account climate change impacts. Drought management plans could be included within this approach. However, other policies also need to addressed, such as the Common Agricultural Policy. Some change might be expected in the 2008 CAP Health Check, but more strategic change is likely to be required. However, many policy areas are the competence of the Member States, such as those relating to land use planning, tourism and detailed aspects of rural development plans. It is likely that hard choices will need to be made.

It is, therefore, recommended that:

- **River Basin Management Plans are scrutinised to ensure water quantity issues are adequately considered, including within the programmes of measures.**
- **The issue of water scarcity and droughts should be addressed more concretely within other EU policies such as the CAP and regional funding.**
- **Member States should identify key policy constraints in different sectors affecting water scarcity and drought issues.**

While considerable information is available on water scarcity and droughts at an EU level, there are significant constraints, such as river basin-based information and the lack of common definitions of issues such as ‘drought’ across the Member States. The Commission has identified these problems and the development of the WISE information system will provide a platform for improved information. However, agreement is still needed on some fundamental data collection issues.

It is, therefore, recommended that:

- **Consideration is given within the Common Implementation Strategy of methods to standardise data collection on water scarcity and droughts.**
- **Recommendations are also made on how the data are collected and presented, such as on a river basin basis and in relation to an exploitation index.**

Technology development has a major role to play in reducing water use by improving efficiency. There are a number of initiatives at EU level to support technology innovation in different sectors and considerable efficiency savings have been delivered. However, further development is required on issues such as small scale treatment and re-use, intelligent irrigation, etc.

It is, therefore, recommended that:

- **A detailed analysis is undertaken on areas where research on technology development is less prevalent but where water savings are achievable and that these results are used to inform funding strategies.**
- **Research and development is undertaken to obtain operational, region specific thresholds and indicators on water scarcity and droughts.**
- **Alternative solutions and water saving technologies should be promoted and further explored.**

Water scarcity issues are a major challenge to cohesive policy development and implementation by the EU institutions. The emphasis on the issue given by the Council, Parliament and DG Environment is very welcome. It is evident that different parts of the Commission services are involved in the debate on the issue. However, it remains to be seen how far policy change across the Commission services will reflect the seriousness of the issue and where trade-offs will arise.

It is, therefore, recommended that:

- **The actions identified in the 2007 Commission Communication are expanded to include specific targets for different policy areas relating to different DGs.**
- **Individual relevant DGs adopt short strategic plans on water scarcity issues relating to their areas of policy work, identifying actions to be taken on the policies for which they are responsible.**

The neighbouring countries to the EU also experience major water scarcity and drought problems. The EU Water Initiative is a major step forward in bringing together support on water management for these countries. Much of the support on infrastructure is related to water quality, while water resource issues are often addressed through policy and governance support. This is not unexpected, but it is important for the country dialogues/plans that are developed to evolve into specific actions on water scarcity and drought management which can form the focus of future EU funding.

It is, therefore, recommended that:

- **Emphasis is given to ensuring that water scarcity and drought, including taking account of climate change, are central to strategic planning on water management in neighbouring countries.**
- **Consideration is given to identifying SMART support projects on water supply, water use and other relevant scarcity and drought management actions.**

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Annex 1 Water Pricing in the Water Framework Directive (2006/60)

Article 9

Recovery of costs for water services

1. Member States shall take account of the principle of recovery of the costs of water services, including environmental and resource costs, having regard to the economic analysis conducted according to Annex III, and in accordance in particular with the polluter pays principle.

Member States shall ensure by 2010:

- that water-pricing policies provide adequate incentives for users to use water resources efficiently, and thereby contribute to the environmental objectives of this Directive,
- an adequate contribution of the different water uses, disaggregated into at least industry, households and agriculture, to the recovery of the costs of water services, based on the economic analysis conducted according to Annex III and taking account of the polluter pays principle.

Member States may in so doing have regard to the social, environmental and economic effects of the recovery as well as the geographic and climatic conditions of the region or regions affected.

2. Member States shall report in the river basin management plans on the planned steps towards implementing paragraph 1 which will contribute to achieving the environmental objectives of this Directive and on the contribution made by the various water uses to the recovery of the costs of water services.

3. Nothing in this Article shall prevent the funding of particular preventive or remedial measures in order to achieve the objectives of this Directive.

4. Member States shall not be in breach of this Directive if they decide in accordance with established practices not to apply the provisions of paragraph 1, second sentence, and for that purpose the relevant provisions of paragraph 2, for a given water-use activity, where this does not compromise the purposes and the achievement of the objectives of this Directive. Member States shall report the reasons for not fully applying paragraph 1, second sentence, in the river basin management plans.

Annex 2 Non-exhaustive list of the most relevant FP6 projects

Project	Goals	Timeline	Website
AQUATRESS (Mitigation of Water Stress through new Approaches to Integrating Management, Technical, Economic and Institutional Instruments)	To develop stakeholder driven, European scale, comprehensive multisectoral, integrated (institutional, socio-economic, technical) approaches for the diagnosis and mitigation of water stress.		http://www.aquastress.net/
ALERT (Sustainable Management of Water Resources by Automated Real-Time Monitoring)	To develop a different strategy for monitoring and managing the impact of climatic change and land-use practice on scarce water resources. Innovative ALERT technology will be designed that will allow the near real-time measurement of geoelectric, hydrologic and hydrochemical properties, virtually "on demand".		http://coastal-alert.bgs.ac.uk/
RECLAIM WATER (Water reclamation technologies for safe artificial groundwater recharge)	To provide effective technologies to monitor and mitigate emerging risks posed by chemical contaminants and pathogens in reclaimed wastewater streams used for groundwater recharge.	2005-2008	http://www.reclaim-water.org/
MEDIANA (Membrane-based Desalination: An Integrated Approach)	To improve the performance of membrane-based water desalination processes by the integration of different membrane operations in pre-treatment and post-treatment stages.		http://medina.unical.it/
MEDESOL	To develop an environmentally friendly improved-cost desalination technology to fresh water supply in arid and semi-arid regions in EU and Third Countries based on solarmembrane desalination.		http://www.psa.es/webeng/projects/medesol/index.html
KASSA (Water Assessment and Sharing of Sustainable Agriculture)	This project aims at the capitalisation of results from past on-going research on sustainable agriculture, including water pollution degradation and consumption.	2005-2007	http://kassa.cirad.fr/

Project	Goals	Timeline	Website
SWITCH (Sustainable Water management Improves Tomorrow's Cities' Health)	The development, application and demonstration of a range of tested scientific, technological and socio-economic solutions and approaches that contribute to the achievement of sustainable and effective urban water management schemes	2006-2011	http://www.switchurbanwater.eu/
IRRISEASOIL (A cheap easy-to-handle desalination approach for crop irrigation under Mediterranean conditions)	• The development of selective polymeric materials (cheap to produce) for desalination of seawater, post-irrigation water and soil with the aim of developing a most effective technological approach than the existing ones. • The use of biotechnological modes and means for promoting efficient and nutrient use of water by plants, improving their immunity and resistance towards diseases and droughts	2004-2007	http://www.surrey.ac.uk/Chemistry/research/IRRISEASOIL/
SAFIR (Safe and High Quality Food Production using Poor Quality Waters and Improved Irrigation Systems and Management)	Three important objectives have been envisaged: new irrigation systems; quality and safety of fresh and processed food from 'farm to fork'; and the feasibility and applications of the system to the food production sector, through the identification of the financial and economic aspects, and institutional and consumer barriers.	2005-2011	http://www.safir4eu.org/SAFIR.asp
SCENES (Water scenarios for Europe and for Neighbouring States)	To develop and analyse a set of comprehensive scenarios of Europe's freshwater futures up to 2025, covering all of Greater Europe reaching to the Caucasus and Ural Mountains, and including the Mediterranean rim countries of North Africa and the near East	2006-2010	http://www.environment.fi/default.asp?contentid=249174&lan=EN

Project	Goals	Timeline	Website
PURATREAT (New Energy Efficient approach to the operation of Membrane Bioreactors for Decentralised Wastewater Treatment)	To study a new approach to the operation of membrane bioreactors. This study will include a comparison of the three leading hollow membrane technologies. The operating procedure to be studied is expected to yield very low energy consumption and reduced maintenance costs	2006-2008	http://www.puratreat.com/
Promembrane	To support the current research and development activities in membrane technology focused on water treatment in the Mediterranean area	2006-2008	http://www.promembrane.info/
IWAPIL (Innovative Wastewater Treatment Application for Isolated Locations)	To develop and test an innovative a membrane bioreactor (MBR) intended for use in remote communities, mountain hotels, campsites, etc.	2004-2006	http://www.iwapil.com/
MEMBAQ (Incorporation of Aquaporins in Membranes for Industrial Applications)	To explore the possibilities to incorporate recombinant aquaporin[2] molecules in different types of industrial membranes for water filtration.	2006-2009	http://www.membaq.eu/
RESYSPRODESAL (Systems Analysis Environment for the Integration of Renewable Energy with De-central Water and Power Production in Mediterranean Partner Countries)	To transfer and disseminate know how and tools for systems analysis on the appropriate integration of renewable energy technologies with de-central water and power services under local conditions	2005-2006	http://www.resyspro.net/

[2] Proteins, which only transport water i.e. pure water molecules

Project	Goals	Timeline	Website
CYCLER-SUPPORT (Supporting the implementation of FP6 research activities related to waste water use and recycling by using new generation greenhouse systems, adapted to the requirements of the MED partner countries)	To implement research activities related to wastewater use and - recycling within new generation greenhouse systems, adapted to the requirements of the Mediterranean Partner Countries	2006-2008	http://www.cycler-support.net/wp7.php
STEELWATER (Effective use of water in coal and steel industry)	To introduce the technologies and the dissemination of knowledge regarding effective use of water in Egypt	2006-2008	
AQUA SOLIS (Innovative Applications of Solar Trough Concentration for Quality Fresh Water Production and Waste Water Treatment by Solar Distillation)	To assess the use of solar trough concentration plants for applications other than heating and cooling, in particular for the production of fresh water for human consumption and for agriculture for Mediterranean countries	2006-2007	http://www.crear.unifi.it/react/Aquasolis.htm
CROPWAT (A centre for sustainable crop-water management)	To contribute to development of agriculture in Serbia and the Western Balkans by reinforcing existing experience on water saving in agricultural production using a multidisciplinary approach.	2007-2010	http://www.cropwat.agrifaculty.bg.ac.yu/?lang=en

Project	Goals	Timeline	Website
INNOWATECH (Innovative and integrated technologies for the treatment of industrial wastewater)	To investigate, assess and enhance the potentiality of promising technological options (i.e., technologies, processes and concepts) for the treatment of industrial wastewater with the specific aim to provide tailor-mad e solutions to end-users for a wide range of wastewaters.	2006-2009	http://www.innowatech.org/
FLOW-AID (Farm level optimal Water Management: Assistant for irrigation under deficit)	To contribute to sustainability of irrigated agriculture by developing, testing in relevant conditions, and fine-tuning through feed-back, an irrigation management system that can be used at farm level in situations where there is a limited water supply and water quality.	2006-2009	http://www.flow-aid.wur.nl/UK/
Gabardine (Groundwater Artificial recharge Based on Alternative sources of wateR: aDvanced INtegrated technologies and managEment).	• To explore the viability of supplementing existing water resources in semi-arid areas with alternative sources of water that could be exploited in the context of an integrated water resources management approach. • To investigate techniques for their artificial recharge and injection of the produced alternative in aquifers • To evaluate and quantify the potential impact of degrading factors	2005-2008	http://www.gabardine-fp6.org/

Annex 3 Recent water- saving related LIFE projects (from 1999 onwards)

Project Reference	Title
LIFE05 ENV/IT/000907	Abrasive-abraded sludge transformation into "abrading paste", to be re-inserted in the bull-nose
LIFE05 ENV/E/000313	Excellence in irrigation water management
LIFE05 ENV/IT/000812	Project for recovery and reuse of industrial waters and trivalent chromium generated by tannery waste processing
LIFE03 ENV/D/000025	Sanitation Concepts for separate Treatment of Urine, Faeces and Greywater
LIFE03 ENV/NL/000488	A dairy industry which is self-supporting in water
LIFE03 ENV/E/000164	Optimizagua project in Spain
LIFE02 ENV/IT/000052	Microfinishing: A new dry process of microfinishing of gres porcelain and natural stone surfaces, which will substitute the stage of smoothing/polishing, drastically decreasing the environmental impact of this stage, to aim for a sustainable development
LIFE02 ENV/E/000210	Tools of self-management for water irrigable in the overused hydric systems
LIFE02 ENV/E/000183	Durable Regions On Peripheal Areas for Water Reduction
LIFE00 ENV/EE/000922	Demonstration Activities for the Reduction of Water Losses and Preservation of Water Quality in Over
LIFE99 ENV/IT/000122	TIEPRINT: Technology Transfer of low environmental impact ink jet printing for the production of textile products
LIFE98 ENV/D/000509	Reuse of filter backwash water from groundwater treatment for drinking water purposes with a submerged membrane system
LIFE96 ENV/E/000509	Zaragoza: water saving city. Small steps, big solutions

Annex 4 Comparison of the water footprints of selected countries 1997-2001

(From Hoekstra and Chapagain, 2007)

Country	Population	Use of domestic water resources					Use of foreign water resources			Water footprint		Water footprint by consumption activity				
		Domestic water withdrawal (Gm^3/y)	Crop evapotranspiration		Industrial water withdrawal		For national consumption		For re-export of imported products (Gm^3/y)			Domestic internal water footprint ($m^3/cap/y$)	Agricultural goods		Industrial goods	
			For national consumption (Gm^3/y)	For export (Gm^3/y)	For national consumption (Gm^3/y)	For export (Gm^3/y)	Agricultural goods (Gm^3/y)	Industrial goods (Gm^3/y)		Total (Gm^3/y)	Per capita (Gm^3/y)		Internal water footprint ($m^3/cap/y$)	External water footprint ($m^3/cap/y$)	Internal water footprint ($m^3/cap/y$)	External water footprint ($m^3/cap/y$)
DE	82169250	5.45	35.64	18.84	18.771	13.15	49.59	17.50	38.48	126.95	1545	66	434	604	228	213
FR	58775400	6.16	47.84	34.63	15.094	12.80	30.40	10.69	31.07	110.19	1875	105	814	517	257	182
IT	57718000	7.97	47.82	12.35	10.133	5.60	59.97	8.69	20.29	134.59	2332	138	829	1039	176	151
NL	15865250	0.44	0.50	2.51	2.562	2.20	9.30	6.61	52.84	19.40	1223	28	31	586	161	417
UK	58669403	2.21	12.79	3.38	6.673	1.46	34.73	16.67	12.83	73.07	1245	38	218	592	114	284
India	1007369125	38.62	913.70	35.29	10.065	6.04	13.75	2.24	1.24	987.38	980	38	907	14	19	2
USA	280343325	60.80	334.24	138.96	170.777	44.72	74.91	55.29	45.62	696.01	2483	217	1192	267	609	197
Global total/ average	5994251631	344	5434	957	476	240	957	240	427	7452	1243	57	907	160	79	40

ACRONYMS

BAT	Best Available Techniques
BREFs	BAT Reference Documents
CAP	Common Agricultural Policy
EEA	European Environmental Agency
EECCA	Eastern Europe, Caucasus and Central Asia
EETVS	European Environmental Technology Verification System
ENVI	European Parliament on Environment, Public Health and Food Safety
ERA-Net	European Research Area Networks
ETAP	Environmental Technology Action Plan
ETV	Environmental Technology Verification
EU 10	The ten new Member States of the European Union
EU 15	The fifteen Member States in the European Union before the expansion on 1 May 2004
EUWI	EU Water Initiative
FP5	Fifth Framework Program of the European Commission
FP6	Sixth Framework Program the European Commission
FWG	Financial Working Group
FYR Macedonia	Former Yugoslav Republic of Macedonia (FYROM)
GDP	Gross Domestic Product
GEF	Global Environmental Fund
IPCC	Intergovernmental Panel on Climate Change
IPPC	Integrated Pollution Prevention and Control Directive
IWRM	Integrated Water Resources Management
IWRN-NET	Regional and national research programmes network on Integrated Water Resource Management
MEDA programme	Financial instrument of the EU for the implementation of the Euro-Mediterranean Partnership
NRC	US National Research Council
OECD	Organisation for Economic Co-operation and Development
UNDP	United Nations Development Program
UNEP	United Nations Environmental Program
WEI	Water Exploitation Index
WFD	Water Framework Directive
WISE	Water Information System Europe
WSSD	World Summit on Sustainable Development
WSSTP	Water Supply Sanitation Technology Platform