# Vulnerability to Water Scarcity and Drought

## Zero draft capturing information from first draft ETC-ICM background document

## 1.) Introduction

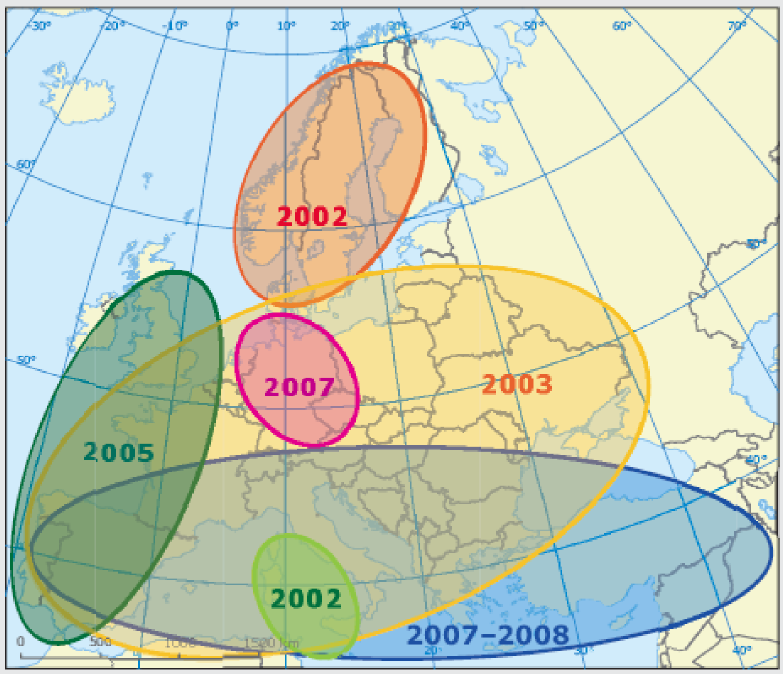
## 2.) Water Stress across Europe

The problems of water stress are typically most acute when drought and periods of low rainfall coincide with water scarcity. Whilst the impacts arising from each phenomenon are not easily distinguishable, a clear conceptual difference exists; Drought is a natural phenomenon defined as a sustained and extensive occurrence of below-average water availability, caused by climate variability. Water Scarcity, however, reflects an imbalance between water availability and the demand for, and hence abstraction of, water (EEA, 2009).

### 2.1 Drought

Droughts can affect both high and low rainfall areas of Europe and can develop over short periods of weeks and months, or over several seasons, years and even decades. In many cases drought develops gradually, making it difficult to identify and predict. All components of the water cycle are affected, resulting in low soil moisture and reduced groundwater levels, drying up of wetlands and reductions in river flow. Drought may refer to meteorological drought (precipitation well below average), hydrological drought (low river flows, lake and groundwater levels), agricultural drought (soil moisture deficit), and socio-economic drought (impacts on economic goods and services) (EEA-JRC-WHO, 2008).

Figure X. Main Drought Events in Europe, 2000-2009

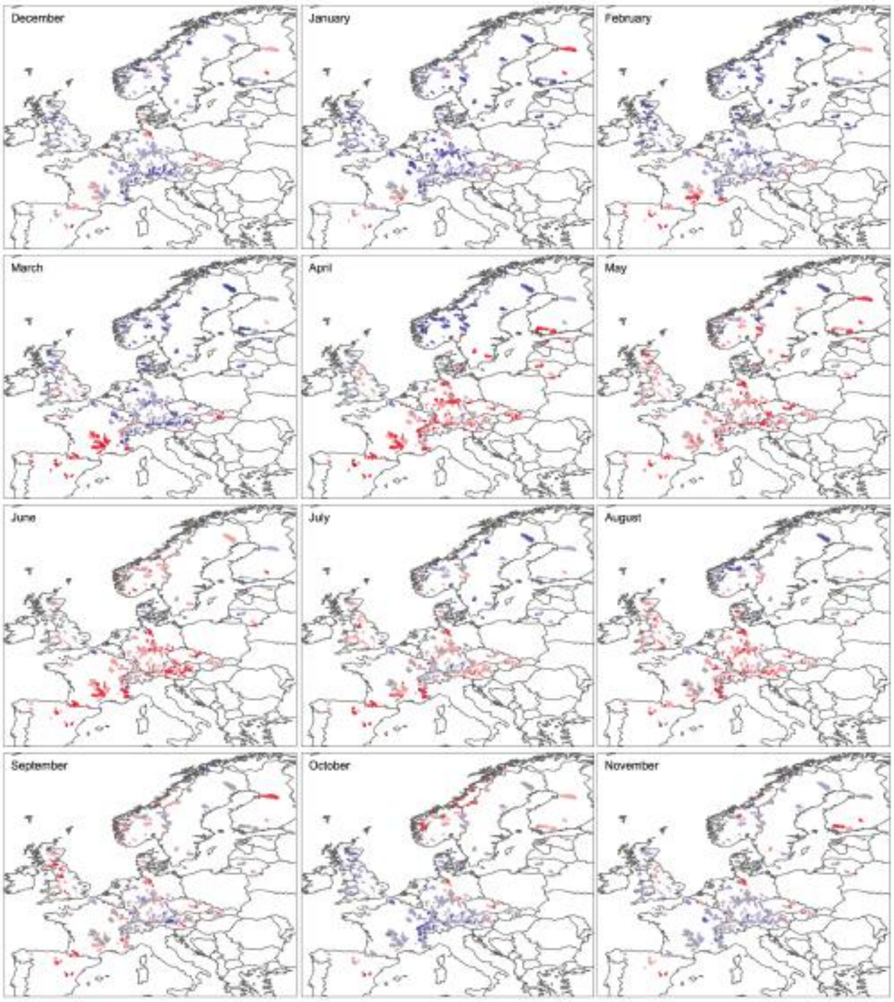



**Source:** Adapted from Tallaksen, 2007.

2011 SPI textbox, plus text – see NTUA Background Report; Photo

***Past Trends***

Anthropogenic interventions in catchments including abstractions, river regulation and land-use change have considerably altered river flow regimes in large parts of Europe, making it difficult to discern any climate driven changes to date. One important recent study, however, has attempted to overcome this issue, addressing pan European flow, from the 1930's up to 2004, from small catchments with near-natural flow regimes (Stahl et al. 2010). The findings indicate that annual flow has increased in the north and decreased in the south, broadly reflecting results from earlier studies (e.g. Milly et al., 2005). Monthly changes are also apparent, with an increase in flow during winter months being evident for many catchments in northern, western and central Europe (Figure X), supporting findings from national and regional studies (Birsan et al., 2005; Wilson et al., 2010).  In contrast, decreasing trends have occurred across much of Europe during summer months (Figure X).



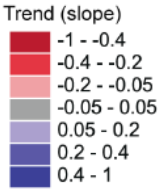



Figure X. Trends in monthly streamflow for the period 1962–2004 (Stahl et al. 2010)

The magnitude of these monthly changes clearly raises implications for water resource management both today and in future decades. To date, however, despite the evidence of monthly changes to flow, there is no conclusive evidence that river flow droughts have generally become more severe or frequent in Europe during recent decades (Stahl et al., 2008).

Also map of current availability?

## 2.2 Abstraction of water across Europe

In Europe as a whole, 45 % of freshwater abstraction is for cooling in energy production, followed by agriculture, 22 %; public water supply, 21 %; and industry, 12 %. Strong regional differences are apparent, however, and in southern Europe agriculture accounts for more than half of total national abstraction, rising to more than 80 % in some river basins, while in Western Europe more than half of water abstracted is used for cooling in energy production (Figure X).

These sectors differ significantly in their consumptive use of water. Almost all water used as cooling water in energy production is returned to a waterbody. In contrast, the consumption of water through crop growth and evaporation typically means that only about 30 % of the amount abstracted for agriculture is returned.

### *Agriculture*

Agricultural water use across Europe has generally increased over the last two decades, driven in part by the fact that farmers have seldom had to pay the 'true' cost of water. The Common Agricultural Policy (CAP) bears part of the responsibility, having in some cases provided subsidies to produce water-intensive crops using inefficient techniques. Recent reforms of the CAP have, however, reduced the link between subsidies and production from agriculture. In general, agricultural water use has now stabilised across Europe but at a high level, particularly in the south (reference to Irrigation Map). Demand for energy crops, however, has the potential to increase agricultural water use still further in future years.

Since the early 1990s there has been an 88 % decrease in water abstraction for irrigation in Eastern Europe (Figure X). This was driven mainly by the decline of agriculture in Bulgaria and Romania during the period of economic transition, with poor maintenance and abandonment of irrigation systems. In the remaining eastern EU countries, the total irrigable area has declined by about 20 %.

Water abstraction for irrigation decreased by about 2 % in Southern Europe excluding Turkey, where it increased by up to 36 % from the 1990 level. In Southern Europe there is a growing tendency to use irrigation water more efficiently with a higher proportion of the area using drip irrigation (SOER, 2010). In addition, the use of recycled water in these areas has increased (EEA, 2009).

While reliable quantitative information on the issue is scarce, it is clear that the illegal abstraction of water, particularly from groundwater and often for agricultural purposes, is widespread in certain areas of Europe. Illegal water use may involve drilling an unlicensed well or exceeding a consented abstractable volume from wells that are licensed. In addition, it can occur from surface waters using transportable pumping devices.

Dutch irrigation example here or link to low flows

*Public Water Supply*

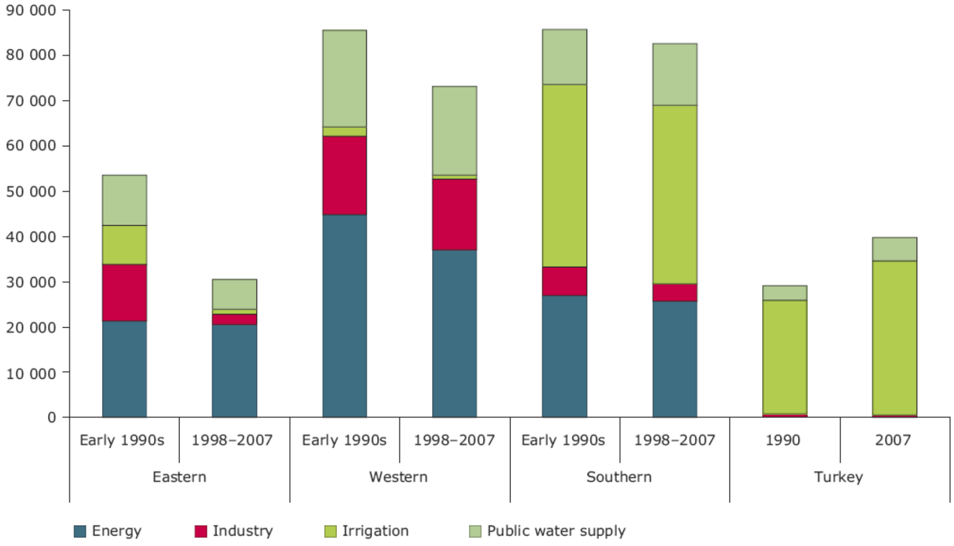
A range of factors influence public water demand, including population and household size, tourism, income, technology, and lifestyle. In addition, 'leakage' in the distribution and supply networks plays a key role in determining the amount of water reaching domestic premises. Public water demand in Eastern Europe has declined by 40 % since the early 1990s as a result of higher water prices and the economic downturn. A similar but less marked reduction in demand is apparent in Western Europe over recent years, driven by changes in awareness and behaviour and increases in water prices.

Tourism can markedly increase public water use, particularly during the peak summer holiday months and especially in southern European coastal regions already subject to considerable water stress. Not only do tourists use water for food, drink and personal hygiene purposes, leisure facilities such as swimming pools, water parks and golf courses (which need irrigating) can significantly increase water use. The Aegean islands, for example, are subject to more than 15 million overnight stays per year and on some islands the summer population is 30 times greater than that of the winter months. Demand for water has risen markedly and is now met through water importation from the mainland by tanker, and desalination (Gikas and Tchobanoglous, 2009).

*Industry*

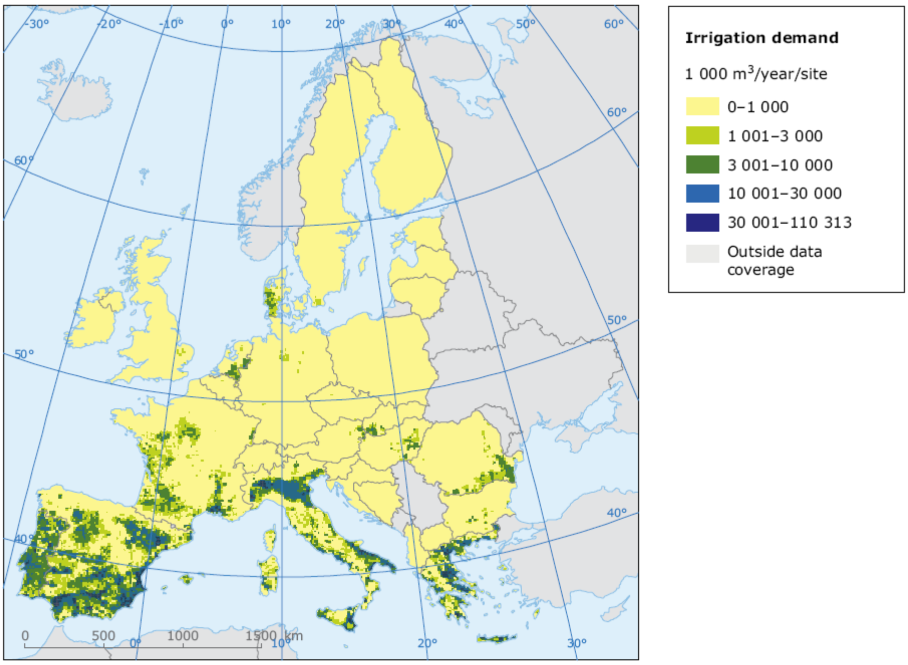
The abstraction of water for industrial use has decreased over the past 20 years, partly because of the general decline in water-intensive heavy industry but also because of increases in the efficiency of water use. Abstraction for cooling water has also decreased, due mainly to the implementation of advanced cooling technologies that require less water.

**Figure 2.2** **Water abstraction for irrigation, manufacturing industry, energy cooling and public water supply (million m³/year) in the early 1990s and 1998–2007**




**Source:** EEA CSI 018 — Figure 2 Sectoral water use www.eea.europa.eu/data-and-maps/figures/water-abstractions-for-irrigation-manufacturing-industry-energy-cooling-and-public-water-supply-million-m3-year-in-early-1990s-and-the-period-1997-2005.

**Map 6.2** **Average irrigation demand per site (10 x 10 km cell) in the EU and Switzerland (1 000 m³/year/site over a simulation period 1995–2002)**



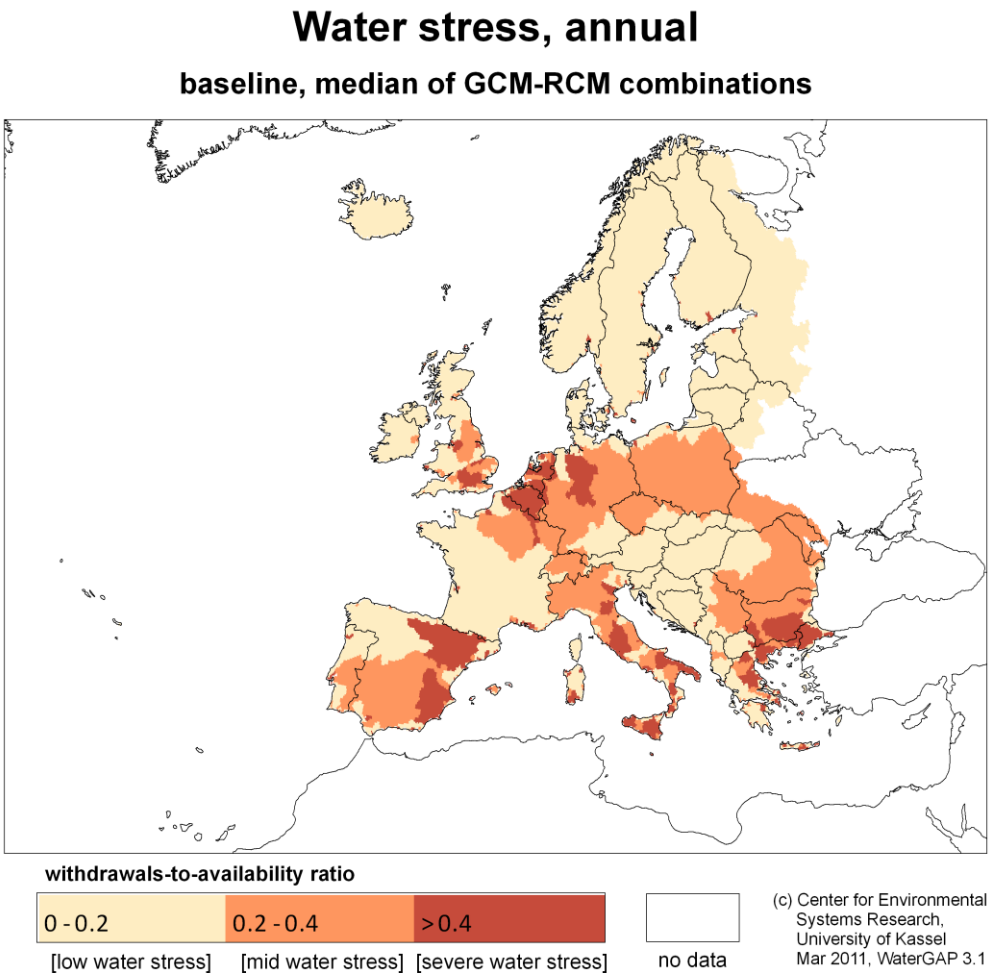

**Source:** Wriedt *et al.*, 2008.

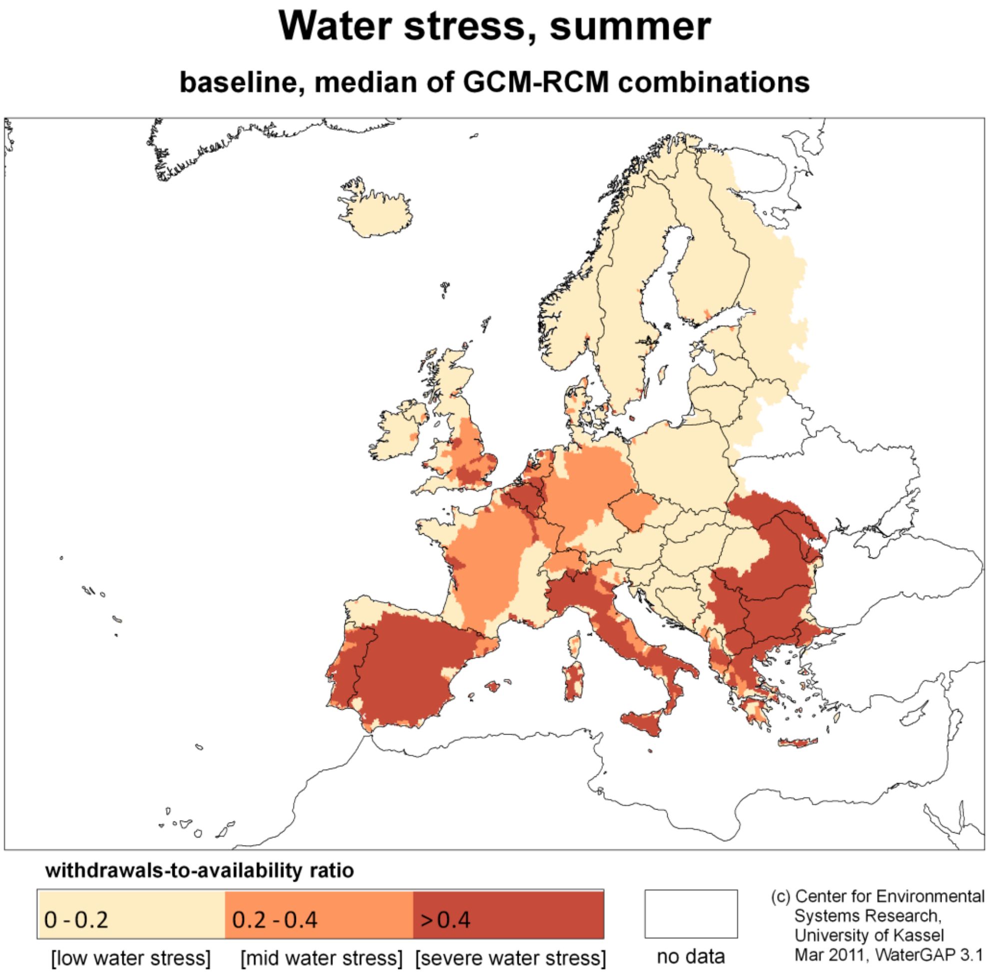
## 2.3 Present day water stress across Europe

The stress upon freshwater resources can be evaluated through determining the ratio of total freshwater abstraction to the total renewable resource. Derived ratios of between 0.2 and 0.4 imply that a resource is under stress, whilst values in excess of 0.4 indicate severe stress and a clearly unsustainable use of the water resource.

Predictions of annual stress at river basin scale (Figure X) indicate that moderate levels of stress are evident across much of Europe……..

Hotspots of High Water Stress – Explain causal factors and spatial patterns. Lack of water in the south, coupled with abstraction for agriculture, tourism, large cities, seasonality, isolated islands. Include RBMP’s where possible (Typsa report)






## 3.) Impacts of Water Scarcity and Drought

The effects of over-abstraction upon water resources vary considerably depending upon the volume and seasonality of the abstraction, the volume and location of returned water, the sensitivity of the ecosystem and specific local and regional conditions. Of critical importance is the timing of abstraction. Peak abstraction for both agriculture and tourism, for example, typically occur in the summer months when water availability is generally at a minimum. As a result, the potential for detrimental impacts upon, for example, freshwater ecology is maximised.

Imbalance between demand and water availability becomes most acute when abstraction occurs during prolonged dry periods or drought. Under these circumstances, a negative feedback can occur, particularly with agricultural water use, whereby the lack of rainfall drives greater abstraction in order to fulfil crop water requirements. Water stress has now reached a critical level in parts of Europe, typically caused by combination of drought and over-abstraction by at least one economic sector.

Socio-economic sectors affected, growing competition for a depleting resource, global corporate water report.

Costs to source new supplies – references from FW contract; Habitats Directive?
Saline Intrusion Example – Belgium.

Unless detailed water accounting has been undertaken, not easy to distinguish between scarcity and drought

### *Freshwater Ecosystems*

This decline in the water resource will be reflected not only by reduced river flows, but lowered lake and groundwater levels and a drying up of wetlands.

Lack of water detrimentally impacts freshwater ecosystems including fish, invertebrates, vegetation and riparian bird life (EEA, 2009). Diminished flow also strongly influences water quality, reducing a river's ability to dilute pollutants – use BE example in NTUA report.

Environmental Flows

### *Agriculture*

An intense drought throughout the Iberian Peninsula during 2004-05 led to a 40% decline in cereal production (Garcia-Herrera, 2007), whilst low rainfall led to a 30% fall in agricultural production in Lithuania, in 2006, with an estimated loss of EUR 200 million (EC, 2007). In Slovenia, the Ministry of Agriculture, Forestry and Food estimated direct losses attributable to drought in 2003 to be around EUR 100 million. State aid was provided to the agricultural community (Susnik and Kurnik, 2005).

### *Energy production*

Lack of water has had an adverse impact, at times, on the electricity generation sector where rivers provide cooling water. This is because power stations have to be shut down when the temperature of intake water or river levels fall below certain thresholds (EEA, 2008). Electricity production has already been significantly reduced in various locations in Europe during very warm summers (Lehner et al., 2005). The production of hydropower can also be seriously affected by dry periods. Considerable reductions in river flow during the 2004-05 drought across the Iberian Peninsula, resulted in a 40% drop in hydroelectric power which had to be replaced by electricity from thermoelectric power plants (Garcia-Herrera, 2007). Similarly in 2005, Portugal had to compensate for low hydro-electrical production by using fossil fuel worth EUR 182 million, with an additional expense of EUR 28 million to purchase $CO_2$ emissions licenses. The total cost was finally estimated at EUR 883 million, equivalent to 0.6% of GDP (Demuth, 2009).

### *Public Water Supplies*

Whilst public water supplies have priority over other uses during periods of water stress, restrictions on use can arise, together with a significant cost associated with emergency water supplies. In 2008, Cyprus suffered its fourth consecutive year of low rainfall and the drought situation reached a critical level in the summer months. To ease the island's crisis, water was shipped in from Greece using tankers. In addition, the Cypriot Government was forced to apply emergency measures, including the cutting of domestic supplies by 30 %.

Similarly in Catalonia during the spring of 2008, water levels in the reservoirs supplying 5.8 million inhabitants were only 20% of capacity. Plans were made to ship fresh water in, at an estimated cost of EUR 35 million. Luckily, May was wet and, in the end, only a few shiploads were transported to Barcelona (Change, 2009)……..

***Barcelona case study*** – text from Hazards report

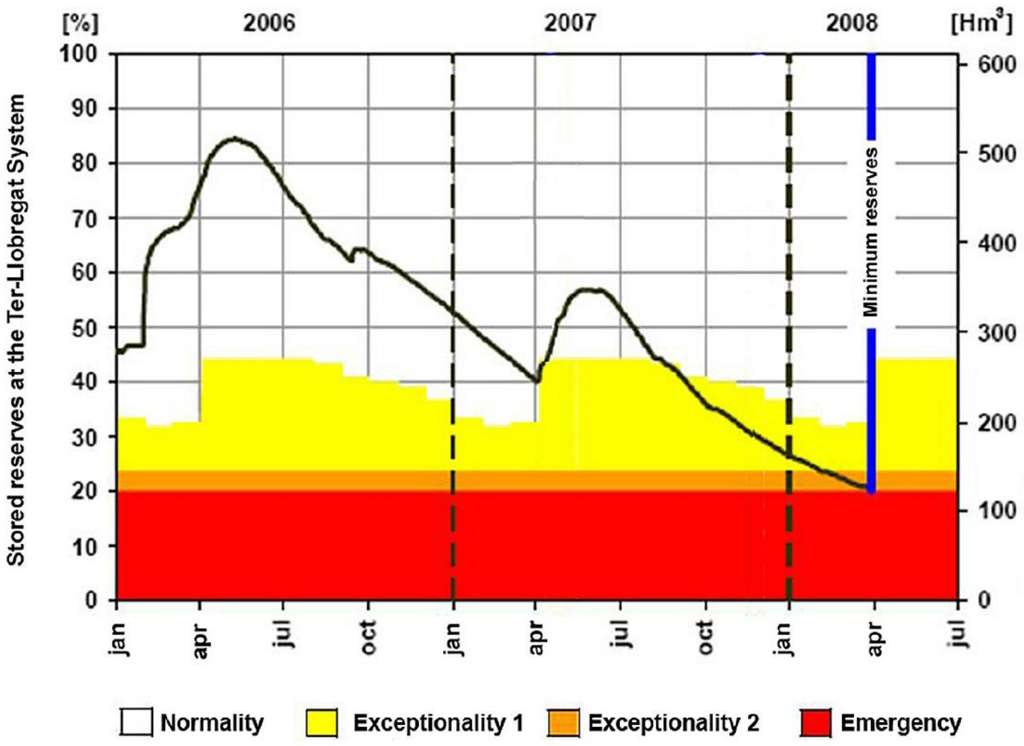
During the first half of 2008, the metropolitan area of Barcelona (4.6 million people) was on the verge of suffering domestic water cuts. The precipitation deficit was considered to be the largest in 60 years but lack of rain also revealed the precariousness of the water supply system serving this urban agglomeration.

Low water inputs following two years of abnormally high precipitation deficits in the springs of 2006 and 2008 meant that the basins supplying Barcelona with freshwater registered almost half the average values (Figure 6.4). In April 2008 the situation began to change and during the rest of the spring and the summer of 2008 precipitation returned so that the drought alert order issued by the Catalan Government was lifted by the end of 2008.

In the case of Barcelona, a major impact of the event was the images reproduced by the international media of tankers bringing water to the city. This had potentially important economic consequences as the negative images could have damaged tourism, one of the main sources of income for the city. Other, more tangible impacts of the event were the economic costs of water shipments (some 18 million euro) and the costs of emergency measures to increase supply (some EUR 450 million). Paradoxically, WSD events may have positive impacts, such as the increase in the collective awareness of the need for water conservation. After several public awareness campaigns in 2007 and 2008, the citizens of Barcelona were able to reduce per capita water consumption from 130 l/person per day to 110 l/person per day.

The Catalan Water Agency put a Drought Management Plan into practice. It was structured in three stages (see Figure 6.4) to be implemented as the event became more acute. The first stage applied to agricultural uses (exceptionality I), followed by non-essential urban users such as garden irrigation and swimming pools (exceptionality II) and finally essential urban uses (domestic cuts). Drought warnings related to these stages are issued when stored water falls to a certain level. At the same time, new resources have to be mobilised as the situation worsens, including bringing water by sea and recovering polluted wells. A connection to the Ebro catchment was even envisaged, although this was highly contested and abandoned after the rains returned after the 2008 event. The citizens of Barcelona did not see their water supply curtailed during the event, except for a few small towns which had to be supplied by water trucks. Many proposals were made to avoid this situation, including the possibility of using treated waste water for domestic purposes. Finally desalinisation was chosen as the (supposedly) definitive cure for all future WSD events.

**Figure 6.4 Evolution of water stored between January 2006 and April 2008 in the Llobregat-Ter reservoir systems supplying Barcelona and the related drought warning scenarios (exceptionality 1, 2 and emergency)**



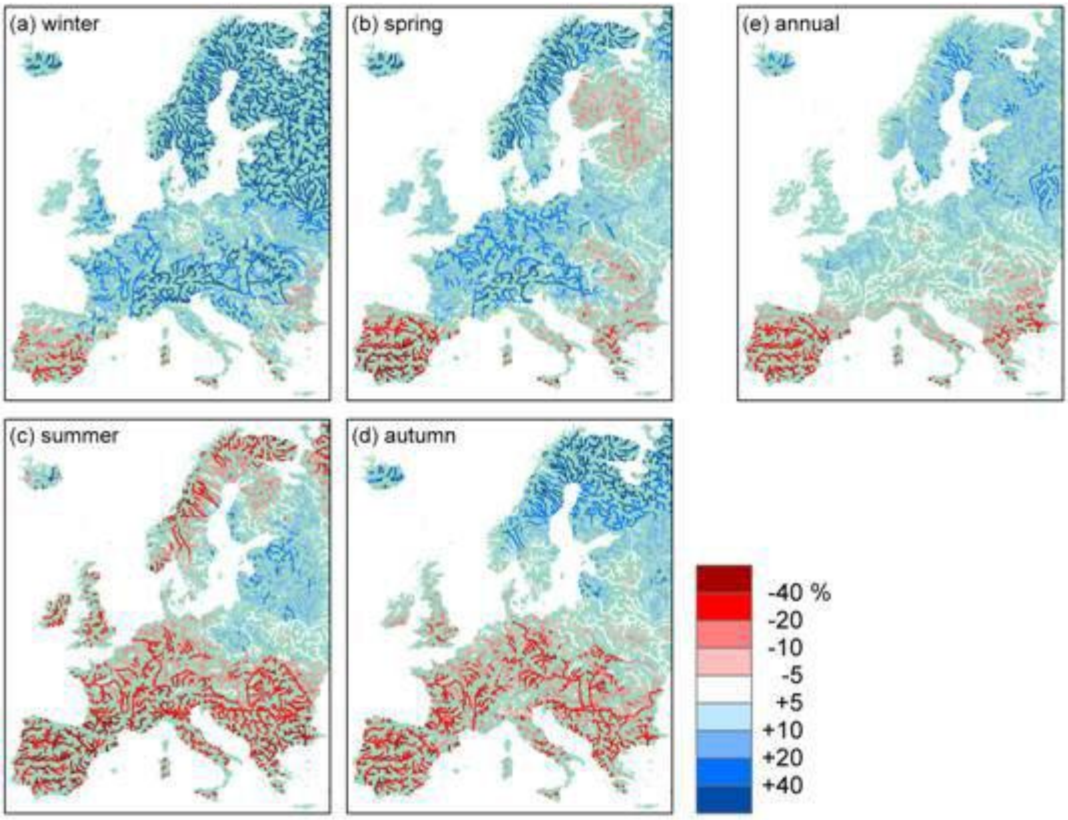

**Source:** Adapted from Catalan Water Agency.

*Navigation*

## 4.) Scenarios

### Projected changes in water availability due to climate change

Annual river flow is projected to decrease in southern and south-eastern Europe and increase in northern and north-eastern Europe (Milly et al., 2005, Alcamo et al., 2007; JRC Ref). Strong changes are projected in the seasonality of river flows, with large differences across Europe. In line with the past trends discriminated by Stahl et al. (2010), winter and spring river flows are projected to increase in most parts of Europe, except for the most southern and south-eastern regions. In summer and autumn, river flows are projected to decrease in most of Europe, except for northern and north-eastern regions where autumn flows are projected to increase (Dankers and Feyen, 2009). In snow dominated regions, such as the Alps, Scandinavia and the Baltic, the fall in winter retention as snow, earlier snowmelt and reduced summer precipitation will reduce river flows in summer (updated refs) when demand is typically highest.




River flow droughts are projected to increase in frequency and severity in southern and south-eastern Europe, the United Kingdom, France, Benelux, southern Scandinavia and western parts of Germany over the coming decades. In snow-dominated regions, where droughts typically occur in winter, river flow droughts are projected to become less severe because a lower fraction of precipitation will fall as snow in warmer winters. In most of Europe, the projected decrease in summer precipitation, accompanied by rising temperatures which enhances evaporative demand, may lead to more frequent and intense summer droughts (Douville *et al.*, 2002; Lehner *et al.*, 2006; Feyen and Dankers, 2009).

*Regional – Turkey*

## 5.) Sustainable Water Management

*CLIMWATADAPT*
*Adaptation to climate change*
*Demand Management*
*Drought Management Plans*
*Efficiency of Use – link to other assessment*

In the light of projected climate change impacts upon freshwater resources, Europe needs to implement a much more sustainable approach to water resource management, focusing on conserving water and using it more efficiently. Integral to this is a more equitable approach to water abstraction that addresses not only the requirements of competing economic sectors but also the need for healthy freshwater ecosystems. Successfully achieving a demand management approach to water across Europe will address the need to adapt to climate change and contribute to lower energy consumption because water and energy use are closely linked. Achieving sustainable water resource management will require the implementation of a number of policies and practices, including water pricing, efficient use of water, awareness raising and tackling illegal water abstraction. The EU and its Member States can play crucial roles in these policy areas, using public spending and grants to create and maintain necessary infrastructure, promote technological innovation and incentivise behavioural change. As such, many tools and approaches could feature as elements of the 'Green New Deal' programmes of public investment that some Governments are considering in response to the current global economic downturn. Key measures include:

• facilitating appropriate water pricing across all sectors, including the implementation of metering to support volume-based charging;
• ensuring that agricultural subsidies are linked to more efficient water use;
• investing in new technologies to increase water use efficiency and upgrading water infrastructure networks;
• focusing investment on the sustainability of alternative water sources where demand measures are already fully exploited.

Implementation of a sustainable approach to the management of Europe’s water resources is projected to lead to a considerable reduction in water stress under a scenario of ‘sustainability first’ (Ref to final CLIMWATADAPT project report). Present day annual stress (left hand figure) as predicted by the ratio of water abstraction to long-term availability is markedly reduced across much of Europe (right hand figure) by 2050, under a scenario that captures not only a range of demand management measures but also the impact of climate change upon water availability.

Also include Economy First scenario to show the impact of a lack of sustainable management of water resources

Cross reference to Resource Efficiency Assessment to capture technical details