Environmental assessment report No 1

Sustainable water use in Europe

Part 1: Sectoral use of water

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Cataloguing data can be found at the end of this publication

Luxembourg: Office for Official Publications of the European Communities, 1999

ISBN   XXXXXXXXXXXXXXXX

Printed in XXXXXX

Printed on recycled and chlorine-free bleached paper

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Preface

This report is the first in a series on "Sustainable Water Use in Europe", and as such examines and assesses the available information on the Sectoral Use of Water. It has been produced by the European Topic Centre on Inland Waters (ETC/IW) on behalf of the European Environment Agency (EEA). The project was led by the Centro de Estudios y Experimentación de Obras Públicas (CEDEX), Spain, with the assistance of the Water Research Centre (United Kingdom), International Office for Water and Agences de l'Eau (France), and the Institute of Hydrology (United Kingdom).

Information was obtained from a questionnaire distributed to the EEA's National Focal Points, from published literature (for example, national state of the environment reports and reports produced by international organisations such as Eurostat and the Food and Agriculture Organization), unpublished reports and through links with various research projects. The focus was primarily on the 18 member countries of the EEA though information readily available from other European countries, and in particular from the Phare Topic Link on Inland Waters, was also used.

This report is also the source document for information on water resources used in ***Europe's Environment: The Second Assessment*** published by the European Environment Agency in June 1998.

The report aims to inform and provide information for policy- and decision-makers at both the national and European level. For example, it will aid the European Commission's review of the progress made in implementing the Fifth Environmental Action Programme "Towards Sustainability". It will also be of value to Non-Governmental Organisations and of general interest to members of the public.

The report highlights the need to improve existing information by establishing reliable definitions, a common understanding, and quantitative and consistent records on a European scale. This is a highly complex issue that requires co-operation between, and co-ordination of, those organisations currently responsible for collecting information on Europe's water resources. Reliable and comparable information is required to ensure that existing policies are effective and that any new policies are targeted correctly so that there can be a sustainable use of water in Europe.

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Executive summary

The European Environment Agency and its Topic Centre on Inland Waters is undertaking an assessment of the sustainable use of water in Europe. This report describes the first part of that assessment and looks in particular at the sectoral use of water across Europe. There are many pressures on water resources including those arising from agriculture, industry, urban areas, households and tourism. These driving forces requiring water are intimately linked with national and international social and economic policies. Additional driving forces arise from the natural variability in water availability (rainfall) and changes in Europe's climate. Recent history has demonstrated that extreme hydrological events such as floods and drought can create additional stress on water supplies essential for human and ecosystem health. The prudent and efficient use of water is thus an important issue in Europe and a number of policies and mechanisms are being used or are being formulated to ensure sustainable use of water in the long term. Information for this report has largely been collected from Western Europe though some information has also been obtained from some Eastern European countries.

Reliable water supply and the protection of aquatic resources through adequate water management are essential to support all aspects of human life and dependent aquatic and terrestrial ecosystems. The use of water across Europe is as varied as are the constituent countries, because of different climates, cultures, habits, economies and natural conditions. Common to all European countries is the need to satisfy the water demand of households, industry and agriculture. Also common to many countries is a limitation on water resources, both in terms of quantity and quality.

Sources and uses of water

The principal source of abstracted freshwater in the EU Member States is surface water (about 75% of the total water abstracted for all uses) with a large part of the remainder from groundwater (about 25%) and only minor contributions from desalination of seawater and from re-use of treated effluents. In countries with sufficient aquifers, over 75% of the water for public water supply is abstracted from groundwater. Groundwater has historically provided a local, and least-cost source of drinking water for public supply and private domestic use. As groundwater is generally of superior quality to surface water and requires less treatment, groundwater reserves are increasingly being exploited in preference to surface water sources. In many parts of Europe this has led to over-abstraction and a lowering of the groundwater table resulting in the degradation of spring fed rivers, destruction of wetlands and, in coastal areas, intrusion of saline water into aquifers.

Abstracted freshwater in Europe is used for urban use (14%), agriculture (30%), and industry (10%, cooling water excluded), and for cooling water for power generation and hydropower (32%), and other or undefined uses (14%). The analysis of trends in the total abstraction of freshwater in Europe should take into account the important deviations that exist between data derived from different sources. Given the variety of phenomena observed it is therefore difficult to identify a general trend in freshwater abstractions on a European scale. However, it appears that in most countries of Western and Northern Europe total water abstraction has been relatively stable over recent years, with a possible downward trend in Denmark, Finland, Sweden and the United Kingdom. It appears that in these countries a series of droughts in recent years has increased public awareness that water is a finite resource. The apparent downturn may also be attributed to a shift in management strategies, moving towards demand management strategies, reducing losses, using water more efficiently and recycling. Regarding Eastern Europe, the political upheavals of 1989-90 and the changes from centralised to market based economies help to explain the decline in the amount of water use in the Czech and Slovak Republics and in Poland. Total abstractions have been rising in Hungary. In Southern European countries it appears that the growth of total abstraction has been slowing down over recent years.

Agriculture

One of the biggest driving forces and pressures on water resources is agriculture and the changes in its practices. On average, agriculture accounts for about 2.3% of the Gross Domestic Product (GDP) of EU Member States. Percentages, however, vary considerably from 1% in Germany to about 12% in Greece. In most countries these percentages have been declining over the past decades, reflecting the relative decrease of importance of agriculture in comparison to other economic sectors. However agriculture is still a very important economic sector in the EU Accession Countries. In terms of water use agriculture accounts for approximately 30% of total water abstractions and around 55% of consumptive water uses. However, in Southern European countries (Greece, Italy, Portugal and Spain) these percentages rise to 73% of consumptive uses and 62% of total uses.

The most important agricultural water demand is for irrigation. This is particularly so in the Mediterranean countries where agriculture accounts for about 83% of total demand in Greece, 57% in Italy, 68% in Spain and 52% in Portugal. This is in marked contrast to northern and eastern European countries where, on average, less than 10% of the resources are used for irrigation. The volume of irrigation water applied depends on climate, the crop being cultivated, the area being irrigated and the method of application. Nationally the area under irrigation varies greatly in terms of hectares and in terms of percentage of total agricultural area, partially reflecting differences in climate. Thus irrigated land varies from close to zero in many Central and Northern European countries up to 60% of the total agricultural land in the Netherlands. In Southern countries percentages of irrigated land range from 18% of total agricultural land in Spain to 38% in Greece. With a total irrigated surface in EU of about 11.3 million hectares and a total agricultural water use of around 73,000 million m^3 /year the mean water use for irrigation is 6,500 m^3 /ha/year. Over the past decades the trend in agricultural water use has, in general, been upwards, due to increasing irrigation. However, more recently the rate of increase of the irrigated area has been diminishing in several countries.

In Southern Europe agriculture requires a much higher share of water resources than would be expected from its relative contribution to national production and employment. It is also clear that the gains in agricultural productivity observed in Western Europe have not yet been achieved in the South and the East of Europe. Pressures on agriculture water use may therefore increase in these areas. In Eastern Europe agricultural water demand has been falling as a result of economic problems and changes in land ownership. In general a major influence on the increase in irrigated land in the EU has been the Common Agricultural Policy, which controls the type and quantity of crops grown.

Population and urbanisation

Changes in population, population distribution and density are key factors influencing the demand for water. The population of the EU has increased by more than 72 millions since 1960 with growth rates being positive in nearly all countries. Some forecasts indicate that the population growth rates are expected to decrease over the next 30 years. More than two thirds of the population in the EU live in urban areas with, for most countries, the proportion of the population living in settlements below 2,000 inhabitants clearly decreasing.

Water use by households and small businesses shows large differences between countries. Denmark, Germany, Luxembourg and Sweden have decreased their consumption whereas in countries like Austria, Belgium, France, Italy, the Netherlands, Switzerland and especially Norway, there have been increases. Consumption measured as volume and percentage of total water use also increased in most countries between 1980 and 1993, except for Denmark, Luxembourg and Germany where volumes were stable. Estimates of future public water supply over the next 30 years show that demand is expected to increase further in France, Greece, the Netherlands and the United Kingdom, remain stable in Hungary and decrease in Bulgaria and Italy. It is assumed that population will increase with changes in lifestyle such as further use of water consuming appliances with also an increase in water prices and growing public awareness leading to more economic water use.

The share of water for urban use in total abstraction in EU15 is about 34,803 million m^3/year. In most countries water for urban use includes domestic, commercial- industrial and public services use.

Tourism

Over the last 40 years mass tourism has become very important in some national economies with income accounting for about 1.2% of total GDP in OECD countries. In countries with a strong tourist sector this share may rise to over 4% (Greece, Portugal, Spain) and even reach close to 7% (Austria). Tourism has a tendency to have distinct seasonal variations and to be in "good weather areas", which are often associated with limited availability of water resources particularly in peak holiday periods. For example in Spain the major part of tourism is directed to the eastern and southern coasts, regions which already are suffering from stress on water resources. Also in the Alps, tourism puts considerable pressure on water resources. Consumption of water by tourists is nearly two times higher than for local consumers. Also tourists often require large volumes of water for recreation such as for swimming pools, water parks and golf courses. The water needed for maintaining a hectare of golf course is around 10,000 m^3 /year, the same as for well irrigated agricultural systems).

Industry

Industrial use of water (about 25,400 million m^3 /year in the EU) also varies greatly between countries and comparisons are complicated by the inconsistent inclusion of cooling water in national statistics. Industrial water use, excluding cooling, accounts for about 10%, and cooling water for power generation and hydropower 32% of total water abstraction in the countries considered in this study. In many European countries (e.g. the Netherlands, France and the United Kingdom), industrial water demand has been decreasing through the 1980s and 1990s. This is due, primarily, to economic recession with plant closures in heavy water using industries such as textiles, iron and steel and a move towards less water intensive service industries. Technological improvements in water using equipment and increased recycling are also contributing to the decline. In Eastern Europe, abstractions have declined due to falling industrial production.

Between 1989 and 1994 the average economic growth in the EU was around 8% in terms of GDP. Over the same period the growth in industrial production was around 2.5%, indicating relative stagnation and a decline of industrial production in relation to other sectors of national economies. In Eastern European countries industrial activity slowed down considerably in 1990 and 1991 at the peak of the political and economic crisis. Industrial production then grew in Poland in 1992, in Bulgaria in 1993, and in Hungary and the Czech and Slovak Republics by 1994.

Climate change

Estimations of climate change indicate a temperature increase of 1º C to 3.5º C by 2100, which together with an increase in precipitation in Northern Europe and a decrease in Southern Europe, could lead to a reduction in renewable water resources in Southern Europe. Furthermore, a temperature increase could cause snow to melt earlier, increasing winter run-off and reducing the thawing processes in spring and summer. Even in areas where precipitation increases, greater evaporation could lead to lower run-off. A variation in the risk and intensity of droughts is the most serious negative impact of climate change on water resources in arid and semi-arid regions. A reduction in water availability could lead to desertification in zones where the balance is particularly fragile. Climate change may have considerable repercussions on the flood regime. The predicted variation in storm magnitude and frequency could give rise to a marked increase in run-off in short periods of time, which would aggravate the already catastrophic effects of floods, thus making it necessary to review present techniques for water resources estimation, flood prevention and prediction, and management.

Water availability

Freshwater resources across Europe vary greatly with annual run-off ranging from over 3000 mm in parts of Norway to less than 25 mm per year in South East Spain and parts of Eastern Europe. Transboundary flows make a significant contribution to the resources of many countries. In Hungary, for instance, freshwater originating from neighbouring countries accounts for as much as 95% of the total resource. In the Netherlands and Slovak Republic this figure is over 80%, while Germany, Greece, Luxembourg and Portugal all rely on imported water for over 40% of their resources. Although there are international agreements to control the quantity and quality of imported water, tensions inevitably arise, especially where resources are limited in the downstream country.

Potentially, all countries have sufficient resources to meet national demand. However, the national statistics presented describe the resource situation at a very general level. Such information tends to mask problems that may be occurring at regional or local scale. The greatest demand for water is normally concentrated in the densely populated urban conurbations. The demand for European water resources has increased from 100 km^3 per year in 1950 to 551 km^3 per year in 1990, with forecasts that this will increase to 661 km^3 by the end of this century.

Impacts and stress on water resources

Water stress is generally related to an over-proportionate abstraction of water in relation to the resources available in a particular area. Urban demand for freshwater can exceed the local long-term availability of the resource, especially in Southern Europe and the industrial centres of the North. In these areas such demand can not be sustained unless action is taken to artificially boost local supply (e.g. reservoir construction). Seasonal or inter-annual variation in the availability of freshwater resources will, at times, induce problems of water stress.

The impact of a drought depends on the combination of hydrological conditions and water resource pressures. The biggest impacts of the drought at the beginning of the 1990s in Europe have been in areas with the greatest pressures on resources, and especially in those areas with high irrigation demands. These are not necessarily the areas with the greatest hydrological drought. Low river flows and depleted reservoir stocks caused problems for irrigation over a large part of Europe, ranging from Hungary to Spain, where agricultural production was heavily affected.

Desertification is a problem in some areas of Europe, particularly semi-arid and water scarcity areas in Southern Europe. The tendency towards desertification is often enhanced and accelerated by the activity of mankind. The over-exploitation of water resources is one example of activities that encourage desertification in areas prone to developing arid conditions.

Over-abstraction of both surface waters and groundwaters is having serious impacts on associated terrestrial and aquatic ecosystems. Such impacts can be exacerbated during periods of low rainfall and river flow when there may also be increased pressures on supplies to meet urban needs, such as from watering gardens, and from irrigation of water dependent crops. The exceedance of demand over supply leads to restrictions of uses (e.g. hose-pipe bans) during extended periods of time in countries such as the United Kingdom.

Responses - European policy

Because of the long term deterioration of the quality and quantity of water, particularly groundwater, resources, the European Council called for a Community Action and required that a detailed action programme be drawn up for comprehensive protection and management of groundwater as part of an overall policy on water protection. This led to a draft proposal for a Groundwater Action and Water Management Programme (COM(96) 315 final) which required a programme of actions to be implemented by the year 2000 at national and Community level, aiming at sustainable management and protection of freshwater resources. Many of the recommendations in the GAP are now found in the proposed Framework Water Directive (COM(97) 49 final) which once implemented will establish a legally binding framework to promote sustainable water consumption based on long-term protection of available water resources.

Responses - Demand side management

Economic instruments, such as abstraction charges and pricing mechanisms, are widely seen as valuable tools to achieve sustainable water management. However, they are only effective in terms of their environmental goal to reduce water abstractions when the person who has to pay the charge or tax can actually benefit by responding to the increased charge by reducing consumption. When applying economic instruments to public water supply the impact on health and hygiene, and also on the affordability by the poorer section of society needs to be taken into account as such charges will generally hit the poorer population proportionately harder than the other consumers. In addition, in order to maintain the income of the water supplier to carry out its duty, the charges will normally have to be raised as consumption goes down because of the high fixed costs. The overall benefit to consumers of saving money by saving water may therefore be small unless of course major infrastructure expenditure can be saved (e.g. the building of a new reservoir) which would otherwise have increased charges substantially. Also when introducing economic instruments for water management the impact on the wider economy needs to be taken into account. For instance very large water users may become uncompetitive if the charges are only introduced in one particular country or region.

Charges are generally not related to the true cost of water and are not the same for all users. In particular agricultural users are considered to pay very low charges that are not related to the quantity used or the real environmental impact. To be effective in protecting the environment, charges need to reflect the true value of the water for the particular aquatic environment taking into account all the uses. The charges therefore need to be site specific or catchment specific. However, at present no standard method has been devised to assess the true value of water at different sites. The proposed Water Framework Directive, however, introduces the concept of full cost recovery.

Water prices for domestic consumers in Western Europe vary from 52 ecu/year per family in Rome to 287 ecu/year per family in Brussels. Water charges in Central European cities are lower and vary from 20 and 20.5 ecu/year per family in Bucharest and Bratislava to 59 ecu/year per family in Prague. Nevertheless, the annual water charge in relation to GDP per capita shows that the cost in Bucharest is the highest in Europe amounting to 3.5% of GDP per capita followed by Vilnius 2.6% and Prague 2.3%, and the lowest is 0.2% in Oslo. In Western Europe, the highest percentage is 2.2% of GDP per capita in Portugal. Several studies have demonstrated that rising water prices for domestic consumers have a positive effect on both indoor and outdoor water conservation efforts (use of low-flow toilets, taps and shower heads, for example).

Domestic metering is widespread in many countries (e.g. Denmark, France, Germany, the Netherlands, Portugal and Spain), but less common for example in the United Kingdom. Water metering is assumed to increase population awareness of water use. For example, in the United Kingdom the use of water in metered is estimated to be 10% lower than in non-metered households. The installation of water meters is frequently in line with public concerns for better use of water resources and the request for better management of the water environment. Reliable water metering is an essential requirement for the implementation of effective water charges.

Responses - Infrastructure responses

Network efficiency has direct consequences on total water abstractions. In most countries leakage in water distribution networks is still important. Comparison of leakage in three European countries (United Kingdom, France and Germany), shows that leakage in main and customer supply pipes varies from 8.4 (in parts of the United Kingdom) to 3.7 (West Germany) m^3 per km of main pipe per day, which correspond to 243 and 112 l/property/day, respectively.

The use of storage reservoirs overcomes the uneven distribution of natural water resources over time. Run-off in the wet season can be held back and used in dry seasons and years. At present there are about 3,500 major reservoirs with a total gross capacity of approximately 150,000 million m^3 in operation in Europe (EU15 plus Norway and Iceland). The greatest storage capacities are available in Spain (52,000 million m^3), Norway (38,000 million m^3), Sweden (21,000 million m^3) and Finland (15,000 million m^3). The greatest numbers of major reservoirs are found in Spain, France and the United Kingdom with 849, 521 and 517, respectively.

Waste water re-use is increasing within the EU, mostly to alleviate the lack of water resources in certain regions, such as in southern European countries but also to protect the environment especially in coastal waters by removing all discharges into sensitive receiving waters. Article 12 of the Urban Waste Water Treatment Directive (91/271/EEC) states that treated water shall be re-used whenever appropriate. The largest application of this re-use is the irrigation of crops, golf courses and sports fields where pathogens from the wastewater may come in contact with the public. However, there are at present no regulations on wastewater re-use in Europe.

At present seawater desalination is being applied mainly in areas where no other sources of supply are available at competitive costs. The total volume of desalinated water in Europe is very small compared to other sources of supply. There are also examples of inter-basin water transfer schemes being used to alleviate short and long term water shortages in particular basins or regions.

Conclusions

The objective of this series of reports, the first of which is presented here, is to improve the state of information and to prepare the way for future research and policy-making towards a sustainable water use in Europe. The problems of over-exploitation of water resources are extremely complex, not only from a hydrological point of view but also regarding the socio-economic and political circumstances. Solutions have to be environmentally sound as well as socially and politically feasible. It is therefore recommended that research, national monitoring and data-gathering concentrate on the improvement of the present state of information, trying to establish reliable records on a European scale and provide meaningful information to decision-makers. The complexity of the problems to be tackled has to be fully recognised out and understood if programmes and regulations are to be effective. Furthermore, the essential element of any policy to protect the aquatic environment has to be the regular monitoring of the implementation of the measures taken. The next (second) part of this series of reports will investigate further the movement from facilitating infrastructure supply to demand side management and how this relates to the sectoral use of water. It will also analyse the importance of extreme hydrological events and human interventions in relation to sustainable water resource management.

1. Introduction

1.1. Objectives and scope

Reliable water supply and the protection of aquatic resources through adequate water management are essential to support all aspects of human life. The use of water across Europe is as varied as are the constituent countries, due to different climates, cultures, habits, economies and natural conditions. Common to all European countries is the need to satisfy the water demand of households, industry and agriculture and the requirement to protect the aquatic environment and ecosystems. Also common to many countries is a limitation of water resources and the problems faced by the water supply sector, both in terms of quantity and quality.

As a result of increasing stress (demand exceeding supply or availability) on water resources, the environmental consciousness of the public and governments in relation to water use is much more developed today than it has been in the past. Adding to this the tight financial situation of public (and private) entities involved in the provision of hydraulic infrastructures, a certain re-orientation in the approach to water management seems appropriate, turning from traditional infrastructure facilitating water supply (IFS) (e.g. construction of reservoirs and damming) to demand side management (DSM) (e.g. water metering and pricing). Demand management and, in a wider sense, 'Water Conservation' not only concern water quantities but also refer to a environmentally more friendly use of water in order to avoid the negative impact that water use can have on resources and environment.

The aim of this report is to review water use in various sectors across Europe, giving a description of the present situation and gaps in existing information thereby making recommendations for future investigation and study. It aims also to analyse the conditions which are favourable to improve the efficiency of use in different sectors and to encourage sustainable use and conservation of resources. The uses of water considered are those relating to urban supply, industry, agriculture and tourism.

Information was obtained through the review of a large amount of published (and unpublished) information, establishing links to various research projects and through consultation with the National Focal Points[1].

1.2. Methodology applied

The study is based on the concept of **Integrated Environmental Assessment** (IEA). This is defined as '*the interdisciplinary process of identification, analysis and appraisal of all relevant natural and human processes and their interactions which determine both the current and future state of environmental quality and resources on appropriate spatial and temporal scales, thus facilitating the framing and implementation of policies and strategies'*.

The EEA assessment framework linking Driving Forces, Pressures, State, Impacts and Responses has been used. Agriculture, population (and its growth), urbanisation and industry are considered here to be the main **Driving Forces** affecting the water cycle. These result in **Pressures** on water resources such as those relating to water abstraction for different uses (urban use, industry, agriculture). Climate change is also considered. The **State** of water resources is assessed in terms of quantity and quality, and **Impacts** are described through general information and regional examples. The assessment of these impacts provides information for setting targets for future research and policies. The potential societal **Responses** are described in terms of regulating instruments (Water Framework Directive, Common Agricultural Policy, supply and demand control), financial instruments (tariff systems and financial incentives) and infrastructure responses (reservoir construction, inter-basin transfers). Figure 1.1 shows the principles of the DPSIR framework, applied to the present case.

(1) National Focal Points: Contacts of the European Environment Agency in Member Countries.

Figure 1.1: The DPSIR Framework

Driving Forces ⇒	Pressures ⇒	State ⇒	Impact ⇒
Agriculture	Abstraction	Run-off	Water stress
Population	surface water	Renewable resources	Drought
Industry	groundwater	Quality for use	Deterioration
Climate	Climate change		quantity
Rainfall			quality
Temperature			Ecological status
⇑	⇑		⇓
Policy measures	**Responses ⇐**		**Setting of targets**
Framework Directive	Infrastructure responses		
Common Agricultural Policy	Supply and demand control		
	Financial incentives		
	Costs		

1.3. Regional groupings of countries

Regional analyses have been undertaken in this report according to the following groupings of countries:

- **Northern**: Finland, Iceland, Norway, and Sweden.
- **Eastern**: Belarus, Bulgaria, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Moldova, Poland, Romania, Russian Federation, Slovak Republic, Ukraine.
- **Southern**: Albania, Bosnia-Herzegovina, Croatia, Cyprus, Greece, Italy, Malta, Portugal, Federal Republic of Yugoslavia, Slovenia, Spain and the Former Yugoslavian Republic of Macedonia (FYROM).
- **Western**: Austria, Belgium, Denmark, France, Germany, Ireland, Liechtenstein, Luxembourg, the Netherlands, Switzerland, and United Kingdom.

1.4. Glossary

A glossary of the terms and definitions used in this report are given below. The understanding and definition of the different aspects of water abstraction, demand and use is very important. As this report highlights, the different interpretation of these definitions and terms is the cause of much of the non-comparability of the information on water resources at a European level.

The ***renewable freshwater resource*** for use in a country is the amount flowing in rivers and aquifers, originating either from local precipitation over the country itself, or by water received from neighbouring countries in transboundary rivers and aquifers.

Water abstraction: means water physically moved from its natural site of occurrence.

Water demand: need for water (in this report, the concepts water demand and water abstraction has been used to mean the same thing, even if they are not exactly the same).

Water supply: portion of abstraction supplied to user (excluding losses in storage, conveyance and distribution).

Water consumption: portion of supply which in terms of the water balance remains with users: some evaporates, while the remainder is reintroduced into the natural cycle through, discharges and returns to rivers, lakes and aquifers.

Water stress: occurs when there is an excessive abstraction of water in relation to the resources available in a particular area.

Water use: means all uses of water, both within and away from the river, lake or aquifer.

Industrial demand: refers to water supplied to industry excluding that supplied through the urban supply network.

Energetic demand: includes cooling water for thermal power generation plants and for hydroelectric power generation.

Urban demand: includes private households, commercial-industrial use and public services use.

Agricultural demand: agriculture, including irrigation.

Irrigation water: water artificially applied to soils in the process of irrigation. It does not include precipitation.

Demand for other uses: includes environmental water demand, navigation, and recreation.

Losses: losses of water in transit from the source of supply to the point of delivery.

Surface water: water that flows over, or rests upon, the surface of the lithosphere.

Groundwater: the water that occurs in the zone of saturation from which wells and springs or open channels are fed.

Rainfall: the amount of rain, usually expressed as millimetres of water that reach the surface of the earth.

Run-off: portion of the total precipitation (rainfall) from a given area that appears in natural or artificial surface streams. Also the total quantity of run-off over a specified period.

Evapotranspiration: the amount of water utilised by plant growth plus evaporation from the soil if the soil contained sufficient moisture for plant growth at all times.

Drought: the main characteristic of drought is a decrease of water availability in a particular period and over a particular area.

Desertification: the set of environmental degradation processes occurring in hot (hyper-arid, semi-arid and sub-arid) dry lands, which result either from climatic stress, or human mismanagement, or both.

2. Driving forces

2.1. Agriculture

2.1.1. Introduction

Agriculture creates pressures on water resources through direct abstraction for agricultural uses such as irrigation and watering of livestock, and by potentially polluting activities such as the use of fertilisers and pesticides. Agriculture is thus an important Driving Force in the sustainable management of water, and current activities and trends are outlined in this section. The pressures it creates are discussed in more detail in Section 3.

2.1.2. General scenario

European agriculture is rather diverse and heterogeneous in terms of the products generated the nature and structure of production units, the methods applied and the yields achieved, as well as the differences in potential impacts on the environment. Although generalisations are difficult to make, this section describes in broad terms the present status of agriculture in Europe, indicates current trends and outlines potential future developments.

Immediately after the last war in Europe there was a demand for a more secure, cheaper and plentiful supply of food. Agriculture responded with remarkable increases in average yields and productivity. This was achieved through application of improved production methods and technologies, such as use of fertilisers and pesticides, mechanisation, irrigation and seed improvements, and was supported by a complex system of government subsidies and production incentives. European agriculture, on the whole, is now in a position to meet the basic needs of about 680 million people in Europe more reliably than at any previous moment in history.

At the same time EU agriculture is suffering from its own success in that it is able to produce more food than is actually needed within the EU (surpluses). Over the past decades a situation has been created in which a major part of the EU budget is assigned to agricultural subsidies. The market mechanisms common to other sectors have been put to one side, and considerable amounts are spent on generating and subsequently disposing of surplus food stocks. Also the success achieved in increasing agricultural production is causing increased impacts on the environment, ranging from pollution of groundwater, over-abstraction from ground and surface waters to soil erosion, from changes of landscape to the loss of habitat for plants and animals.

It is recognised therefore that European agriculture has to undergo changes with regards to its political, economical and institutional framework. In EU, reforms are being undertaken gradually, mainly following four lines of action:

1. Reduction of overproduction and the costs related to dealing with surplus food stocks.

2. Reduction of EU farm subsidies and preparation of European agriculture for world market competition.

3. Opening of tariff frontiers that have been protecting EU agriculture markets from world market competition.

4. Establishment of more environmentally friendly and sustainable agriculture.

Progress on these, sometimes contradictory, objectives is slow, because of the multiple political and social constraints imposed on the European agricultural sector.

2.1.3. Socio-economic relevance

In order to illustrate this general picture of European agriculture at present and potentially in the future, some figures related to the issue are presented in this section. Wherever possible, the EEA countries and six of the potential candidates (Accession Countries) for the next EU enlargement (Cyprus, Czech Republic, Estonia, Hungary, Poland and Slovenia) have been considered. For comparison the relevant data from the USA and some additional European countries have also been included were available.

From an economic viewpoint, agriculture today on average accounts for about 2.3% of the Gross Domestic Product (GDP) of the EU Member States. Percentages vary considerably between countries, ranging from 1% in Germany to about 12% in Greece. Table 2.1 and Figure 2.1 give a brief overview of the contribution of agriculture to the GDP in various European countries.

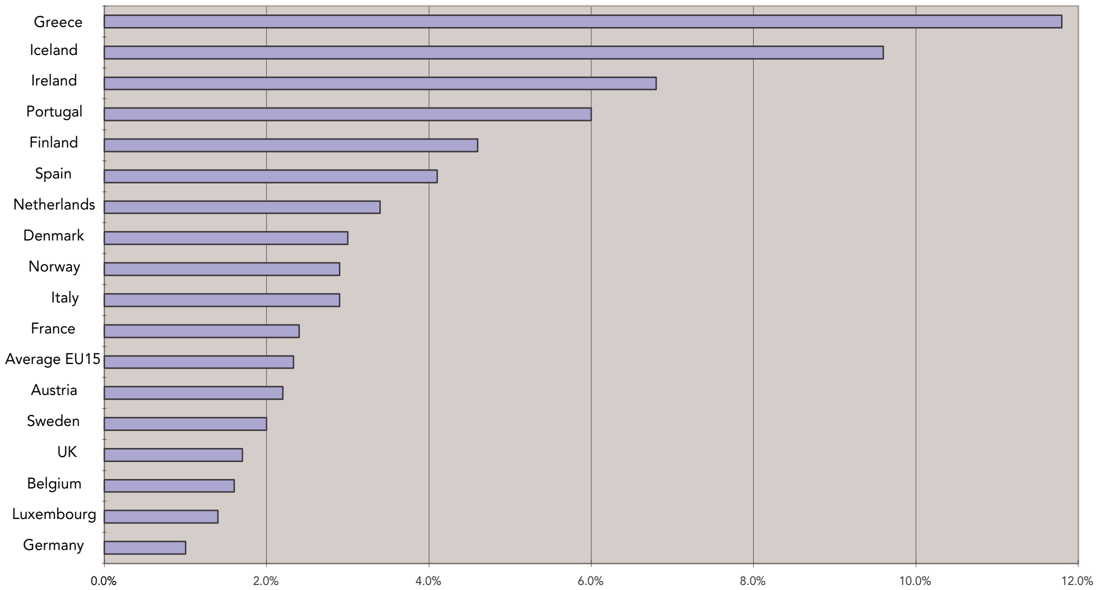
Table 2.1: Share of agriculture in total GDP

Country	Share of Agriculture in total GDP (%)	
	1984	1994
Austria	3.8	2.2
Belgium	2.4	1.6
Denmark	5.5	3.0
Finland	7.7	4.6
France	4.0	2.4
Germany	2.0	1.0
Greece	15.5	11.8
Ireland	7.8	6.8
Italy	4.7	2.9
Luxembourg	2.5	1.4
Netherlands	4.0	3.4
Portugal	7.1	6.0
Spain	5.9	4.1
Sweden	3.4	2.0
United Kingdom	2.0	1.7
Average EU15	3.6	2.3
Iceland	9.6	8.1
Norway	2.9	3.3

(Source: OECD, 1996)

In most countries these percentages have been declining over the past decades, reflecting the relative decrease in importance of agriculture in comparison to other economic sectors. In terms of employment agriculture represents about 6% of the total workforce in the EU and 8% in Europe as a whole. Also here the differences between EEA member countries are considerable, with figures ranging between less than 5% in most Western and Northern European countries and 22% in Greece. Again the tendency for employment in agriculture during the past decades has been downwards as can be seen in Table 2.2.

Figure 2.1: Share of agriculture in total GDP



(Source: OECD, 1996)

It should be noted that the share of agriculture in GDP and in total workforce increases when considering the Accession Countries. Cleary in these countries agriculture still has a higher relevance when compared to other sectors of the economy.

Table 2.2: Evolution of employment in agriculture

Country	Percentage of agricultural employment in relation to total workforce		
	1980	1990	1994
Austria	9.0	5.7	4.8
Belgium-Luxembourg	2.9	1.8	1.5
Denmark	7.3	4.7	3.9
Finland	12.0	8.1	6.9
France	8.6	5.2	4.3
Germany	6.9	4.7	4.0
Greece	30.9	24.2	22.0
Ireland	18.6	13.6	11.9
Italy	12.0	7.1	5.7
Netherlands	5.5	3.7	3.1
Portugal	25.6	16.3	13.6
Spain	17.1	10.7	8.9
Sweden	5.7	3.8	3.3
United Kingdom	2.6	2.0	1.8
Average EU15	11.7	7.9	6.8
Cyprus	26	20.6	18.8
Czech Republic	11.0	9.1	5.8
Hungary	18.2	11.5	9.5
Poland	28.5	20.8	18.2
Slovak Republic	14.8	12.1	9.5
Average Europe	13.9	9.8	8.3

(Source: FAO, 1995, ETC/IW, 1998)

2.1.4. *Agricultural productivity*

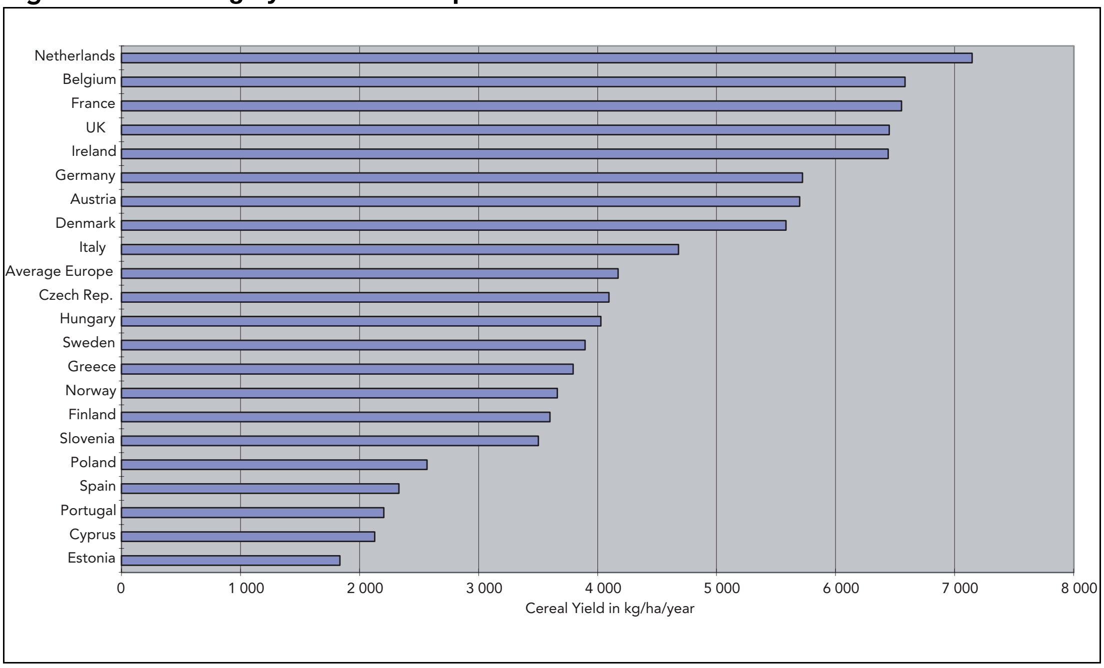
Agriculture in Eastern Europe has a higher potential for increasing production and efficiency. Table 2.3 shows the average yield of cereal production and the changes in yield over the last 15 years and Figure 2.2 illustrates the average yield in cereal production during 1994.

Table 2.3: Yield of cereal production

Country	Average yield of cereal production in kg/ha/year		Country	Average yield of cereal production in kg/ha/year	
	1979-81	1994		1979-81	1994
Austria	4 131	5 699	United Kingdom	4 791	6 451
Belgium-Lux.	4 861	6 585	Cyprus	1 793	2 129
Denmark	4 040	5 584	Czech Rep.	5 460	3 800
Finland	2 511	3 599	Estonia		1 836
France	4 700	6 554	Hungary	4 519	4 027
Germany	4 166	5 721	Poland	2 345	2 566
Greece	3 090	3 794	Slovak Rep.	3 900	4 300
Ireland	4 733	6 443	Slovenia		3 504
Italy	3 548	4 679			
Netherlands	5 696	7 146	Europe	3 552	4387
Norway	3 634	3 661			
Portugal	1 102	2 203			
Spain	1 986	2 332			
Sweden	3 595	3 896			

(Source: FAO, 1995, ETC/IW, 1998)

Figure 2.2: Average yield of cereal production 1994



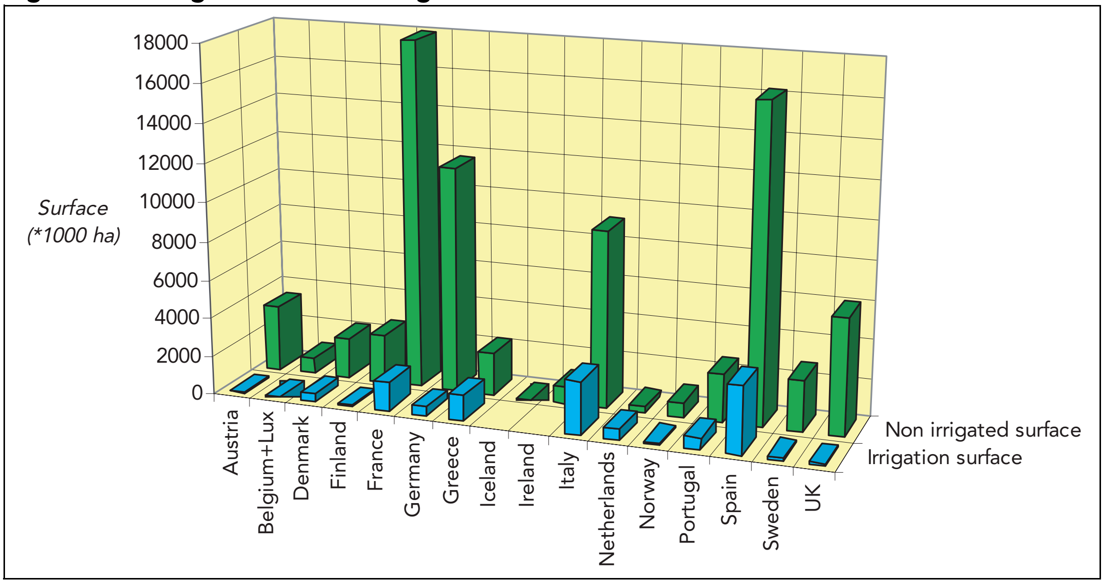
(Source: FAO, 1995)

The differences in average yield achieved in the various countries of the European Union is remarkable, ranging from around 2200 kg/ha in Portugal and Spain to over 7000 kg/ha in the Netherlands. The figures clearly reflect the effects of different climates, and different ways of farming.

2.1.5. Role of irrigation

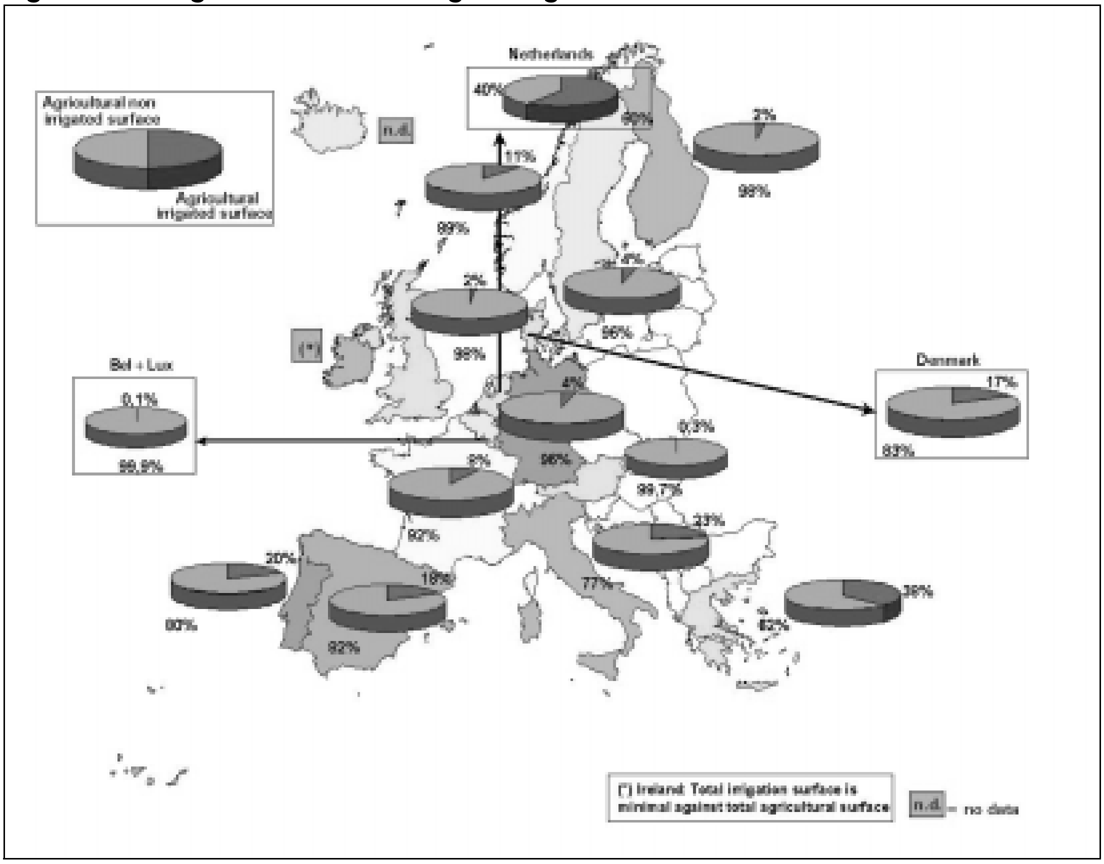
The area under irrigation in different countries varies greatly in terms of hectares and in terms of percentage of total agricultural area. Table 2.4 shows the statistics of total area, agricultural area and irrigated area in absolute and relative terms. Figure 2.3 presents the respective areas in hectares, Figure 2.4 shows the share of irrigated land in relation to the total agricultural area.

Figure 2.3: Irrigated and non-irrigated area in EEA countries



(Source: FAO, 1995; arable land and permanent crops)

Figure 2.4: Irrigated versus non-irrigated agricultural area in EEA countries



(Source: FAO, 1995; arable land and permanent crops)

Table 2.4: Agricultural and irrigated surface

Country	Total area (1000 km²)	Total agri-cultural area 1993 (1000 ha) (1)	Agricul-tural area in relation to total area (%)	Irrigated area 1993 (1000 ha)	Irrigated area in rela-tion to agri-cultural. area (%)
Belgium-Luxembourg	33.1	794	24	1	0.1
Denmark	43.1	2 542	59	435	17.1
Finland	338.0	2 580	8	64	2.5
France	549.0	19 439	35	1 485	7.6
Germany	356.9	12 116	34	475	3.9
Greece	132.0	3 494	26	1 314	37.6
Austria	83.9	1 498	18	4	0.3
Ireland	70.3	923	13	-	-
Italy	301.2	11 860	39	2 710	22.8
Netherlands	40.8	934	23	560	60.0
Portugal	92.4	3 160	34	630	19.9
Spain	504.8	19 656	39	3 453	17.6
Sweden	450.0	2 780	6	115	4.1
United Kingdom	244.8	6 127	25	108	1.8
Total EU15	3240.3	87903	27 Average	11354	12.9 Average
Iceland	103.0	6	-		
Norway	324.2	890	3	97	10.9
Cyprus	9.25	158	17	39	24.7
Czech Republic	78.863	3 239	41	24	0.7
Estonia	45.226	1 143	25		
Hungary	93.03	4 973	53	206	4.1
Liechtenstein	0.158	4	25		
Poland	312.68	14 608	47	100	0.7
Slovenia	20.251	301	15	2	0.7
Total Europe	-	135 945		16 717	12.3

(Sources: FAO, 1995 and OECD, 1996)

Notes: (1) agricultural area including arable land and permanent crops.

The tables and figures indicate the varying role of irrigation in European agriculture, depending above all on the climate of the country considered. As can be seen, the area set aside for irrigation varies from close to zero in many Central and Northern European countries to up to 60% of the total agricultural land in the Netherlands. The major part of irrigated land in Europe is located in the South with Spain, Italy, France, Greece and Portugal accounting for 85% of the total irrigated area in the EU.

The analysis of agriculture in arid and semi-arid countries requires careful distinction between traditional non-irrigated farming and the normally much more modern and productive irrigated agriculture. For example, in Spain irrigated agriculture accounts for 56% of total agricultural production, occupying only 18% of the total agricultural surface. Table 2.5 includes data on total agricultural production and production of irrigation agriculture for some countries.

Table 2.5: Agricultural production and production of irrigated agriculture for some countries

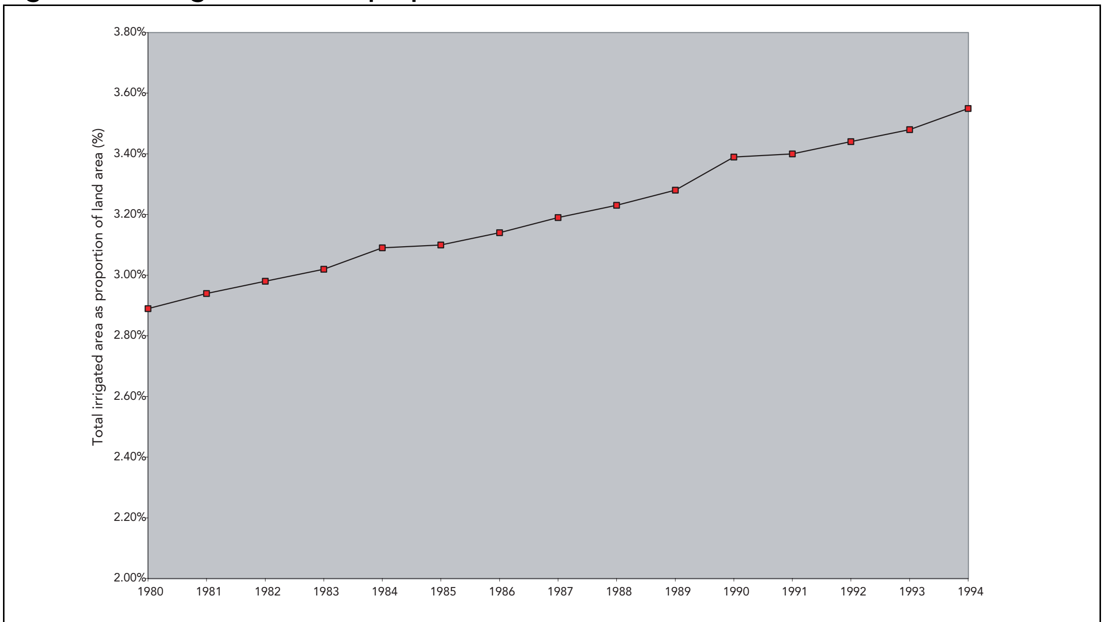
Country	Total agricultural production	Production under irrigation	
	(Mio. ecu)	(Mio. ecu)	(% of total production)
Austria	1 724	86	5
Denmark	6 514		
France	24 490		
Ireland	535		
Spain	22 729	12 723	56
Sweden	1 500		
United Kingdom (1)	8 470		

Notes: (1) Crops and horticulture

In terms of water use agriculture accounts for approximately 55% of consumptive water uses and 30% of total water use in the EU. However, in Southern European countries (Greece, Italy, Portugal, Spain) these percentages rise to 73% of consumptive uses and 62% of total uses, respectively. Detailed information about water abstraction and sectoral water use is included in chapter three of this study. However, it should be noted that in Southern Europe agriculture requires a much higher share of water resources than would be expected from its relative contribution to national production and employment.

As can be seen from Figure 2.5, the area of irrigated land in EU countries has risen steadily since 1980, with approximately 3.5% of the total land area under irrigation in 1994 (FAO, 1996). A major influence on the increase in irrigated land in the European Union has been the Common Agricultural Policy, which controls the type and quantity of crops grown. In contrast in Eastern Europe, agricultural water demand has been falling as a result of economic problems and changes in land ownership (ICWS, 1996).

Figure 2.5: Irrigated area as proportion of total land area for EU15 + CH



(Source: FAO, 1996)

2.2. Population growth and urbanisation

2.2.1. European population - evolution since 1960

Changes in population, population distribution and density are key factors influencing the demand for water resources. Table 2.6 presents some key data relating to population in the countries considered.

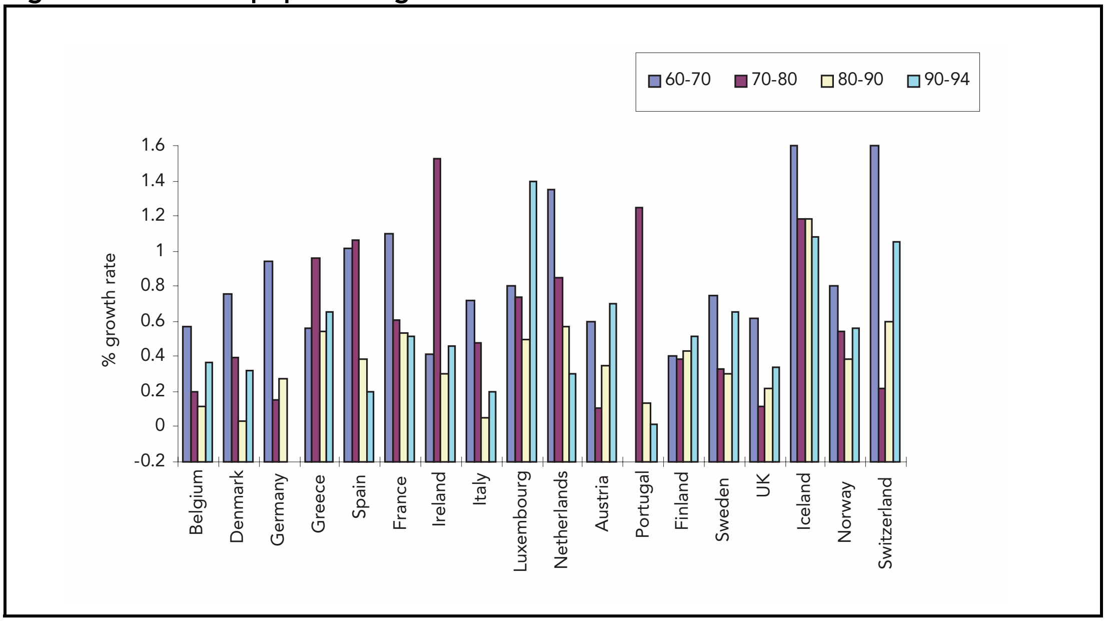
Table 2.6: General data of countries considered

Country	Total area (1000 km^2)	Total population 1996 (1000 inhab)	Population density (inhab/km^2)
Austria	83.9	8 106	97
Belgium	30.5	10 116	332
Denmark	43.1	5 237	122
Finland	338.0	5 126	15
France	549.0	58 333	106
Germany	356.9	81 922	230
Greece	132.0	10 490	79
Ireland	70.3	3 554	51
Italy	301.2	57 226	190
Luxembourg	2.6	398	153
Netherlands	40.8	15 575	382
Portugal	92.4	9 808	106
Spain	504.8	39 270	78
Sweden	450.0	8 819	20
United Kingdom	244.8	58 368	238
Total EU15	3 240.3	372 348	115 (average)
Iceland	103.0	271	3
Norway	324.2	4 348	13
Cyprus		756	
Czech Rep.	78.9	10 330	131
Hungary	93	10 049	110.7
Poland	312.6	38 601	123.2
Slovak Rep.	49.0	5 350	109

(Sources: OECD, 1996 and FAO, 1997)

The population of the 15 EU Member States has increased by more than 72 millions since 1960. In all countries, except Portugal between 1960 and 1970, growth rates have been positive in all decades since 1960. In most countries the highest growth rates occurred during the period 1960-1980. In general, the population growth rates decreased between 1980 and 1990 but since 1990 (until 1994) rates appear to be increasing again in many countries (Figure 2.6) (Eurostat, 1991; UN, 1997).

Figure 2.6: Annual population growth rates



(Source: Eurostat, 1991)

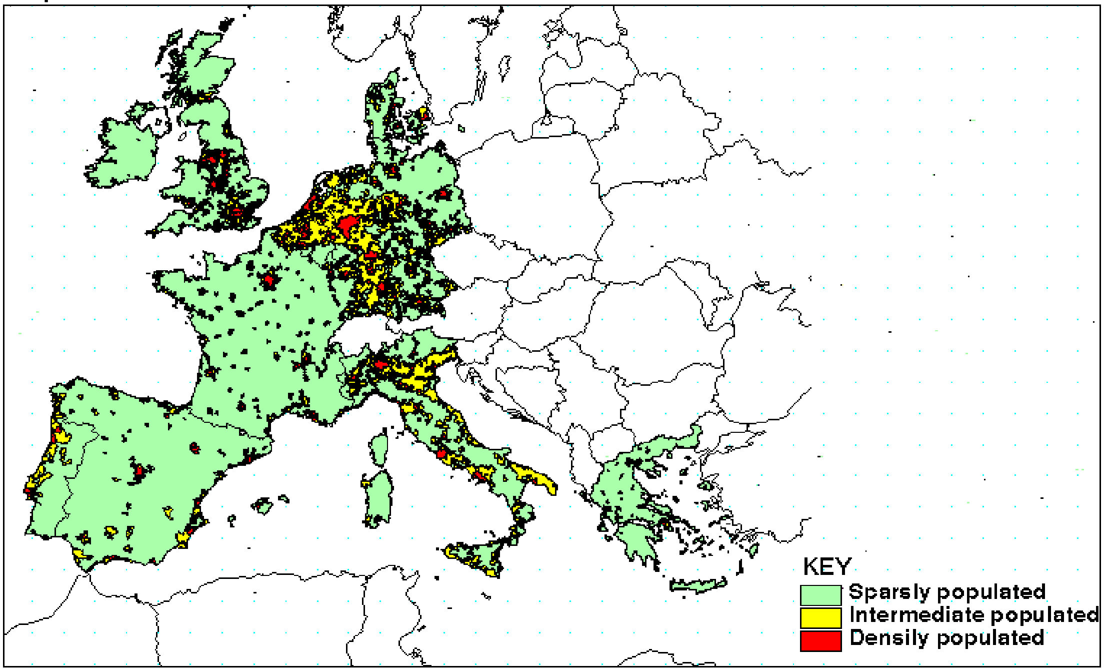
2.2.2. Future trends

A long-range study of the International Centre of Water Studies (ICWS, 1996) on water supply and demand in Europe has estimated future population changes in France, Bulgaria, Greece, Hungary, Italy, the United Kingdom and the Netherlands. In most of these countries growth rates were lower during the period 1975-90 compared with the period 1960-75. The forecasts included in the above study indicate that the population growth rates are expected to continue to decrease over the next 30 years. In France, the population has increased by almost 50% over the last 50 years, growing from 40 millions in 1946 to 58 millions in 1996. Similar phenomena can also be observed in other European countries. The increase was mainly due to high birth rates after the second world war and immigration, especially between 1955 and 1973 (Insee, 1996). Projections show that the population increase is expected to continue for the next 30 years, total population in France reaching around 64-69 million in 2030 (IOW, 1996).

2.2.3. Urbanisation and population movements

More than two thirds of the population in the European Union live in urban areas. Map 2.1 illustrates the population density in EU12 (ie Austria, Finland Sweden excluded).

Map 2.1: Urbanisation in the EU12



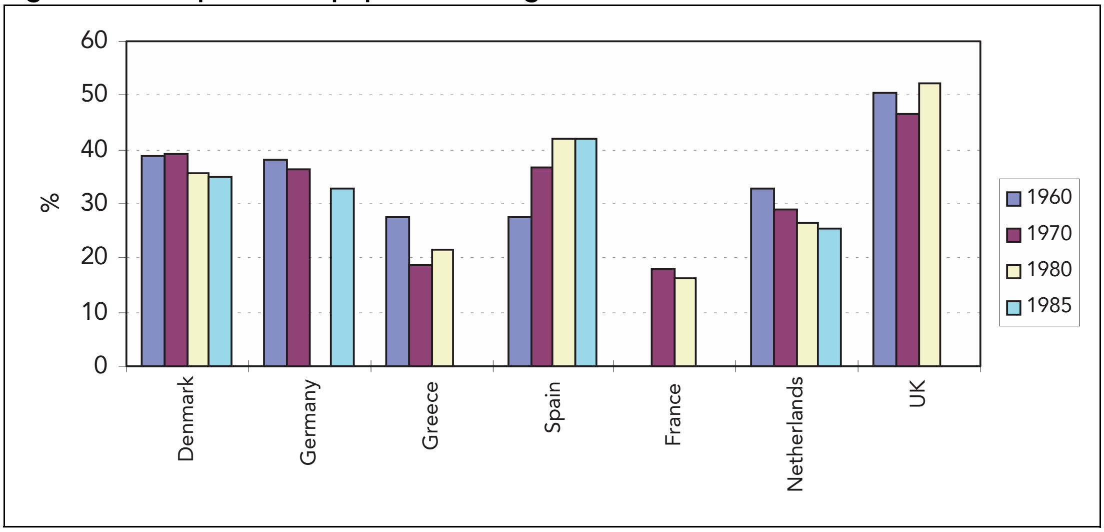
(Source: Eurostat, 1996)

Statistics on urbanisation are difficult to compare from one country to another since settlements are not defined in the same way. However, for most countries the proportion of the population living in settlements below 2,000 inhabitants is clearly decreasing. For settlements greater than 100,000 inhabitants the picture is more variable, with an increase in Spain, a decrease in the Netherlands and a stabilisation or absence of trend in other countries (Figures 2.7 and 2.8).

In France, over the last 30 years a phenomenon termed "peri-urbanisation" has appeared, consisting of population movements from town centres and suburbs to formerly rural outskirts of cities, leading to more extensive forms of settlement and an increase in the numbers of houses. Between 1975 and 1982 the growth of towns in rural areas was greater (for the first time since the beginning of the century) than the growth of towns in urban areas. Between the 1960s and 1990s, the population living in town centres, suburbs and traditional rural areas decreased whereas that living in rural peri-urban areas increased and is expected to continue to increase. There is also continued population movement toward the South East regions and the Paris region (Ille de France) where water supply is already under pressure.

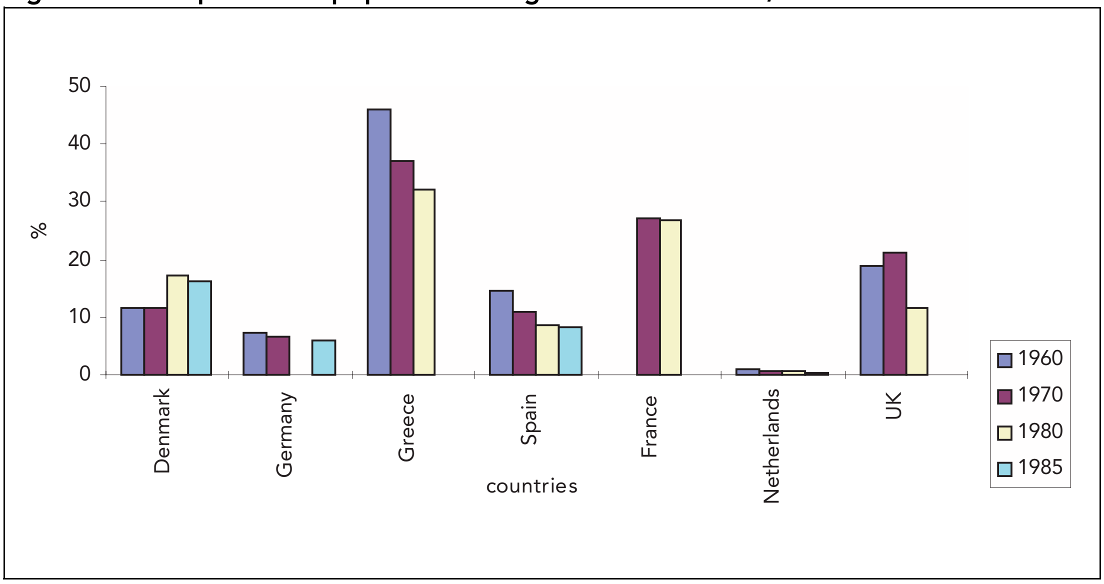
In Spain trends in movement from rural areas to towns on the one hand and from town centres to suburbs and "peri-urban" areas on the other can be observed. Also, population movements from inner parts of the country towards the coast can be observed, putting under pressure especially the coastal regions in the South East, which are already suffering from water deficit.

Figure 2.7: Proportion of population living in settlements >100,000 inhabitants



(Source: Eurostat, 1991)

Figure 2.8: Proportion of population living in settlements <2,000 inhabitants



(Source: Eurostat, 1991)

2.3. Industry

The level and structure of industrial production are important determinants of economic activity and the way it affects the environment. Industrial activities generate pressures on the environment. These include direct pressures, such as emission of pollutants, production of hazardous waste and consumption of natural resources in production processes, as well as indirect pressures through the subsequent consumption and use of industrial products.

In EU Member States the value added by industry at present contributes about 30% to the total national production (GDP) (OECD, 1996). Table 2.8 indicates the shares of industrial production in various European countries.

Table 2.7: Share of industrial production in relation to GDP (1994)

Country	Percent	Country	Percent
Austria	34	Luxembourg	34
Belgium	28	Netherlands	27
Denmark	24	Portugal	37
Finland	28	Spain	34
France	27	Sweden	27
Germany	34	United Kingdom	28
Greece	22	Average EU15	30
Ireland	35	Norway	35
Italy	32	Poland	32

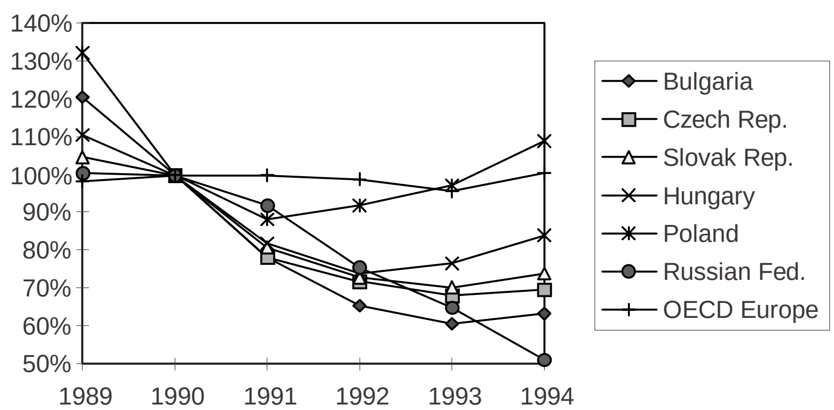
(Source: OECD, 1996)

Average economic growth in EU countries between 1989 and 1994 has been around 8% (growth of GDP in constant prices). In the same period growth of industrial production has been around 2.5%, indicating a relative stagnation and a decline of industrial production in relation to other sectors of national economies (OECD, 1996).

Trend analysis in Eastern European countries indicates that industrial activity slowed down considerably in 1990 and 1991 at the peak of the political and economic crisis. Industrial production returned to growth in Poland in 1992, in Bulgaria in 1993, and in Hungary and the Czech and Slovak republics by 1994.

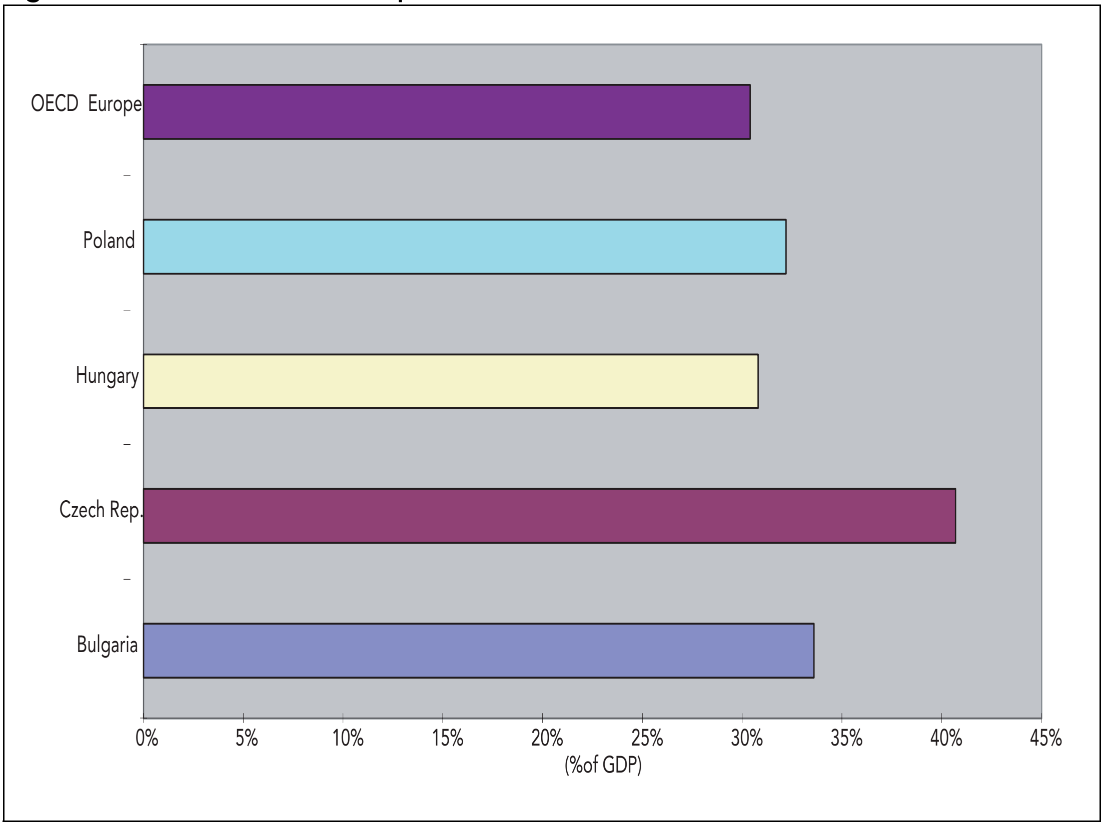
Figures 2.9 and 2.10 present respectively the evolution in industrial production over the last five years and the share of value added in the industrial sector in 1994.

Figure 2.9: Trend in Industrial Production (1990=100)



(Source: OECD, 1996)

Figure 2.10: Share of industrial production



Note: OECD Europe includes all European member countries of the OECD as of 1994, i.e. Austria, Belgium, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, Turkey and United Kingdom.

(Source: OECD, 1996)

In all these countries, the importance of the industrial sector in the economy is above the average of the full set of OECD countries.

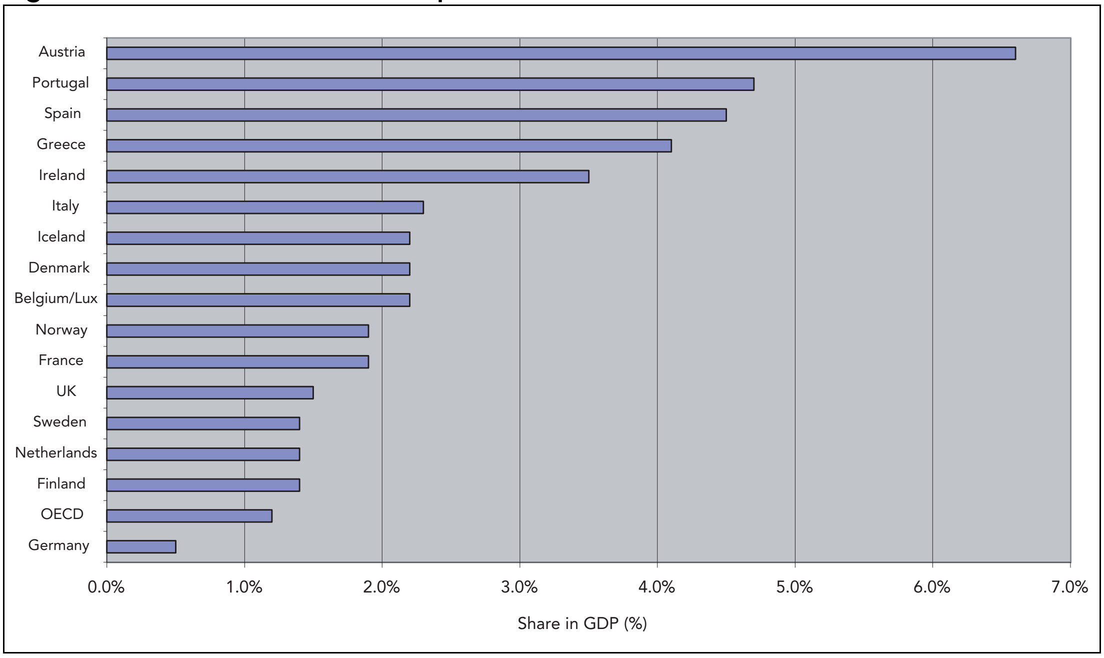
2.4. Tourism

Tourism is also an important Driving Force as seasonal increases in population, often during periods of minimum or low water resource renewal, create pressures on water resources through direct consumptive use and through the supply of leisure facilities for the tourists.

Over the last 40 years mass tourism has developed into an important branch of national economies. At present, income through tourism accounts for about 1.2% of the total GDP in OECD countries. In countries with a strong tourist sector this share may rise to over 4% (Greece, Portugal, Spain) and even reach close to 7% (Austria). Figure 2.11 represents the share of tourism receipts as a percentage of GDP in various European countries.

The largest number of arrivals at frontiers in the European Union is in France with 61 million arrivals per year, followed by Italy with 52 millions and Spain with 43 millions (OECD, 1996, data: 1994).

Figure 2.11: Share of tourism receipts in GPD



(Source: OECD, 1996)

The trend in tourist activities has in general been upwards, following increasing economic wealth, rising living standards and reduced costs of transport. During the period 1993-94 total expenditure on tourism increased by almost 7%.

Tourism affects the environment in many ways. Increased transport consumes resources and causes pollution and noise. The influence of great masses of people can have severe consequences for environmentally sensitive areas and natural wildlife and habitats. Insufficiently controlled urban planning and massive construction of apartment blocks and hotels is a common feature in many parts of the Mediterranean shoreline.

Tourism has a natural tendency to be in "good weather areas", which frequently means regions with limited availability of water resources. For example in Spain the major part of tourism is directed to the Eastern and Southern coast, regions which already suffer from stress on water resources.

However tourism not only affects the coast. In the Alps, tourism puts considerable pressure on water resources. The Austrian and German Alpine associations together have more than 750 refuges and lodges in the Austrian Alps, giving rise annually to about 1 million overnight stays. A further 1.5 million day visitors and about 2000 full-time staff are to be added to these figures. There are in addition 300 lodges belonging to other associations.

Another characteristic feature of tourism is distinctive seasonal variations, frequently with marked peaks in the main holiday periods (Easter, Summer, Christmas/New Year) and a much reduced activity during the rest of the year. This causes considerable problems with regard to resource consumption (peak water demand during the dry season) and pollution (dimensioning and operation of sewage systems and treatment plants for peak and off-peak activity rates).

Consumption of water by tourists is nearly two times higher than for local consumers. Also tourists require large volumes of water for recreation such as for swimming pools, water parks, golf courses (the need for maintaining a golf course is around 10,000 m^3 /year per hectare, the same as for well irrigated schemes), and other activities. The largest proportion of water is not consumed but used and disposed of as waste. The result is large volumes of sewage discharged to sewage treatment plants, to the sea or to rivers. In all cases, if water is not treated, recycled or disposed of properly, it will cause pollution. For example, the total waste water load generated by tourism in the Alps (Austria) has been estimated at 430,000 persons equivalents during the holiday season. This increase produces technical and financial problems associated with treating fluctuating discharges at low temperatures. Especially in karstic formations the discharge of sewage represents a threat to drinking water supplies.

In future it can be expected that tourism and the movement of people in Europe will continue to grow, in line with rising living standards and further international integration. However, it should be considered that future destinations for mass tourism may not necessarily coincide with present destinations.

3. Pressures on water use

The previous chapter has outlined the main societal Driving Forces (Agriculture, Population, Industry and Tourism) and how they are changing with time. The resulting Pressures on Europe's Water Resources are described in more detail in this chapter.

3.1. Water abstraction

3.1.1. Total abstraction

Quite a number of programmes and initiatives deal with environmental issues in Europe in general and with water in particular. Among the studies available, Europe's Environment: the Dobris Assessment (EEA, 1995) and Europe's Environment: The Second Assessment (EEA, 1998), constitute major milestones for further work relating to the environment in Europe. Also a variety of studies promoted by the various Directorate Generals of the European Commission, the Joint Research Centre and the European Commission's Environment Water Task Force, as well as publications of Eurostat, OECD, FAO, United Nations, World Bank and several non-governmental organisations (e.g. World Resources Institute, Worldwatch Institute) offer information on environmental issues.

When analysing and comparing the information on abstraction and use of water in different countries the data from different sources often do not correspond. Although data are normally consistent there are also numerous cases in which the information given is clearly contradictory.

These differences seem to be due mainly to different definitions of the concepts analysed. For example, different approaches exist in the definition of urban water use, also described as Public Water Supply (PWS), with regards to the inclusion of municipal water use and of industries supplied through the urban network. Similarly the definition of industrial use may vary between countries, for example by including in the industrial share the use of cooling water for thermal and nuclear power plants and the water used for hydroelectric power production.

Also the various concepts used to describe water volumes at different stages of the water cycle require careful differentiation. **Water demand** is the need for water. **Abstraction** is commonly defined as the total volume extracted from the natural water cycle for human use. **Supply** in contrast is that portion of total abstraction that is delivered to users, after discounting losses in storage, conveyance and distribution. **Consumption** refers to the part of supply that in terms of water measurement remains with users: some evaporates, while the remainder is reintroduced into the natural cycle through discharges, rivers, lakes and aquifers.

In this report, the concepts of **water demand** and **water abstraction** have been used **synonymously**, even if they are not strictly the same.

Although within the technical and scientific community general agreement on definitions and concepts exists, a common approach to set up comparable water quantity records at a European level is necessary. Also the establishment of a consistent methodology to determine environmental (ecological) water demand would improve the evaluation of water use and water requirements.

In any case the disparities often observed indicate that different conceptual approaches have been followed in establishing the respective records in the countries analysed. In spite of these obstacles a comparison of water abstraction and uses in different European countries is presented in the following text. The references that have been consulted and used are:

- European Environment Agency (EEA), 1995, Europe's Environment - The Dobris Assessment.
- Eurostat, 1995, Europe's Environment - Statistical Compendium for the Dobris Assessment.

- Eurostat, 1997, Estimation of renewable water resources in the European Union - Final report.
- European Commission Environment Water Task Force - Working document presented at the validation workshop on water research priorities for Europe, June 1997.
- FAO, 1995, Yearbook 1994 - Production, Vol. 48.
- FAO, 1997, World Wide Web - Database.
- Organisation for Economic Co-operation and Development (OECD), 1997, OECD Environmental Data Compendium 1997 (DRAFT), OECD, Paris.
- Organisation for Economic Co-operation and Development, 1996, OECD in Figures - Statistics on the Member countries.
- World Resources Institute (WRI), 1992, World resources 1992/93: A guide to global environment.
- ETC/IW questionnaire "Sustainable use of water in Europe", 1997.

In all cases the most recent information available from these references has been used in this report.

Data on total water abstraction comprising consumptive and non consumptive water uses in the various countries are given in Table 3.1. Data are taken from the Dobris Assessment (EEA, 1995), the above mentioned working document of the EC Environment Water Task Force (1997), the OECD (1997) and a questionnaire issued and evaluated by the European Topic Centre on Inland Waters (1997).

Table 3.1: Total water abstraction

Country	Total abstraction (10^6 m³ /year)					Abstraction per capita (m³ /inhab/year)
	Total population 1996 (1000inhab.)	Dobris 1986/1993 [1]	Task Force 1980/ 1995 [1]	OECD, 1997 1995	ETC-IW [2] questionnaire, 1997 1995	Based on [2] ETC/IW, 1997
Austria	8 106	2 120	2 630	2 250	2 360	291
Belgium	10 116	9 200	9 030	9 029	7 015	693
Denmark	5 237	1 200	4 860	900	916	175
Finland	5 126	3 001	6 353	2 437	3 345	653
France	58 333	37 730	37 731	40 641	40 641*	697
Germany	81 922	58 852	49 000	46 273	58 862	718
Greece	10 490	6 945	9 425	5 040	5 040	480
Ireland	3 554	793	997	1 176	1 212	341
Italy	57 226	56 200	44 972	56 200	56 200	982
Luxembourg	398	59	92	57	57*	143
Netherlands	15 575	14 481	11 196	7 806	12 676	814
Portugal	9 808	7 288	10 849	7 288	7 288*	743
Spain	39 674	36 900	37 092	33 289	35 323	890
Sweden	8 819	2 932	11 588	2 725	2 709	307
United Kingdom	58 368	14 237	13 754	11 751	12 117	208
Total EU15	372 752	251 938	249 569	226 772	245 761	659 average

(Table 3.1: Continued)

Norway	4 348	2 025	2 025	2 025	466
Iceland	271	100	164	164	605
Liechtenstein	28			9	321
Cyprus	756	380			
Estonia		3 300			
Hungary	10 709	6 263	6 259		623
Poland	38 500	15 097	12 066		313
Slovenia	1 892	495			

(1) Range of years included in dataset
(2) Data from France, Greece, Luxembourg and Portugal are not available from ETC/IW questionnaire, OECD data have been adopted.

As can be seen total water abstraction in the European Union amounts to about 250,000 million m³/year according to the sources considered. A comparison between the different sources shows that in most cases the records on total water abstraction are more or less similar, except for several examples where clear conceptual differences between the datasets used appear to exist (e.g. Denmark, Finland and Sweden). The average abstraction in the EU15 countries is 659 m³/person/year though there are large variations between countries.

The principal source of abstracted freshwater in Europe is surface water with the remainder coming from groundwater sources and with only minor contributions from desalination of seawater (in Spain).

Groundwater sources have historically provided a local and least-cost source of drinking water for public supply and private domestic supply. Of the total water abstracted in the EU about 22% (OECD, 1997) is taken from groundwater (29% according to EEA, 1995). Table 3.2 presents an overview of groundwater abstraction in various countries.

Table 3.2: Share of groundwater in total abstraction

Country	Groundwater abstraction in relation to total abstraction (%)		Country	Groundwater abstraction in relation to total abstraction (%)	
	OECD, 1997 (1991/1993)	EEA, 1995 1990 (1)		OECD, 1997 (1991/1993)	EEA, 1995 1990 (1)
Austria	34	53	Spain	9	15
Belgium	9	9	Sweden	20	20
Denmark	25	99	United Kingdom (E & W)	19	19
Finland	10	8	Average EU15	22	29
France	16	16			
Germany	13	13	Iceland	91	95
Greece	26	28			
Ireland	19	31	Czech Rep.	18	
Italy	23		Estonia		15
Luxembourg	46	46	Hungary	16	16
Netherlands	13	7	Poland	16	16
Portugal	42	42	Slovenia		22

(1) Mostly 1990 data but also some from 1980

(Sources: OECD, 1997 and EEA, 1995)

The relative portions of abstracted surface and ground water vary considerably between the countries, depending on the natural conditions and the characteristics of water uses in each country. In countries with extensive aquifers (e.g. Iceland, Denmark and Austria) a major part of total abstractions comes from these sources, compared with less than 10% in Belgium, the

Netherlands and Finland.

Table 3.3 shows the apportionment of **public water supplies** (not total water abstracted as given in Table 3.2) in Europe between the two primary sources, groundwater and surface waters.

Table 3.3: Apportionment of public water supply between groundwaters and surface waters (Eurostat 1997a, and ETC/IW 1998a ^)

	Surface water	Groundwater		Surface water	Groundwater
Austria	0.7 [3]	99.3	Portugal	20.1 [0]	79.9
Belgium - Brussels	100.0	0	Spain	77.4 * [5]	21.4 *
- Flanders	48.5	51.5			
Denmark	0.0 [5]	100.0	Sweden	51.0 [4]	49.0
Finland	44.4 [4]	55.6	United Kingdom	72.6 [4]	27.4
France	43.6 [3]	56.4			
Germany	28.0 [1]	72.0	Norway	87.0 [3]	13.0
Greece	50.0 ^	50.0	Iceland	15.9 [5]	84.1
Ireland	50.0 [4]	50.0	Liechtenstein	Ni	
Italy	19.7 ^	80.3	Switzerland	17.4 [4]	82.6
Luxembourg	31.0 [5]	69.0	Czech Rep.	56.0[5]	44.0[5]
Netherlands	31.8 [5]	68.2			

Notes:
* Other public supply water sources amounting to 1.2% of total
^ For supplies greater than 5000 persons (ETC/IW 1998a)
0 = 1990 1 = 1991 3 = 1993 4 = 1994 5 = 1995

In Austria, Denmark, Portugal, Iceland and Switzerland over 75% of the water for **public water supply** is abstracted from groundwater, between 50-75% in Belgium (Flanders), Finland, France, Germany, Ireland, Luxembourg and the Netherlands, and less than 50% in Norway, Spain, Sweden, United Kingdom, Belgium (Brussels) and Czech Republic (Eurostat, 1997). As groundwater is generally of superior quality to surface water and requires less treatment, groundwater reserves are increasingly being exploited in preference to surface water sources. In many parts of Europe this has led to over-abstraction and a lowering of the groundwater table resulting in the drying up of spring fed rivers, destruction of wetlands and, in coastal areas, saline intrusion of aquifers. (See ETC/IW 1998b for further details).

3.1.2. Trends in total water abstraction

The analysis of trends in the total abstraction of freshwater in Europe should take into account the important differences between data derived from different sources. Also particular climatic conditions over a given period (humid or dry years) can erroneously suggest general upward or downward trends which in reality may only be transitory.

Given the variety of phenomena observed it is, therefore, very difficult to identify a general trend in freshwater abstraction on a European scale. Figure 3.1 indicates the evolution of total freshwater abstraction in European countries as a percentage of the 1980 values, taking as reference the data given in the OECD Environmental Data Compendium (1997).

Looking at the different European regions (Figures 3.2 to 3.4), it appears that in most countries of Western and Northern Europe total water abstraction has been relatively stable, with a possible downward trend in Denmark, Finland, Sweden and the United Kingdom (Figure 3.2). It appears that in these countries a series of droughts in recent years has increased public awareness that water is a finite resource. The apparent downturn can also be attributed to a shift in management strategies, moving towards demand management strategies, reducing losses, using water more efficiently and recycling.

In Eastern Europe, the political upheavals of 1989-1990 and the change from centralised to a market based economies help to explain the decline in the amount of water used in the Czech and Slovak Republics and in Poland. Total abstractions have been rising in Hungary. In southern European countries it appears that the growth in total water abstraction has been slowing down over recent years. Figure 3.4 shows a relatively stable water abstraction in Italy and Spain and a steady growth in Turkey, probably because of increasing irrigation.

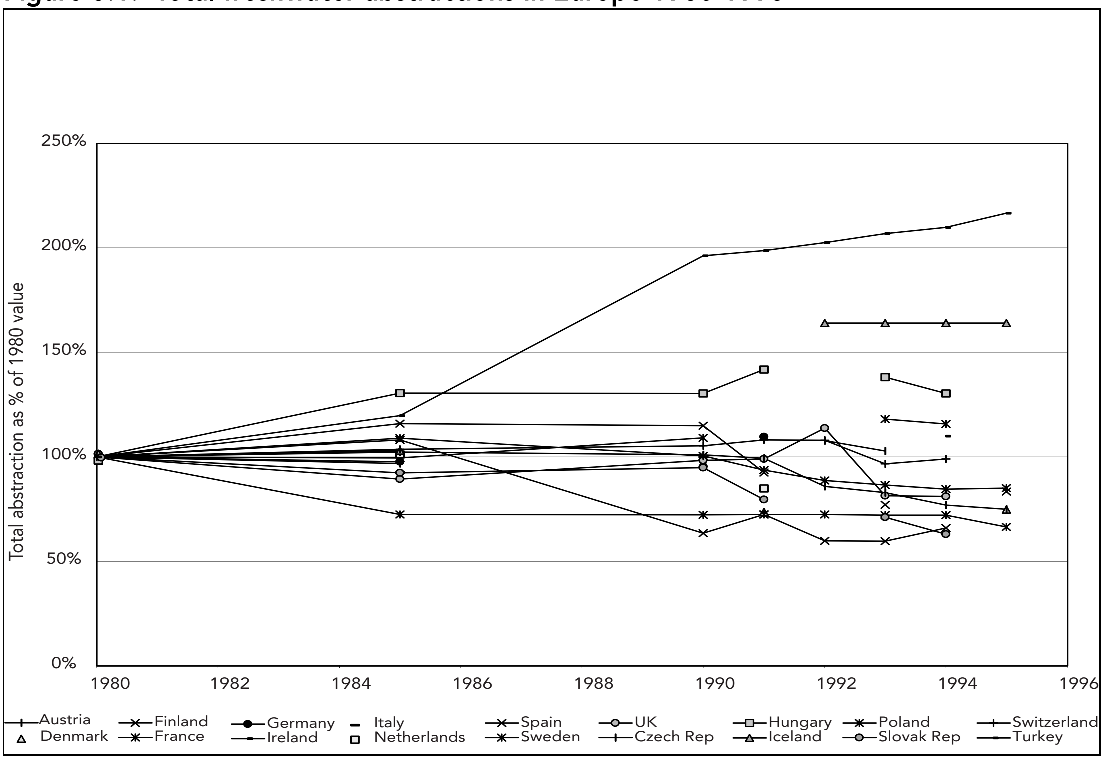
Table 3.4 shows the rates of average annual increase in **total freshwater abstraction** in various European countries during the decades 1970-80 and 1980-90. It can be seen that in Greece, Spain, Italy and France the rates of average annual growth in total water abstraction during the period 1970-80 were close to 5%. In the period 1980-95, however, mean annual trends have been decreasing significantly in France and Germany, and they are below zero in Finland, the Netherlands, Sweden, United Kingdom and Spain.

Table 3.4: Trend in total water abstraction

Country	Mean annual trend in total abstraction (%)		Country	Mean annual trend in total abstraction (%)	
	1970-80	1980-95		1970-80	1980-95
Austria		0.2	Norway	-1.6	
Belgium	-0.5		Portugal		1
Denmark		-1.9	Spain	5.0	-1.2
Finland	1.2	-2.9	Sweden	0.1	-2.7
France	4.1	1.1	United Kingdom	0.2	-1.5
Germany	2.9	0.8			
Greece	5.0		Estonia		0.5
Italy	3.0	0.0	Hungary	4.9	1.9
Luxembourg			Poland	3.4	-1.1
Netherlands	1.1	-1.5			

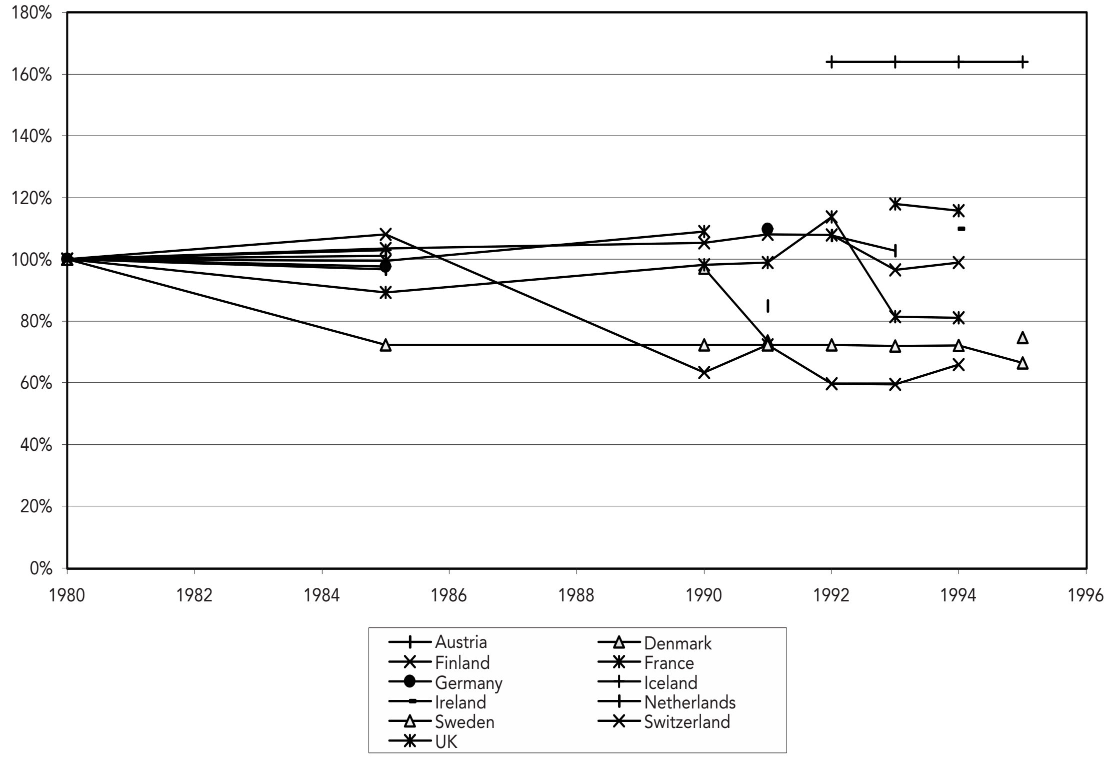
(Source: EEA, 1995, OECD, 1997)

Figure 3.1: Total freshwater abstractions in Europe 1980-1995



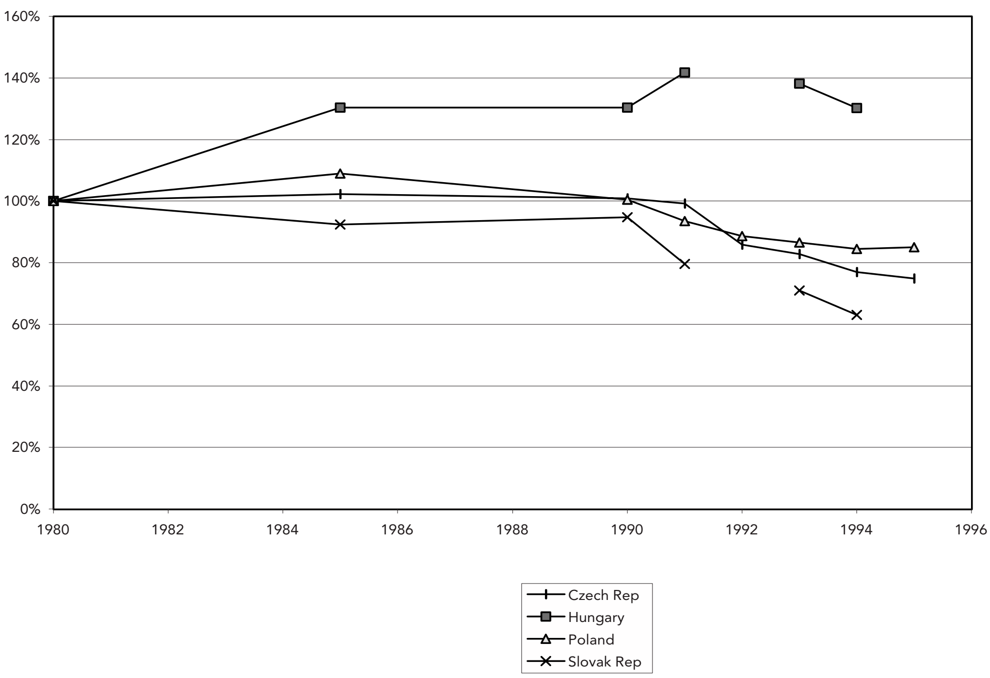
(Source: OECD/Eurostat, 1997)

Figure 3.2: Trend in total freshwater abstractions in Western Europe, Percentage change in relation to 1980 (=100%)



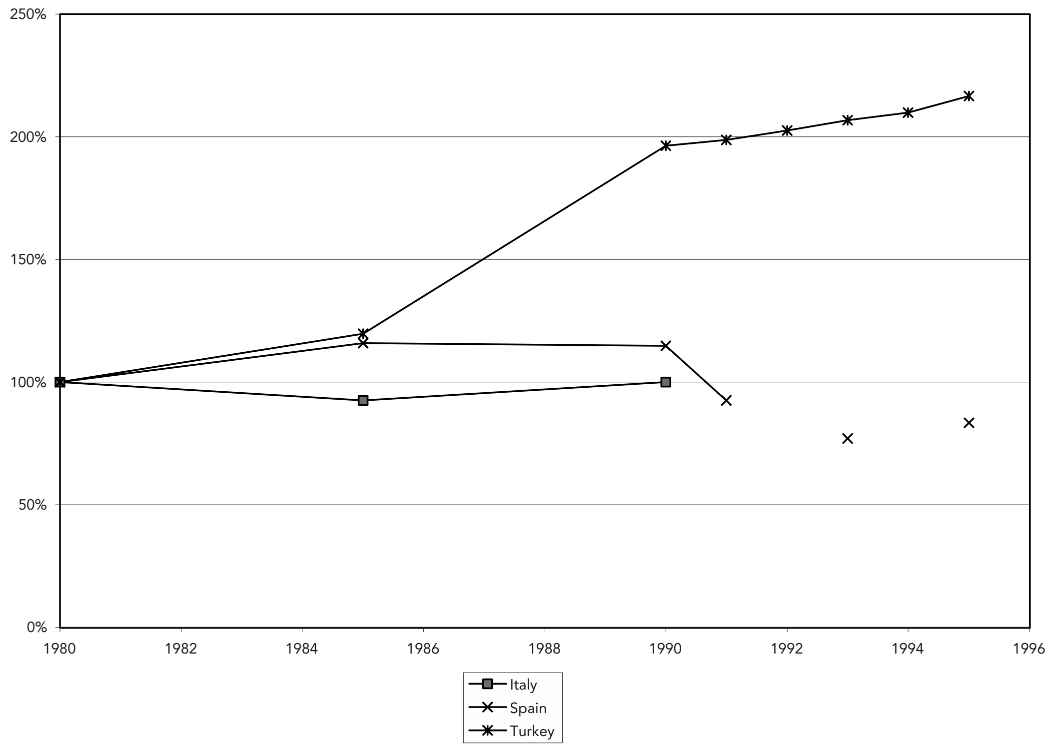
(Source: OECD/Eurostat, 1997)

Figure 3.3: Trend in total freshwater abstractions in Eastern Europe. Percentage change in relation to 1980 (=100%)



(Source: OECD/Eurostat, 1997)

Figure 3.4: Trend in total freshwater abstractions in Southern Europe. Percentage change in relation to 1980 (=100%)



(Source: OECD/Eurostat, 1997)

3.1.3. Sectoral water use

General considerations

A very variable picture appears when analysing the sectoral uses of water as reported by different sources. Table 3.5 shows the percentage use as given in the Dobris Assessment (EEA, 1995), the EC Environment Water Task Force (1997), OECD (1997) and ETC/IW questionnaire (1997). Here use for **energy** is taken to be water used for electricity generation either for cooling purposes or for hydro-power generation.

Table 3.5: Sectoral use of water in Europe

Country	Total Abstraction (Mm³ /y)				Urban %				Industry %				Agriculture %				Energy %			
	1	2	3	4*	1	2	3	4 *	1	2	3	4*	1	2	3	4	1	2	3	4*
Austria	2630	2120	2250	2360	28	19	31.0	33.3	27	73	21.3	20.7	8	8	8.9	8.5	38		38.7	37.5
Belgium	9030	9200	..	7015	11	11	..	10.6	25	85	..	3.0	4	4	..	0.2	65		..	73.4
Denmark	4860	1200	887	916	13	30	53.0	49.0	8	27	9.0	9.0	8	43	15.8	38.2	72		..	..
Finland	6353	3001	2437	3345	7	12	17.2	12.6	25	85	66.4	33.2	0	2	0.9	2.4	68		15.4	50.5
France	37731	37730	40641	40641	16	16	14.6	14.6	12	69	9.7	9.7	13	15	12.1	12.1	59		63.5	63.5
Germany	49000	58852	46272	58852	13	11	14.1	6.5	25	85	23.7	11.0	3	4	..	3.1	59		62.2	28.8
Greece	9425	6945	5040	5040	8	8	12.2	12.2	1	29	2.7	2.7	56	63	82.5	82.5	35		1.8	1.8
Ireland	997	793	1176	1212	47	10	40.0	38.8	25	74	21.3	20.6	0	16	15.2	14.8	28		25.9	22.8
Italy	44972	56200	56200	56200	18	14	14.2	14.2	17	27	14.2	14.2	46	59	57.3	57.3	20		12.5	12.5
Luxembourg	92	59	57	57	46	52	58.9	58.9	30	45	24.5	24.5	0	2	0.4	0.4	24		..	..
Netherlands	11196	14481	7806	12676	11	5	8.0	8.0	12	61	4.0	4.0	30	34	1.0	1.0	46		87.0	87.0
Portugal	10849	7288	7288	7288	9	15	7.9	7.9	7	37	3.3	3.3	79	48	52.6	52.6	4		36.8	36.8
Spain	37092	36900	33288	35323	12	12	12.9	13.2	5	26	5.6	4.6	65	62	72.4	68.2	18		9.0	13.9
Sweden	11588	2932	2725	2709	8	36	35.0	34.6	15	56	27.7	54.6	1	9	3.9	6.4	76		2.5	2.6
United Kingdom	13754	14237	9342	12117	49	52	65.4	52.3	17	47	5.5	7.0	1	1	1.6	14.2	33		2.8	14.2
Total EU	249569	251938	215410	245761																
Liechtenstein				9			..	64.4			..	35.6			..	..			..	..
Iceland		100	164	164		31	50.0	50.0		63	6.1	6.1		6	..	..			..	..
Norway		2025	2025	2025		20	26.6	26.6		72	68.1	68.1		7	3.4	3.4			..	..
Switzerland		1166	2665	2595		23	42.1	..		73	..	..		4					57.9	..

1 Task Force 2 Dobris 3 OECD 4 ETC/IW

(Source: Different sources. Data from France, Greece, Luxembourg and Portugal are not available from ETC/IW questionnaire, OECD data have been adopted)

As it can be seen there are some significant differences in the sectoral uses from the various information sources. Also the sum of the different percentage sectoral uses does not necessarily add up to 100% for each country. This is illustrated in Table 3.6 where the statistics made available for the ETC/IW (column 4 in Table 3.5) are summed and the percentage deficits or surpluses (in terms of accounting for all the water abstracted) are given. As pointed out above these differences and shortfalls can be attributed to different definitions of the concepts analysed. For example, different approaches exist with regards to the inclusion of municipal water use and of industries supplied through the urban network in the records of public water supply (PWS). Similarly the definition of industrial use may vary in relation to the inclusion or otherwise of cooling water for thermal and nuclear power plants or hydroelectric power production. This again demonstrates the **urgent need** for a common approach to quantify water resources at a European level.

Table 3.6: Sum of sectoral uses of freshwater as reported to the ETC/IW, 1997

Country	Sum of colmn 4 values (1)	Deficit	Country	Sum of colmn 4 values (1)	Deficit Surplus (+)
Austria	100	0	Luxembourg	83.8	16.2
Belgium	87.2	12.8	Netherlands	100	0
Denmark	96.2	3.8	Portugal	100.6	+0.6
Finland	98.7	1.3	Spain	99.9	0.1
France	99.9	0.1	Sweden	98.2	1.8
Germany	49.4	50.6	United Kingdom	87.7	12.3
Greece	99.2	0.8	Liechtenstein	100	0
Ireland	97.0	3.0	Iceland	62.1	37.9
Italy	98.2	1.8	Norway	98.1	1.9

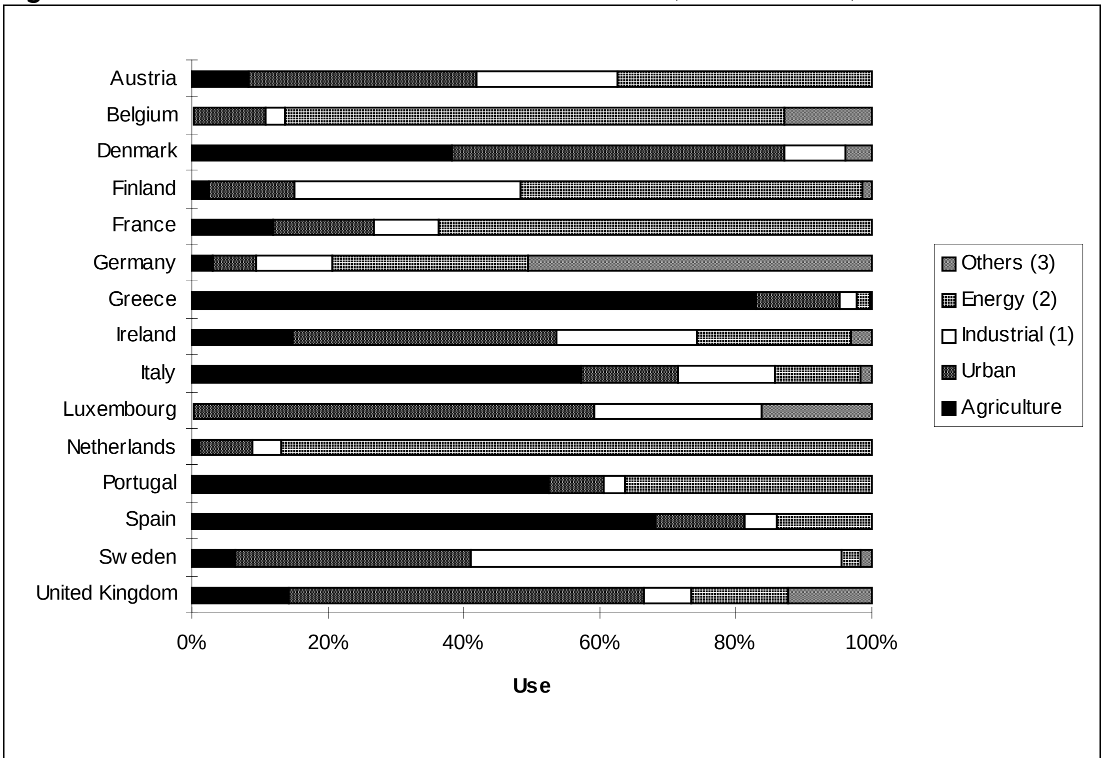
(1) Sum of Urban, Industry, Agriculture and Energy use as given in Table 3.5, column 4

Using the figures reported to the ETC/IW (column 4 in Table 3.5), the average percentage uses of the total abstracted freshwater in Europe are:

- urban water demand 14.1%;
- agriculture 30.1%;
- industry 10.4%, cooling water excluded;
- water for electricity produces (energy) 31.8%; and,
- other miscellaneous or non-defined uses 13.6%.

The proportional use across the 5 sectors in each of the EU15 countries is illustrated in Figure 3.5.

Figure 3.5: Sectoral use of water in EU15 countries (ETC/IW, 1997)



(1) Excluding water for cooling
(2) Water for electricity generation including cooling water and hydropower
(3) Others – remaining volume of total abstracted water, used for undefined, other uses.

Urban water demand is the dominant user sector in many Western European and Nordic countries, but is of lesser importance in Eastern Europe and the Mediterranean countries. This demand rose steadily from 1980 to 1990 in most countries, driven by rising population, and increases in per-capita consumption as the standard of living improved. It is expected that household use will stabilise or even decline in the future reflecting demographic trends and use of more water-efficient appliances.

Agricultural demand in all countries is dominated by irrigation. In the Mediterranean countries, agriculture is the most important use of abstracted water, accounting for about 80% of total demand in Greece, more than 50% in Italy, 68% in Spain and 52% in Portugal (ETC/IW, 1997). This is in marked contrast to Northern and Eastern European countries where, on average, less than 10% of the resources are used for irrigation. The volume of irrigation water applied depends on climate, the crop being cultivated, the area being irrigated and the method of application.

Industrial use of water varies greatly between countries and comparisons are complicated by the possible inclusion of cooling water. The quantities of water abstracted for cooling are generally far in excess of that used by industrial processes (e.g. 95% of all industrial water use in Hungary is for cooling). However, this is regarded as a "non-consumptive" use as water is generally returned to source unchanged apart from an increase in temperature and some contamination by biocides. In most European countries industrial abstractions have been declining slowly since 1980. In Western Europe this is due, primarily, to economic recession with plant closures in heavy water-using industries such as textiles, iron and steel and a move towards less water intensive service industries. Technological improvements in water using equipment and increased recycling are also contributing to the decline. In Eastern Europe, abstractions have declined due to falling industrial production.

The following sections give a detailed analysis of the specific features and trends of water use observed in the various sectors.

Urban water demand

As already pointed out the share of urban water demand varies considerably between different countries. According to the figures collected by the ETC/IW (1997) the proportion of water for urban use in total abstraction ranges from around 6.5% in Germany to over 50% in the United Kingdom. (Table 3.7).

Table 3.7: Share of urban water abstraction in total abstraction in 1995

Country	Share of water for urban use in total abstraction in 1995		Country	Share of water for urban use in total abstraction in 1995	
	Million m³	%		Million m³	%
Austria	786	33.3	Italy	7 980	14.2
Belgium	744	10.6	Luxembourg	35	58.9
Denmark	449	49	Netherlands	1 014	8.0
Finland	421	12.6	Portugal	576	7.9
France	5 946	14.6	Spain	4 667	13.2
Germany	3 826	6.5	Sweden	937	34.6
Greece	615	12.2	United Kingdom	6 337	52.3
Ireland	470	38.8	EU15	34 803	14.1 (average)

Note information for 1995 or the last year available

(Source: OECD, 1997 and ETC/IW questionnaire, 1997)

Since in most countries water demand for urban use not only includes water demand of households but also industry, agriculture, small businesses, public services and recreational water demand, separate statistics on water use of households are often difficult to obtain. A report of the ICWS (1996) describes the proportion of household use in water demand for urban use for several countries, indicating figures within the range of 30-60% of the total demand of water for urban use (Table 3.8).

Table 3.8: Proportion of households demand in total demand for urban use

Country	Share of household demand in total water demand for urban use(%)
Netherlands	57
Bulgaria	39
Greece: Athens	58
Iraklion	32
United Kingdom	44
Hungary	41

Trends in water demand for urban use and households

Water use of households and small businesses in terms of litres per capita per day show large differences between countries (Table 3.9). Denmark, Germany, Luxembourg and Sweden decreased their consumption whereas between 1980 and 1995 in countries like Austria, Belgium, France, Italy, Norway, Switzerland and especially the Netherlands, there were significant increases over the same period.

Table 3.9: Households and small business use per capita and day

Country	Water consumption (l/capita per day) Households and small business	
	1980	1995
Austria	155	162
Belgium	104	120
Denmark	165	145
France	109	156
Germany	137	132
Italy	211	249
Luxembourg	183	169
Netherlands	142	175
Norway	154	160
Spain	157	n/d
Sweden	195	191
Switzerland	229	237
United Kingdom	154	n/d

(Source: IWSA, 1997)

In Eastern European countries household water use is estimated to be within the range of 150 to 300 l/capita/day (Table 3.10).

Water demand for urban use has increased over the last years (from 1975-1980 to 1990) in the countries covered by the ICWS report, although there are important differences between countries (Table 3.11).

The estimates of future water demand for urban use, over the next 30 years, differ between the countries considered in the ICWS report. Demand is expected to increase further in France, Greece, the Netherlands and the United Kingdom. Stable demand is forecast in Hungary (compared with 1990) and a decrease is expected in Bulgaria and Italy. These trends have been estimated based on assumptions of an increase in population and changes in lifestyle (further penetration of water consuming appliances, changing habits, etc.), increase in water prices (e.g. Bulgaria) as well as growing public awareness leading to a more economic water use.

Table 3.10: Households water use in Eastern European countries

Countries	Households use per capita (l/cap/day)
Bulgaria	116
Croatia	350 (1)
	140 (2)
Czech Republic	150
Hungary	180
Poland	203 (1)
	51 (2)
Romania	240
Slovak Republic	179
Moldova	300
Russian Federation	260 (1)
	93 (2)
Ukraine	330

(1) in urban areas
(2) in rural areas

(Source: WSSCC, 1995)

Table 3.11: Evolution of water consumption in households (l/capita/day)

Country	1970	1975	1980	1990	1975-90 increase	2000	2020
Bulgaria	200	208	215	217	5%	171	181
France		127	135	157	24%	180	192
The Netherlands	97	108	118	131	22%	143	153
United Kingdom (England and Wales)	108	116	123	147	27%	155	178

(Source: ICWS, 1996)

The ICWS report provides past trends and forecasts of household use per capita for Bulgaria, France, the Netherlands and the United Kingdom. In all these countries households use has increased by about 25% between the 1970s and 1990, except Bulgaria with 5%, and is expected to increase further, but at a lower rate, again with the exception of Bulgaria where forecasts predict a decrease.

Comparison of household water use in urban and rural areas

Analysis of household use in eight geographical areas in France shows an overall increase in both urban and rural areas from 1975 to 1990 with water use in rural areas being about 13% lower than in urban areas. However, the increase has been greater for the rural population (+30% between 1975 and 1990) than for the urban population (+24% over the same period), due to the increase in the number of domestic equipment and changes in dwelling types. Differences in household water use are also observed between regions. From 1975 to 1990, water use in Northern France showed the highest increase (+34%) but remained the lowest numerically (32.7 and 43.2 m^3 /inh/year respectively) in comparison with other French regions. In contrast the Mediterranean area is characterised by the greatest household water use (61.4 and 73.8 m^3 /inh/year respectively) with an increase of 19% over the same period (FNDAE 1993).

Analysis of the evolution of water demand for urban use and household water use

There are different factors which have some influence on the evolution of the habits of consumers: tariff systems, prices, water availability, public campaigns, increase or decrease of the population, evolution of the industrial sector and others. Nevertheless, the increase in public water supply is mainly explained by the increase in domestic water use, resulting from the increase in population and the modification of living standards (new equipment such as washing machines, more attention being paid to hygiene, garden watering, etc.).

The evolution of household water use in the Netherlands, and in the south and east of the United Kingdom, indicates that the use of water for the washing clothes and dishes, and for flushing toilets, was roughly stable between the mid 1970s and the 1990s. It is expected to remain at the same level for the next years. The main increases in the past and expected in the future relate to water use for showers and baths (+30/40% between 1975 and 1990 and +30% between 1990-2020) and for gardens and lawns (+ 425% and 152% respectively for south and east of the United Kingdom). In Barcelona, Spain, the water used per inhabitant decreased from 74.4 m^3 /year in 1987 to 70.6 m^3 /year in 1996, nevertheless the household use increased from 59.2% of the total water used to 65.1% for the same period.

The analysis of water demand in France from 1981 to 1993 shows a progressive increase in urban water demand (including domestic, collective and commercial demand) from 1981-1989, due to the increase in domestic use per capita, population size and movement of population to peri-urban areas (individual houses with garden). However, after the increase in the volume of municipal abstraction in France from 42 billion m^3 /year in 1975 to 62 billion m^3 /year in 1989, abstractions decreased to 60 in 1993. The key factors explaining this reduction are the:

- widespread use of more efficient appliances in domestic and collective locations (push button taps, low flush volume toilets, rationalisation of municipal uses such as street cleaning or park watering, etc.);
- reduction of network losses;
- possible levelling off of domestic use per capita due to increased public awareness, increase in water prices); and,
- economic recession affecting small businesses.

Water use in industry

Industrial water use excluding cooling accounts for about 10.4% of total water abstraction in the countries considered in this study. The use of cooling water for power generation and hydro-power is estimated to be around 31.8% of total abstraction. Table 3.12 gives the respective shares in EU15.

Table 3.12: Share of industrial water use in total abstraction

Country	Industrial water use (excluding cooling)		Country	Cooling for power generation and hydropower*	
	Million m³	%		Million m³	%
Austria	489	20.7	Austria	885	37.5
Belgium	210	3.0	Belgium	5 149	73.4
Denmark	82	9.0	Denmark	0	0
Finland	1 111	33.2	Finland	1 690	50.5
France	3 942	9.7	France	25 835	63.5
Germany	6 475	11.0	Germany	16 952	28.8
Greece	136	2.7	Greece	91	1.8
Ireland	250	20.6	Ireland	277	22.8
Italy	7 980	14.2	Italy	7 025	12.5
Luxembourg	14	24.5	Luxembourg	0	0
Netherlands	507	4.0	Netherlands	11 028	87.0
Portugal	241	3.3	Portugal	2 682	36.8
Spain	1 647	4.6	Spain	4 915	13.9
Sweden	1 479	54.6	Sweden	70	2.6
United Kingdom	848	7.0	United Kingdom	1 721	14.2
Total EU15	25 411	10.4 (average)	Total EU15	111 612	31.8 (average)

(Source: ETC/IW, 1997)

* Includes cooling water for power plants and hydroelectric power use. The water can be used again several times downstream

In many European countries (e.g. Denmark, France and the United Kingdom), industrial water demand has been decreasing through the 1980s and 1990s. In France, abstractions fell from 5107 Million m^3/year to 3942 Million m^3/year between 1985 and 1995. A variety of possible reasons help to explain this trend, some of which are directly related to efficiency improvements while others refer to external factors influencing industrial activity:

- economic climate: impact on water use especially where closures of major water-consuming industries have occurred (e.g. the coal and steel industry in the north-eastern part of France);
- stricter controls and charges on effluents encourage industries to reduce the volume of effluents (reducing total water use as a means to reduce pollution);
- legislation which affects water use: for example in the plastic transformation industry closed circuits are now compulsory for all new factories (Arrête, 1993).
- policies of individual companies and industries aiming to reduce water costs (which in some regions have increased significantly over the past decade) and to present an environmentally-friendly image;
- availability of new technologies with lower water requirements.

In parallel to the general decreasing trend, it has been observed that demand for better quality and a greater variety of products may increase water requirements in certain industrial sectors (e.g. more colours in the textile industry, greater variety and different qualities of paper products, larger numbers of chemical products).

In Germany power generation uses 28.8 billion m^3 of water per year and is the largest water user, followed by the manufacturing sector which uses 11 billion m^3, including 2.9 billion m^3 of groundwater (statistics of the Federal Statistics Office).

Because of the limited availability of data and the variety of sectors and products considered it is extremely difficult to evaluate efficiency of industrial water use. One possible means of measuring water use efficiency is to calculate the specific water use per unit of product generated.

$$\text{Specific water use (product)} = \frac{\text{Feed water volume}}{\text{Product (measured in tonnes, litres or other units)}}$$

Data are available for example for dairy products (water required per litre of milk produced) or for paper (water required per tonne of paper produced). In some cases, it is more appropriate to measure the specific water use in terms of certain raw materials, because of the difficulty of providing a simple measure of products. This is the case with abattoirs (water required per carcass processed) or many food processing industries.

$$\text{Specific water use (input)} = \frac{\text{Feed water volume}}{\text{Input (measured in tonnes, litres or other units)}}$$

In either case, the industrial processes considered (inputs and end products) must be similar, if meaningful comparisons are to be obtained. For example, a comparison of specific water use in sugar factories using pre-washed beet and unwashed beet would give distorted results. In many cases economies of scale are observed for different-sized factories applying identical processes.

Detailed surveys are therefore required to determine average values of specific water use. As data are more readily available on factories that have taken steps towards reducing their water demand, there tends to be more information about more recent uses of water. The following products and units of measure have been chosen for comparison of industrial water use in different European countries.

Product	**Observation**
1 litre of beer	
1 litre of milk	Water used in milk factories (excludes water use of farms and consumption of animals)
1 kg of cloth	
1 kg of paper	Volume of water used to make paper from dry pulp (water used to produce pulp is not included)
1 kg of steel	Steel production from the delivered ore to the raw steel product (does not include water used in ore production nor water used for making special steels or for surface treatment of steel
1 kg of sugar	Water used to wash beet not included (washing is often done before the beet reaches the sugar factory)

Table 3.13 provides data on specific water uses obtained for various products in different countries.

Table 3.13: Specific water use of industrial production

Country	Water used to produce:					
	1 litre of beer	1 litre of milk	1 kg of cloth	1 kg of paper	1 kg of steel	1 kg of sugar
Austria	10	5	N/d	150 (4)	15	15
Denmark	3.4					
France	25	1 to 4	N/d	250 to 500	300 to 600	21 to 35
Ireland	8				4-5	
Norway	10	1 to 1.5	130 (all kinds)	20	30	n/d
Spain	6 to 9	1 to 5	8 to 20 (wool)	250	30	3.5 to 5
Sweden	3 to 5	1.3	40 – 50	20	0.6 to 5.3	0.5
United Kingdom	6.5 (1)	2.9	6-300 (2)	15-30	100	1.5 (3)

Notes:

(1) Estimated range of water use 2-10 litres
(2) Depends on the type of cloth and on the dyeing process
(3) Estimated range 0.7-6 litres
(4 Printing paper

(Source: ETC-IW, 1997)

The data given tend to be rather different depending on the institution issuing them. They should therefore be treated with extreme caution, keeping in mind the great diversity of industrial processes and the variety of input and product specifications.

Another way of evaluating the effectiveness of water use in different industrial processes is to relate the volumes of water used with the output of the respective sectors in monetary terms. In a detailed study this comparison could be made for different branches and products, obtaining values for the productivity of water in different industrial applications.

In this present study the average productivity of water in industry has been determined by calculating the ratio between national industrial production and industrial water use. It has to be understood that this approach is extremely general, disregarding not only the extreme variations of water productivity between different branches but also the impact of different industrial uses on water quality. Also considerable uncertainty exists as regards the volume of industrial water used in various countries. Nonetheless the comparison could be useful in evaluating in general terms the way in which industries in various countries utilise aquatic resources.

The volume of industrial water use in the EU amounts to about 25 billion m^3 /year (ETC/IW, 1997). With a total industrial production of around 2 600 billion US$/year an average productivity of approximately 100 US$/$m^3$ results. Efficiency of industrial use of water shows large variation across Europe (Table 3.14) ranging from highly efficient use in Denmark to poorly efficient use in Finland, Italy and Sweden.

Considering the limitations of the methodology applied and the possible distortions of the data used described above, the data should be interpreted carefully and be seen above all as indicative reference values, establishing the basis for further investigations.

Table 3.14: Productivity of water use in industry

Country	Industrial production 1994 (in 10^9 US$)	Productivity of water use (in US$/m³)	Country	Industrial production 1994 (in 10^9 US$)	Productivity of water use (in US$/m³ m³)
Austria	81	166	Luxembourg	6	428
Belgium	74	352	Netherlands	107	211
Denmark	41	500	Portugal	38	158
Finland	35	32	Spain	192	117
France	411	104	Sweden	62	42
Germany	828	128	United Kingdom	305	360
Greece	25	184			
Ireland	21	84			
Italy	345	43	Total EU15	2 569	101 (average)

(Source: OECD, 1996 and 1997)

Agricultural water use

On average agriculture accounts for about 30% of total water abstraction in the EU15. In countries where a significant proportion of the total agricultural area is cultivated by means of irrigation this share rises to over 50%. Table 3.15 represents the respective percentages for EU15 countries.

Table 3.15: Share of agricultural water use in total abstraction

Country	Share of agriculture		Country	Share of agriculture	
	Million m³	%		Million m³	%
Austria	201	8.5	Italy	32 203	57.3
Belgium	14	0.2	Luxembourg	0.22	0.4
Denmark	350	38.2	Netherlands	127	1.0
Finland	80	2.4	Portugal	3 833	52.6
France	4 918	12.1	Spain	24 094	68.2
Germany	1 825	3.1	Sweden	173	6.4
Greece	4 183	82.5	United Kingdom	1721	14.2
Ireland	179	14.8			
			EU15	73 901	30.1

Data from 1995 or the latest year available

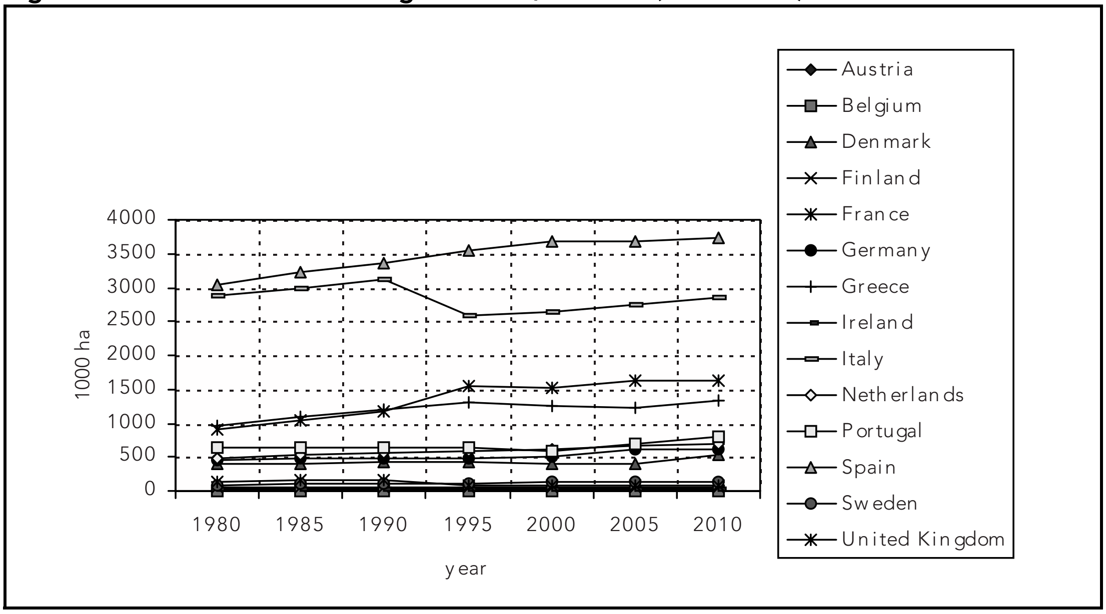
(Source: ETC/IW, 1997)

Over the past decades the trend in agricultural water use has, in general, been upwards, because of increasing irrigation. However, it appears that more recently in several countries the rate of increase of the irrigated area has been diminishing. From 1990, the irrigated area tended to be stable in Austria, Denmark, Finland, Ireland, the Netherlands and Portugal, and there has been a decreasing trend especially in the United Kingdom, Germany and Italy. However, there has been growth in France, Spain and Greece (Figure 3.6).

The intensity of irrigation in different countries obviously varies depending on the climate, the crops cultivated and the farming methods applied. The role of irrigation is completely different in Southern European countries, where it is an essential element of agricultural production, compared to Central and Western Europe, where irrigation is frequently a means to improve production in dry summers. Consequently, the mean water allocation, defined as water supply per irrigated area, varies considerably. Table 3.16 presents the respective values obtained in the EU15 countries, taking as a reference data supplied to the ETC/IW, 1997.

With a total irrigated surface in EU15 of about 11.3 million hectares and a total agricultural water use of around 73 000 million m³ /year the mean water allocation is about 6 500 m³ /ha/ year. As already pointed out the differences between the various countries are considerable, due to different climates, crops and irrigation methods.

Figure 3.6: Evolution of the irrigated land, in EU15 (1980-2010)



(Source: ETC/IW, 1998)

Table 3.16: Mean water allocation per irrigated area

Country	Irrigated area 1993 (in 1000 ha)	Mean water allocation (in m³ /ha/y)
Austria	4	-
Belgium	1	-
Denmark	435	885
Finland	64	1 250
France	1 485	3 312
Germany	475	3 842
Greece	1 314	3 183
Ireland		
Italy	2 710	11 883
Netherlands	560	227
Portugal	630	6 084
Spain	3 453	6 978
Sweden	115	1 504
United Kingdom	108	15 935
EU15	11 354	6 509

(Source: FAO, 1995; ETC/IW, 1997)

3.2. Climate change

Climate change, resulting from global warming, is a global environmental issue identified by the EU as one of the key environmental themes to be tackled under the Fifth Environmental Action Programme. Global warming is expected to take place as a result of increasing amounts of anthropogenic emissions of gases that affect the absorption and emission of radiation in the atmosphere.

The water cycle plays an extremely important role in the climate system, both conditioning the climate and being affected by it. Changes in precipitation can bring about changes not only in run-off magnitude and temporality, but also in frequency and intensity of storms and droughts. Long-term temperature changes undoubtedly cause alterations to evapotranspiration, soil moisture and seepage to the deepest layers. Such changes in the surface water content in turn modify vegetation cover, which initiates a chain reaction, affecting cloud formation, the Earth's albedo and precipitation.

Over the next few decades, climate change may add to the pressures on European water resources. As it is not possible to forecast precisely Europe's future climate, estimates of the potential effect of climate change are derived from a range of reasonable scenarios of the future and on simulations from climate models. According to the second report on scientific evaluation of the Intergovernmental Panel on Climate Change (IPCC, 1996) a temperature increase of 1º C to 3.5º C, which together with an increase in precipitation in Northern Europe and a decrease in Southern Europe, could lead to a reduction in renewable water resources in Southern Europe. Furthermore, a temperature increase could cause snow to melt earlier, increasing winter run-off and reducing the thawing processes in spring and summer. Even in areas where precipitation increases, greater evaporation could lead to lower run-off.

A variation in the risk and intensity of droughts is the most serious negative impact of climate change on water resources in arid and semi-arid regions. A reduction in water availability could lead to desertification in zones where the balance is particularly fragile.

Climate change can have considerable repercussions on the flood regime. The predicted variation in storm magnitude and frequency could give rise to a spectacular increase in run-off in short periods of time, which would aggravate the already catastrophic effects of floods, thus making it necessary to review present techniques for water resources estimation, prevention prediction and management.

Recent research in the United Kingdom simulating run-off (Arnell and King, 1997) under the UK climate scenario (Reynard *et al.*, 1997), suggests that annual rainfall will increase in Northern Europe, temperature will rise everywhere and potential evaporation will increase, resulting in an increase in annual average run-off in Northern Europe and a decrease in the south. The seasonal distribution of run-off will be strongly affected in parts of Eastern and Northern Europe, where the higher temperatures mean that more of the winter precipitation falls as rain, rather than snow, and runs off earlier in the year. In the more maritime parts of Europe, seasonal variation in run-off will increase, with a greater proportion of run-off occurring during the winter period, as winter rainfall increases, summer rainfall declines and evaporation rises. Climate change scenarios from different models show broadly similar changes, although local details differ.

The impacts of these changes will depend very much on local hydrological, ecological and water management conditions. In general, the greater the stress a system is under at present, the more sensitive it will be to climate change.

4. The state of water resources

4.1. The water resource

Freshwater resources are continuously replenished by the natural processes of the hydrological cycle. Precipitation is the primary source of freshwater. Although a relatively small proportion of the World's water, the precipitation that falls on land is still a significant resource, providing more than 110,000 km^3 annually (WRI, 1988). Approximately sixty five percent of precipitation eventually returns to the atmosphere through evapotranspiration; the remaining resource, or run-off, recharges aquifers, streams and lakes as it flows to the sea. In Europe, the average run-off is estimated to be approximately 3,000 km^3/year (equivalent to 6,000 m^3/cap/year) (WRI, 1988; Shiklomanov, 1993). On the continental scale, it would appear that Europe has abundant water resources but, unfortunately, these resources are not evenly distributed. Rainfall and run-off are apportioned in both space and time in a grossly irregular manner (Gleick, 1993). The local demand for water often exceeds the local availability of the resource and problems of water stress and over-exploitation occur frequently in areas of high population density and/or limited precipitation.

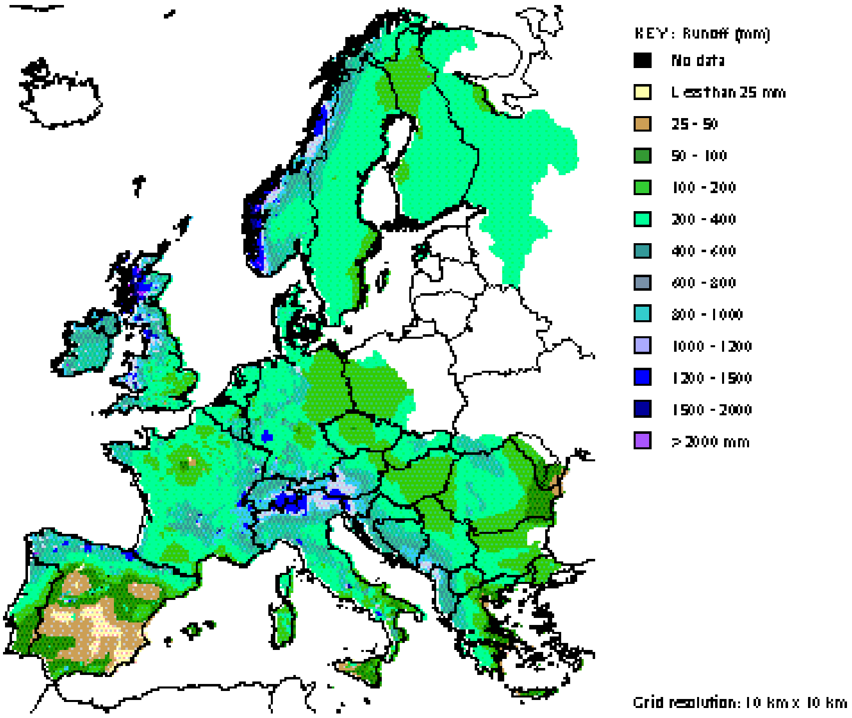
Sustainable use of the freshwater resource can only be assured if the rate of use does not exceed the rate of renewal. Striking this balance requires careful management, a reliable quantitative assessment of the water resource and a thorough understanding of the hydrological regime. The need to monitor the various components of the hydrological cycle has been widely accepted in Europe for many years. Consequently, the region benefits from a relatively dense network of hydrometric (river gauging stations) and meteorological stations having good quality long-term data (WMO, 1987; EEA, 1996). Yet methods for calculating the availability of freshwater resources vary considerably from country to country making comparisons difficult. A recent study commissioned by Eurostat sought to develop a uniform method for calculating renewable freshwater resources at the European Union scale. The method (Rees *et al.*, 1997) advocates the use, wherever possible, of observed river flow data from existing hydrometric networks. In the ungauged areas *not* covered by the hydrometric network, an empirical freshwater balance model, relating run-off to precipitation and potential evaporation, was recommended (Budyko and Zubenok, 1961). Using gauged river flow data available from the FRIEND European Water Archive (Gustard, 1993), together with climatological data supplied by the Climate Research Unit of the University of East Anglia (Hulme *et al.*, 1995), the method was applied to derive a gridded map of long-term average annual run-off at a grid resolution of 10 km by 10 km (see Map 4.1).

This map clearly illustrates the spatial variability of freshwater resources across Europe with annual run-off ranging from over 3000 mm in parts of Norway to less than 25 mm per year in the Spanish interior and parts of Eastern Europe.

A climatic zoning can be established based on the UNESCO moisture index, which is defined as the ratio between average annual precipitation P and potential evapo-transpiration PET, calculated according to the Penman formula. Following the classification of the World Map of Arid Zones (UNESCO, 1979) the following climatic zones can be distinguished:

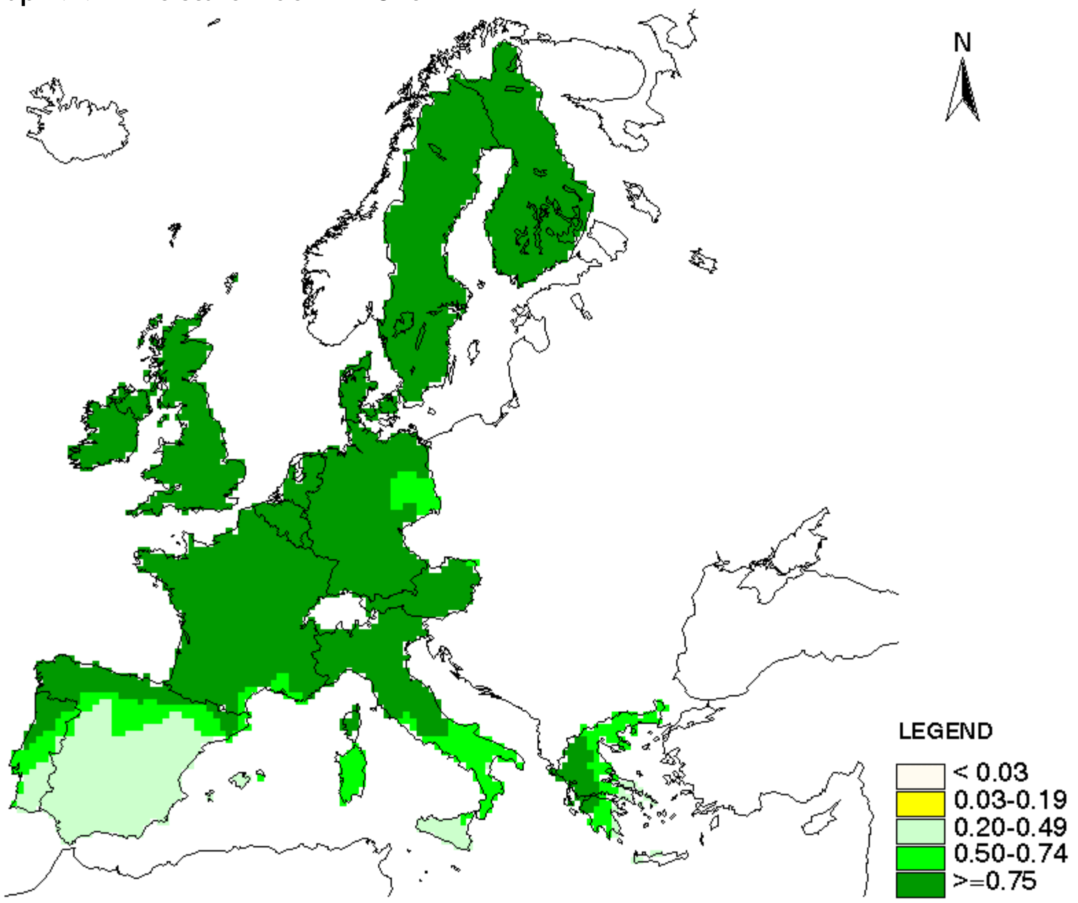
Hyper-arid zones	$P/PET < 0.03$	Deserts
Arid zones	$0.03 \leq P/PET < 0.20$	Sub-deserts or semi-deserts
Semi-arid zones	$0.20 \leq P/PET < 0.5$	Steppes, prairies, certain types of savannah and a large part of the Mediterranean region
Sub-humid zones	$0.5 \leq P/PET < 0.75$	Limits with the humid and the semi-arid zones are fluent
Humid zones	$P/PET \geq 0.75$	

Map 4.1: Long-term average annual run-off in Europe



(Source: Rees et al., 1997)

Map 4.2: Moisture index in EU15



(Source: Eurostat, 1996 and ETC/IW elaboration)

Map 4.2 presents the UNESCO moisture index for the EU15 countries confirming the semi-arid character of many regions in the Mediterranean basin.

Much of Europe is drained by large river systems which cross several international borders. The total renewable freshwater resource available to a country can be calculated as the endogenous resource (i.e. the run-off generated internally) plus the exogenous resource (i.e. the water imported from upstream countries) (Falkenmark and Lindh, 1993).

Table 4.1 presents the amount of total renewable resources (endogenous and exogenous) in various European countries according to the Dobris Assessment (EEA, 1995), the EC Environment Water Task Force (1997), and Eurostat (1997).

Table 4.1: Comparison of total renewable resources according to different sources

Country	Renewable resources (10^6 m³ /year)		
	Dobris	Eurostat	TF
Austria	92 000	84 018	87 667
Belgium	12 500	16 480	12 542
Denmark	13 000	6 119	13 135
Finland	108 000	110 230	105 883
France	198 000	196 382	198 584
Germany	171 000	163 751	196 000
Greece	58 650	60 451	58 906
Ireland	50 000	52 220	49 850
Italy	175 000	175 012	172 969
Luxembourg	5 000	3 204	4 600
Netherlands	91 000	99 578	93 300
Portugal	73 000	72 653	72 327
Spain	117 000	117 109	115 913
Sweden	168 000	174 135	165 543
United Kingdom	120 000	172 541	68 770
Total EU15	1 452 150	1 503 882	1 415 989
Iceland	168 000		
Norway	392 000		
Cyprus	900		
Estonia	15 000		
Hungary	120 000		
Poland	59 000		
Slovenia	18 672		

(Sources: EEA, 1995; EC Environment Water Task Force, 1997; Eurostat, 1997)

National estimates of the renewable resource, expressed in terms of per capita availability, are presented in figure 4.1. Distinguishing between the endogenous and exogenous components of the resource, the figure shows that transboundary flows make a significant contribution to the resources of many countries. In Hungary, for instance, freshwater originating from neighbouring countries accounts for as much as 95% of the total resource. In the Netherlands and Slovak Republic this figure is over 80%, while Germany, Greece, Luxembourg and Portugal all rely on imported water for over 40% of their resources. Although there are international agreements to control the quantity and quality of imported water, tensions inevitably arise, especially where resources are limited in the upstream country.

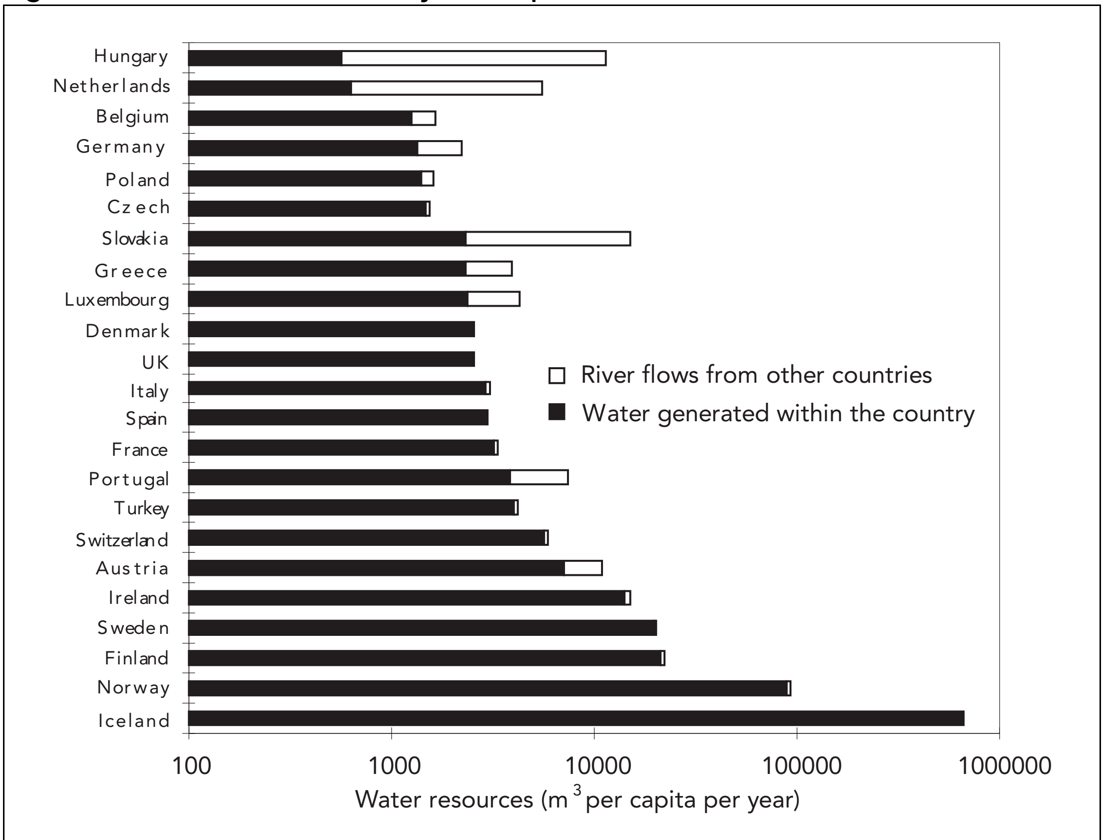
According to the classification in table 4.2, almost half of the countries listed in figure 4.1 may be described as having a low per capita water availability. These include some Northern European countries which, despite having moderate rainfall (Denmark, Germany and the United Kingdom), are densely populated. Freshwater availability appears to be even worse in the Czech Republic, Poland and Belgium, all of which fall into the very low availability category.

Table 4.2: Classification of relative per capita water availability

Category	Water Availability (m^3 per capita per year)
Extremely low	< 1 000
Very low	1 000 - 2 000
Low	2 000 - 5 000
Medium	5 000 - 10 000
Above medium	10 000 - 20 000
High	20 000 - 50 000
Very high	> 50 000

(Source: Shiklomanov, 1991)

Figure 4.1: Freshwater availability in Europe



(Source: Eurostat, OECD, Institute of Hydrology (all 1997))

4.2. Quality for use

The analysis of volumes of abstraction and resources frequently disregards the fact that water can satisfy human and environmental needs only if its quality is adequate for its intended uses. While traditionally in many countries attention has been dedicated mainly to issues related to water quantity, problems relating to the quality of water are becoming more and more relevant for the planning and management of aquatic resources and infrastructure. This section aims to give a brief overview of the current state and trends of water quality and its impact on human activities and the ecological requirements of aquatic ecosystems.

4.2.1. General discussion of main water functions and uses

The main uses and 'functions' of water resources include:

- drinking water supply;
- bathing and other recreational water contact activities;
- industry;
- fish farming;
- irrigation;
- drinking water for livestock;
- ecological functioning of aquatic ecosystems(1).

The requirement for water quality varies from one use/function to another. For example, the presence of organic and oxidisable matter will affect the suitability of water for drinking water and fish farming and will impact on the ecological function but will have less impact on bathing or recreation activities. Table 4.3 summarises the impact of several quality indicators on water uses and ecological function (Agences de l'Eau, 1997).

Standards or values of particular contaminants may be required and set for the protection of different uses and functions. Thus the quality of water fundamentally affects its potential for use. Poor quality water can be treated to make it suitable for uses such as drinking but at some point this may became economically unrealistic.

Table 4.3: Relationships between quality indicators and water uses and ecological function of aquatic ecosystems:

	Function	Uses				
Indicators	**biological potential**	**drinking water**	**bathing and recreation activities**	**irrigation**	**drinking water for livestock**	**fish farming**
Organic and oxidisable matter	✓	✓				✓
Nitrates	✓	✓			✓	✓
Other nitrogen compounds	✓				✓	✓
Phosphorus compounds	✓					✓
Material in suspension	✓	✓	✓			✓
Colour		✓				
Temperature	✓					
Mineralisation		✓		✓	✓	✓
Acidification	✓	✓		✓		✓
Micro-organisms		✓	✓	✓	✓	
Phytoplankton	✓	✓				✓
Inorganic micropollutants	✓	✓		✓	✓	✓
Pesticides	✓	✓		✓	✓	I
Organic micropollutants (excl. pesticides)	✓	✓				

✓ Function and use qualitatively influenced by the indicator
Blank Function and use not or slightly influenced by the indicator
x Needs further investigation

(1) Defined as the biological potential or the suitability of a water body to satisfy the needs for animal and plant life which depend on physical-chemical and physical (habitat, hydromorphology) status of surface waters

4.2.2. Legislative requirements for different water uses and types of pollution

Quality requirements to meet some uses of water have been established in European Directives that may incorporate standards for the protection of the use. For example the Drinking Water Directive, Bathing Water and Freshwater Fish and Shellfish Directives. Other European Directives and national legislation require the compliance with specific limit values but target the main sectors responsible for water pollution (i.e. UWWT, Nitrates Directives).

The Surface Water Directive (75/440) concerns the quality required for surface fresh water intended for abstraction of drinking water and sets limit values which must be met after application of three categories of water treatment. The Drinking Water Directive (80/778) sets limit values for about 70 quality parameters at the point of consumption.

The ecological functioning of surface water is to be included in the proposed Framework Directive on Water Policy (FWD) which requires Member States to achieve or maintain 'good status' for all surface waters (with some derogations). Good status for surface water means both good chemical and ecological status the latter being the expression of physical (including quantity aspects such as flow), biological and chemical quality. These requirements cover the four main objectives of the Directive: the provision of drinking water; water for other economic requirements; the protection of the environment and the alleviation of the impact of floods and droughts. The protection of the environment (which is the principal objective of the Directive) implies strong requirements and efforts for the protection of raw water resources. The attainment of good status for surface and ground waters may imply that all uses and functions of water bodies are satisfied.

4.2.3. Current status of surface water and groundwater in Europe

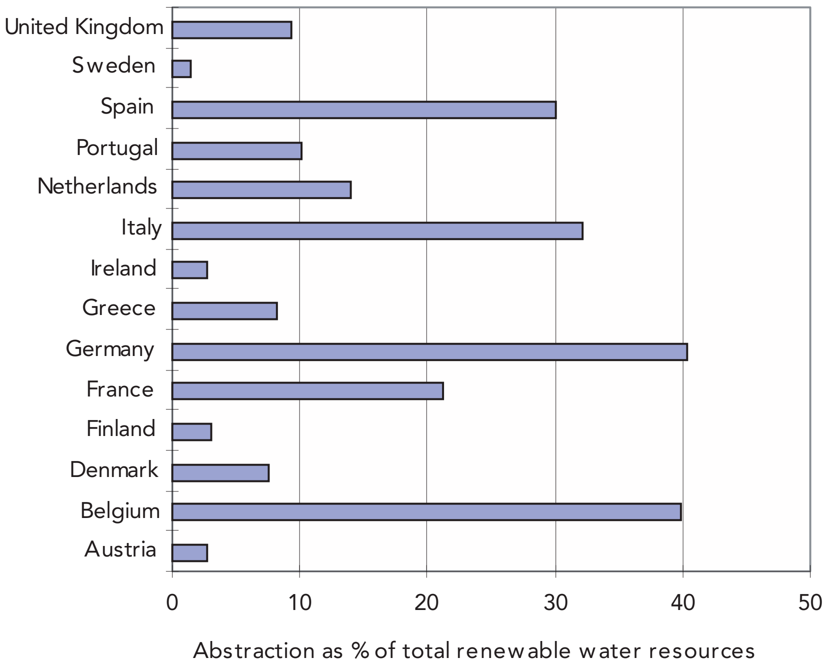
The current quality status of surface water and groundwaters has recently been assessed by the ETC/IW and the EEA, and will be treated no further in this report. Further details can be found in EEA 1998, and ETC/IW 1998a and 1998b. However in these reports there is no assessment of how quality and quantity interact to affect its suitability for use and its effect on aquatic ecology.

5. Impact on water resources

5.1. The pressures creating water stress

Water stress is generally related to an over-proportionate abstraction of water in relation to the resources available in a particular area. The ratio between total freshwater abstraction and total resources indicates in a general way the availability of water and the pressure on water resources. Based on the figures presented in sections 3 and 4 the respective values have been calculated for various European countries (Figure 5.1). The figures suggest that, potentially, all countries have sufficient resources to meet national demand.

Figure 5.1: Freshwater abstractions in Europe

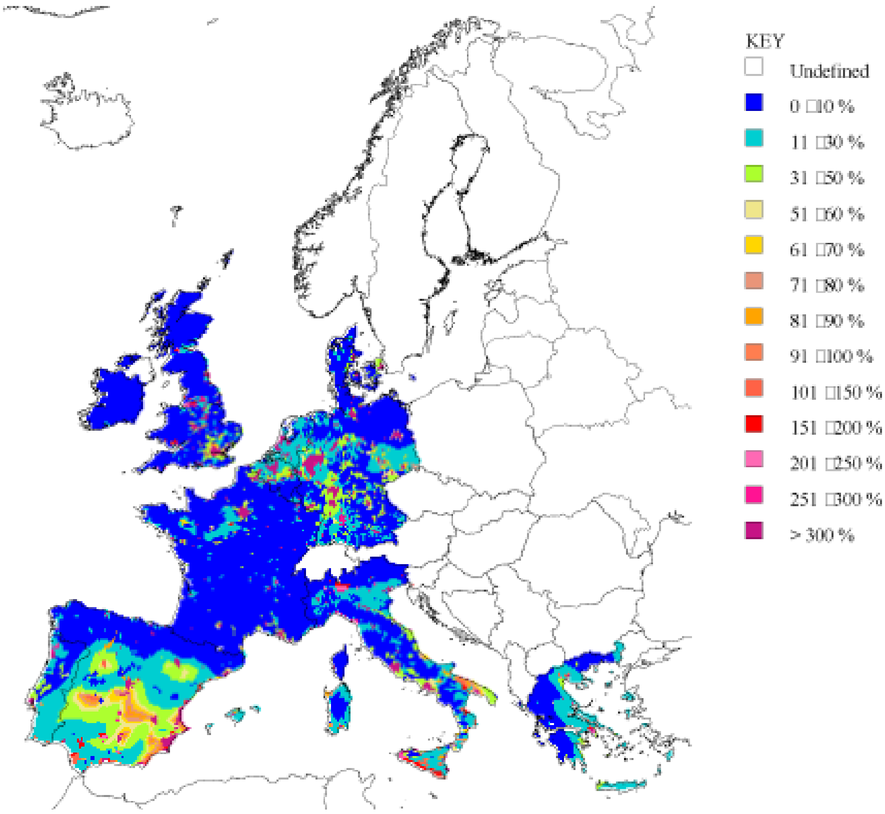


Note: Renewable water resources data from OECD, 1997

(Source: ETC/IW, 1997)

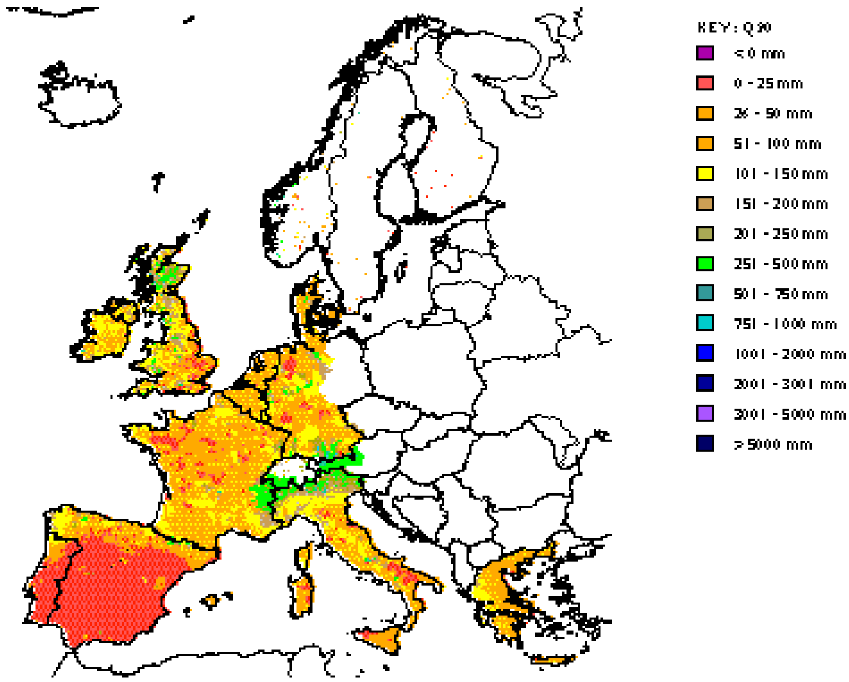
However, the national statistics presented describe the resource situation at a very general level. Such information tends to mask problems that may be occurring on a regional or local scale. The greatest demand for water is normally concentrated in the densely populated urban conurbations. Using the grid of long-term average annual run-off (Map 4.1) in conjunction with the Eurostat GISCO *Degree of Urbanisation* data set, a map of water stress can be derived. The resulting map (Map 5.1) was produced assuming an average annual per capita consumption rate of between 390 and 1500 l/cap/day in urban areas (PWS and industrial demand included). It illustrates how the urban demand for freshwater can exceed the local long-term availability of the resource, especially in Southern Europe and the industrial centres of the North. In these areas such demand could not be sustained unless action was taken to artificially boost local supply. Agricultural abstractions also create stress on water resources particularly in southern countries (see Section 3.1.3).

Map 5.1: Urban demand as a proportion of average annual runoff in EU12



(Source: Rees et al., 1997)

Map 5.2: General distribution of Q90 (expressed in mm) across EU12



(Source: Gustard et al., 1997)

Even where there are sufficient long-term water resources in an area, the seasonal or inter-annual variation in the availability of the freshwater resource will, at times, induce problems of water stress. For water resource planners, decisions on water use are frequently based on the resource they can expect in periods of dry weather or low river flow. A valuable indicator of this is the 90th percentile flow (Q90), representing the freshwater resource which can be relied upon for an average of 328 days a year (i.e. 90% of the time). Q90 may be used operationally to determine limits on the rates of abstraction from a river or for setting levels of minimum (ecological) flow. A grid of Q90, derived using observed flow data, where available and regional characterisation methods for ungauged areas (Gustard *et al.*, 1997), is shown in Map 5.2.

In semi-arid areas the greatest share of water resources is frequently dedicated to agriculture. This situation may cause additional pressure on resources due to the fact that agricultural demand tends to concentrate in areas with high fertility which are frequently characterised by low natural availability of water. As the demand of crops is inversely proportionate to the natural offer of water, it is often concentrated on the dry season and tends to increase in dry years, causing even greater stress on hydraulic resources.

5.2. Drought

The demand for European water resources has increased from 100 km^3 per year in 1950 to 550 km^3 per year in 1990, with forecasts that this will increase to 660 km^3 by the end of this century (EEA, 1995). Recent droughts have already shown the vulnerability of water resource systems to variations in the meteorological and hydrological cycle. The expected increase in water demand will, undoubtedly, result in further conflicts between human demands (commercial, social and political) and ecological needs, most critically in periods of severe and extensive droughts.

Droughts are multi-faceted both in their character and range of impacts. Although the consequences of drought are readily recognised by the public at large, the objective evaluation of drought severity is a complex problem. There is no agreed definition among scientists of drought in anything other than general terms. Beran and Rodier (1985) provide one of the more useful definitions: *"The chief characteristic of drought is a decrease of water availability in a particular period and over a particular area."*

In trying to describe drought severity a variety of indices may be used (Mawdsley *et al.*, 1994). They can be classified in two types:

1. Environmental indicators are those hydro-meteorological and hydrological indicators that measure the direct effect on the hydrological cycle.

2. Water resource indicators measure severity in terms of the impact of the drought on the use of water in its broadest sense, for example, impact on water supply for domestic or agricultural use, impact on groundwater recharge, abstraction and surface levels, impact on fisheries or impact on recreation.

It should be recognised that environmental indicators measure the severity of a "natural" drought. The water resource indicators imply an element of human interference and may reflect as much a lack of resilience in a water resources system or mismanagement of water supplies as a lack of rainfall or run-off.

It should also be recognised that whilst water resource indicators should be most meaningful, especially to the public or other non-hydrologists, in that they reflect the impact of a drought, they often suffer from an inability to express a drought in clear and unambiguous terms. As these indicators are not a direct measure of severity, they are unable to distinguish between an absolute drought and a drought which is unjustified in hydrological or meteorological terms but which has developed due to imprudent management of the water resource system.

The impact on the community during most periods of large rainfall deficiency is likely to be very uneven and dependent on a number of features of the drought. Hot weather and dry soils may generate heavy water demand, thus aggravating the effects of hydro-meteorological and hydrological irregularities.

The most recent period of drought in Europe is the one that occurred between 1988 and 1992, when most European countries experienced lower than average precipitation and run-off. The timing and intensity of maximum deficit varied considerably. In some catchments the deficits were worse during 1991; in others the drought was most extreme during 1990. New record minimum flows were set in many rivers with up to 100 years of data.

On the contrary, the Nordic countries, and especially Western Norway, had generally higher than average run-off between 1988 and 1992. Run-off was particularly high in the winters of 1988/89 and 1989/90, in marked contrast to the rest of Europe.

The impact of a drought depends on the combination of hydrological conditions and water resource pressures. The biggest impacts of the drought of the early 1990s in Europe have been in areas with the greatest pressures on resources, and especially in those areas with high irrigation demands. These are not necessarily the areas with the greatest hydrological drought. Low river flows and depleted reservoir stocks caused problems for irrigation over a large part of Europe, ranging from Hungary to Spain, where agricultural production was heavily affected and uneven regional distribution of water triggered inter-regional political concerns.

The drought of the early 1990s, in the Southern part of Spain, had extremely severe consequences on the local community and economy. In the area of Seville precipitation during the period 1992 to 1995 decreased to around 70% of average (551 mm), with run-off during this period being less than 30% of the normal volume. The drought of 1992-95 was especially severe not only in terms of deviation of average annual rainfall and run-off but also with regard to its duration. The fact that precipitation was extremely low during four consecutive years heavily affected the city's water management which strongly relies on storage in inter-annual reservoirs *.

A factor that aggravated the impact of the drought was the relatively high level of public water supply in 1991, with a per capita use of 400 l/person/day. (EMASESA, 1997). Also the World Exposition of 1992 which was celebrated in Seville also affected water demand, although the water used in 1992 was less than 1991, thanks to public campaigns for water conservation.

Nonetheless, due to low precipitation the reserves of the municipal water company continuously decreased throughout 1992 and, by the beginning of 1993, reached the minimum level considered vital for secure supply. During the years 1992 and 1993 the authorities of Seville issued a whole series of decrees to promote water saving, ranging from calls for voluntary restrictions to supply cuts during nights, some lasting up to 12 hours/day during several months. As a result savings of up to 35% of normal supply could be achieved. In addition a variety of emergency measures were adopted to develop additional sources of supply, opening pump stations and river derivations, establishing the necessary links to incorporate additional water into the network and introducing devices to purify water of inferior quality.

The situation of water supply in Seville slightly improved by the end of 1993, thanks to higher precipitation, and emergency measures could be lifted in November 1993. However, during the second half of 1994 the reserves again diminished and in 1995 further emergency measures and supply cuts had to be imposed. The end of the drought came in winter 1995/96 when finally all restrictions were lifted.

As a result of the drought total supply diminished by 24% from 1991 to 1995. The experience of the 1992-95 drought in Seville shows how heavily life in a city can be affected by the lack of water. Although periodic droughts had been common in the past, citizens and public suppliers had to use an excessively high percentage of the resources available in normal years. Confronted with an extraordinary climate event the city's water management system did not have enough redundancy to maintain the level of supply. Still today supply guarantees in Seville are considered insufficient (EMASESA, 1997).

The temporary reduction in water availability during 1992-95 resulted in severe social and economic consequences. The experience of Seville shows the importance of having programmes in place to efficiently control water demand, and the need to manage water resources responsibly, both in terms of quantity (knowledge of availability and demand, adequate supply guarantees) and quality (resources not used at present may be required in the future).

* reservoirs with enough storage capacity to keep water during dry periods.

5.3. Desertification

Desertification is described as the set of environmental degradation processes occurring in hot (hyper-arid, semi-arid and sub-humid) dry lands, which result either from climatic stress or human mis-management or both (Verstraete and Schwarz, 1991). The process affects both man-made and natural ecosystems and always has severe long-term consequences for the productivity of the land and therefore for the populations that inhabit these regions.

A number of processes are involved, including regional scale climatic feed-back, soil erosion by both wind and water, increased surface water run-off, changed soil infiltration characteristics, degradation of the vegetation cover, soil degradation, etc. The process of desertification, however, is invariably centred on the hydrological cycle of which the sub-surface element is a vital part.

The tendency toward desertification is commonly enhanced and accelerated by human activities. Over-exploitation of water resources, fires, overgrazing and change of land use which exposes the soil to wind or water erosion are human activities which encourage desertification in areas prone to developing arid conditions.

The Mediterranean is an area potentially vulnerable to desertification. Over the centuries the Mediterranean has managed to maintain its general character. Nonetheless, some areas such as Central and Southern Spain are in part affected by desertification phenomena, although exposed areas are also capable of responding to the danger of desertification and achieve a reversal of the process. The destiny of semi-arid Spain depends on future climate trends, and on the degree to which pressures exerted by man impact land surface and water resources. Small changes in precipitation, either in overall magnitude or seasonal distribution, or a change in the demand of the limited water resource can drive conditions either way and cause a region to become wetter or drier. In the Mediterranean region demand on water resources is currently increasing, thus tending to encourage the onset of drier conditions.

Nevertheless the whole subject of desertification is still rife with controversy, beginning with the difficulties in defining the term itself. Recent opinion, for example, suggests that the process may be better defined as “dry land degradation”. It is generally agreed that such degradation results from a combination of human pressures resulting from population growth and climate change. However, there is, as yet, little agreement concerning the way in which the process can be quantified and about the indicator be used for this quantification. There is also considerable uncertainty concerning the way in which degradation feeds back to the climate. It is not clear at what scale, to what degree and in what manner degradation itself contributes to the process of climate change.

The lack of precise information about the extent and severity of the population-hydrology-climate problem has been recognised for many years. The first and perhaps most serious difficulty facing the scientific community is a lack of basic data relating to all aspects of the hydrological cycle in the arid and semi-arid environment. Aubreville (1949), McGinnies (1968), Warren and Maizels (1977) and Bie (1989) have all drawn attention to this problem. One of the aims of the proposed projects still to be implemented is to establish long-term monitoring sites within a selected catchment and in this way to begin to provide such information.

The second problem is that the processes by which changes in the land surface and hydrology interact with climate are poorly understood and difficult to quantify. To achieve the link between hydrology and climate a series of models on various scales need to be developed within inter-disciplinary investigations.

5.4. Impacts of over-abstraction of groundwaters and surface freshwaters

Groundwater over-exploitation, defined as groundwater abstraction exceeding the recharge and leading to a lowering of the groundwater table, is a significant problem in many European countries. The result is dried up rivers, endangered wetlands and saltwater intrusion into aquifers. The main causes of groundwater over-exploitation are intensive water abstractions for public and industrial supply. Mining activities, irrigation as well as naturally occurring dry periods also cause decreasing groundwater tables. **Saltwater intrusion** is the consequence in 9 out of the 11 European countries where groundwater over-exploitation exists (ETC/IW 1998a).

Over-abstraction is one of several factors causing the disappearance of whole lengths of rivers and the drying out of wetlands. “Endangered status” was given to 210 (in 11 European countries) of the 420 named wetlands (16 countries) (Groundwater Quality and Quantity in Europe, EEA 1998).

5.5. Ecological status

Water abstractions modify the natural hydrological regime and flow in surface waters (rivers, lakes, wetlands) and consequently have a direct impact on the ecological status of aquatic ecosystems. Modifications in the river flow regime affect the structural and functional attributes of the biotic community. Three orders of impact from flow reduction in downstream river reaches have been identified:

- 1st order impacts occur with completion and maintenance of dams: modification of flow regime, sediment transport, water quality and temperature,
- 2nd order impacts are the changes in channel geomorphology and primary production, which require a time-lag between 1 and 100 years, or more, to attain new equilibria,
- 3rd order impacts reflect 1st and 2nd order impacts. These affect the fish and invertebrate communities; modify flow patterns that affect fish migration; and cause drying of spawning areas. They decrease the velocity at incubation sites, fish food production, and fish rearing. They disrupt the hydrodynamic equilibrium (modified discharge and sediment regimes), with consequences on channel structure that affect the habitat for rearing, spawning and incubation, and result in changes in species composition, increase temperature and concentration in pollutants.

Low flows can also cause or exacerbate existing pollution problems (decrease the dilution capacity, decrease DO % and increase concentrations in nitrate and phosphate which can cause eutrophication problems).

Increasing demands for water (over-abstraction) is one of the causes of ecosystem damage. Over-abstraction may not only devalue the wildlife but also the cultural and economic benefits of wetlands (e.g. recreation value, decrease of the natural flood defences that may increase the frequency of flooding).

Other examples include the long distance water supply systems created to meet the needs of conurbations. Rapid increases in population during the period of industrialisation resulted in an increase in the demand for drinking water as well as contamination of shallow groundwater that cannot be used any longer). To satisfy increasing urban water demand, long distance water supply has led to the over-abstraction of groundwater in the rural areas surrounding conurbations. This has in turn led to a lowering of the water table, and caused the death of typical local vegetation (Sustainable water management in Germany).

Action plans and legislative measures may contain the following aspects: establishment of minimum ecologically acceptable flows and groundwater levels; review of water abstraction licences to identify all damaging impacts on wildlife and to implement a sustainable water resource strategy. These will include the requirements on water companies to develop long-term sustainable water plans and drought contingency plans, and the setting of environmental standards of performance for water companies, including bio-diversity targets and targets for saving water. Controlling abstraction to ensure a minimum river flow is one of the measures undertaken by several governments (e.g. United Kingdom, France) but they are rarely based on the specific environmental needs of river or wildlife. In addition there is usually more attention being paid to pollution control than to water abstraction control.

Some countries (e.g. France, Portugal and Spain) have now included in their legislation and river basin management plans requirements for minimum flows in rivers. These are intended to mitigate the impacts on aquatic ecosystems (to assure the maintenance/preservation of flora and fauna native species) and to maintain water uses such as irrigation and water supply. It is still difficult to establish minimum flows because of the lack of scientific knowledge concerning the requirements of the aquatic and riverine ecosystems.

6. Responses: Policies and measures

This section examines the various policies and measures associated with the management and use of water resources across Europe. The section starts with a description of current and proposed EU legislation and international agreements. The two main approaches to using and supplying water resources in an efficient and sustainable way are then discussed. These are demand side management and infrastructure facilitating water supply.

6.1. Groundwater Action Programme

A ministerial seminar held in the Hague in 1991, on the long-term deterioration of the quality and quantity of water resources, emphasised the special significance of groundwater in the water cycle and in ecosystems, and as a source for drinking water. As a result, the European Council called for a Community Action and required that a detailed action programme be drawn up for comprehensive protection and management of groundwater as part of an overall policy on water protection. This has led to a draft proposal for an Action Programme for Integrated Groundwater Protection and Management (GAP) (COM (96) 315 final) which requires a programme of actions to be implemented by the year 2000 at national and Community level, aiming at sustainable management and protection of freshwater resources. The draft proposal develops the basic quality standards for groundwater adding, at the same time, a quantitative dimension to water management. National action programmes should aim for full implementation by 2000 and should address elements such as mapping and monitoring of quality and quantity of freshwater resources, identification and designation of protection zones for areas of particular ecological interest and sensitivity, including present and future resources for drinking water and other resources. Water quality and quantity should be appropriately monitored in order to provide information allowing Member States to follow developments in quality and quantity of aquifers and, in particular, detection of early signs of deterioration from leaching of dangerous substances towards groundwater reservoirs.

Many of the recommendations in the GAP are now found in the proposed Framework Water Directive which will become legally binding. However, many other aspects of GAP cannot be implemented through the new proposal but relate to other policy areas and to measures which have a less formal nature.

6.2. Framework Water Directive

The overall purpose of the proposal (COM(97) 49 final) is to establish a framework which:

1. prevents further deterioration and protects and enhances the status of aquatic ecosystems and with regard to their water needs, terrestrial ecosystems, and

2. promotes sustainable water consumption based on long-term protection of available water resources, and thereby contributes to the provision of a supply of water of the qualities and in the quantities needed for the sustainable use of these resources.

The proposal requires the attainment of good surface water and groundwater status by 2010. The former will require the consideration and control of freshwater flow and levels in rivers, lakes, estuaries and coastal waters so that good ecological quality can be achieved and maintained. Good groundwater status will only be achieved when there is not over-exploitation of aquifers or adverse impacts on inter-connected aquatic and terrestrial ecosystems. Thus, on adaptation of this proposal, the control and management of water quantity will be for the first time a legal requirement across the EU.

The proposal also contains requirements for a mechanism to ensure that water use is paid for at full recovery prices. This mechanism aims to improve the efficiency of water use and the effectiveness of environmental provisions relating to its use by ensuring that the price of water reflects the economic costs involved. Costs include services for water users (abstraction and distribution of water, collection and treatment of wastewater, pollution prevention and control measures), environmental costs and resource depletion costs. The latter include the costs of environmental damage caused to other users/society as a whole because of the depletion of a resource beyond its natural rate of recharge. This Directive on adoption will be a means for more fully implementing the polluter-pays principle.

A number of European countries (Denmark, Germany, the Netherlands, Sweden, United Kingdom, Iceland) have implemented the full cost recovery principle for waste water collection and treatment as well as for fresh water abstraction and distribution throughout their economy, or are on the way to doing so. Other countries have partial cost recovery or legislation to that effect (Belgium, France, Italy, Austria, Portugal, Finland and Norway). Therefore, the implementation of the FWD is likely to lead to an increase in water prices for consumers in these countries. Concerning the environmental costs and resource depletion costs, they are already implemented in several EU Member States, mainly through taxes and charges on water pollution and abstraction (Belgium, Denmark, Germany, France, Netherlands, Finland) (COM (97) 49 final - Explanatory memorandum).

6.3. International conventions and agreements

In general, most international conventions and agreements concern water quality protection (including measures to reduce or prevent diffuse and point source pollutant discharges) or relate (in some cases exclusively) to water use aspects, for example, for hydroelectricity or navigation purposes. Themes of concern such as surface water and groundwater abstractions in relation to minimum ecological flows are not yet included in these agreements/conventions. International conventions mainly concern surface waters and, particularly, watercourses. Some examples are described below.

6.3.1. Transboundary Water Courses Convention 1992

The UN Convention on the Protection and Use of Transboundary Watercourses and International Lakes (1992) had been signed by 25 countries by the end of May 1997 including all EEA countries (except Iceland, Ireland and Liechtenstein). Twenty countries had also ratified the Convention by this date. The Convention requires signatories to prevent, control and reduce pollution of water causing or likely to cause transboundary impact with the aim of ecologically sound and rational water management, conservation of water resources and environmental protection. It also covers transboundary groundwaters. The measures to achieve these objectives would include, for example, application of BAT to reduce nutrient inputs from industrial and municipal sources, and best environmental practices for reduction of nutrients from diffuse sources (especially from agriculture).

6.3.2. The Danube Convention

The Danube Convention covers the 11 major riparian countries (Austria, Bulgaria, Croatia, Czech Republic, Germany, Hungary, Moldova, Romania, Slovak Republic, Slovenia and Ukraine). Previous treaties and agreements, established since 1815, were mainly aimed at the regulation of the hydrological regime for navigation purposes. On the basis of the recommendations of the 1985 Bucharest Declaration a co-ordinated water quality monitoring programme was implemented, within the framework of the International Danube Commission. Building on this collaboration, the riparian states decided in February 1991 to develop a convention for the protection and management of the river. In 1994, the Danube Environment Ministers and the European Commissioner responsible for the environment adopted the Strategic Action Plan for the Danube River Basin. The Convention is aimed at achieving sustainable and equitable water management and includes, besides the objective of reducing pollution, the maintenance and improvement of the availability and quality of water and the development of regional water management co-operation. Key aspects relate to regulatory and control procedures, drinking water protection, protection of fisheries, downstream water quality and ecosystem impacts, etc. To date, the negotiation process has led to the signature by all major riparian countries of a Convention on Co-operation for the Protection and Sustainable Use of the Danube River Basin. Each country is now developing national action plans.

6.3.3. The Rhine Convention

The river Rhine is also one of the major international basins covered by numerous treaties. The early treaties (around 1820) involved several aspects, such as the maintenance of river banks; the control of hydraulic works; the free flow of water, including an obligation to maintain the width and the flow of the river; and, the protection of natural flows and actual state of the river banks (since the 1880s). There is also an obligation to inform other riparian countries on projects which may have an effect on these aspects or provisions regarding water quality protection to prevent endangering migratory fish life. Later, in the 1960s, the Hague Treaty recognised the right for equal water use regarding public water supply, agricultural and industrial needs, including the associated implications on water quality to permit these uses. The Treaty also established the International Commission for the Protection of the Rhine against Pollution and set limits on discharges in the water and drainage systems. Further treaties and conventions/agreements comprise rules and programmes to reduce/prevent pollution and maintain a certain capacity which permit the production of electricity while guaranteeing the needs of others users.

6.3.4. The Elbe Convention

Germany, Czech Republic and the European Community signed the Agreement on the Protection of river Elbe in October 1990. The first action programme 1992-95 aimed at substantially reducing loads from Elbe catchment to the North Sea; achievement of near-natural aquatic ecosystem; and making the river suitable for other uses. The long-term action programme for 1996 onwards aimed at further reduction of pollution in Elbe.

6.3.5. Portuguese and Spanish rivers agreements

Several agreements between Spain and Portugal have been adopted since the 1960s but mainly concern aspects regarding hydroelectric use of transboundary rivers. They allow Spain to divert a certain volume of water for energy generation. *However even flows are mentioned as a basis to calculate the partitioning of the potential for energy production and also minimum flows to be guaranteed these are not quantified.* However, qualitative aspects are still not addressed in the conventions.

6.4. Demand side management

6.4.1. Abstraction and effluent charges

To reach the goal of sustainable water management a balance has to be achieved between the abstractive uses of water (e.g. abstraction for public water supply, irrigation and industrial use), the in-stream uses (e.g. recreation, ecosystem maintenance), the discharge of effluents and the impact of diffuse sources. This goal requires that both quantity and quality are taken into account.

The command and control approach, based on a licensing system, has traditionally been applied to try to achieve the required balance between the different demands on the water environment. However, economic instruments are being applied increasingly to complement the licensing system as water resources of adequate quality become more and more scarce and water therefore becomes an important economic good. This is accelerated by the increasing value people are putting on the aquatic environment in terms of minimum flow, quality and aesthetic appearance.

EU policy on economic instruments

The EU Treaty requires unanimity by Member States for the adoption of fiscal measures which has resulted in little progress in agreeing at Community level economic instruments for environmental policy. However, the European Community's Fifth Environmental Action Programme "Towards Sustainability" (COM 1992) encourages Member States to employ, besides the traditional command and control approach, environmental taxes and charges to achieve a more cost-effective environmental policy. By increasingly setting EU environmental policy in the context of framework legislation the use of a wider range of policy instruments including the application of environmental charges and taxes by the Member States is being encouraged. This has led to an increase in the application of a wide range of different environmental charges and taxes in Member States.

The Commission published guidelines in 1997 for Member States on the use of Environmental Taxes and Charges in the Single Market to avoid conflict on competition, the functioning of the single market and taxation policy (COM 1997). The use of economic instruments may also affect third countries for instance in relation to world trade. It is therefore important when considering the use of environmental economic instruments to assess their impact on other countries but also internally on the potential effect on competitiveness.

Design of economic instruments

The purpose of environmental taxes and charges should be to assist in the achievement of an environmental objective and not purely to raise revenue. To be effective charges need to be set at the correct level. If they are too low they will not achieve the desired objective and if they are too high they can lead to a different distortion. However, to be effective they must also be able to influence the behaviour of those causing the environmental impact. For instance if the water abstraction charge is intended to encourage the public to reduce water consumption, this will only be effective if customers are metered and can therefore financially benefit by reducing water consumption.

When designing a charging system it is also important to decide on the use of the revenue collected. This can either be used to cover administrative costs, to finance environmental improvements including financing of research to develop cleaner production or can be used as general taxes (e.g. green taxes) to replace other taxes. However, when using it to replace other taxes, the charges will have to be increased steadily in line with the improvements achieved in order to maintain the revenue flow if that is necessary. This could lead to the situation that excessive charges are levied in relation to the environmental effects leading to distortions.

In addition economic instruments can, like VAT, have a proportionally higher socio-economic impact on the poorer section of society if they are applied directly to essential goods like drinking water.

Abstraction charges

The purpose and the design of the charging scheme for water abstractions vary widely in different countries and reflect the institutional arrangements and geographic conditions in the countries. The charging schemes introduced in four EU Member States are given in Table 6.1 (Zabel and Buckland 1996).

The most widely applied scheme is the revenue raising system. The use of raised funds varies in different countries from providing funds for water resource infrastructures to subsidies for water supply systems. In one German State (Baden-Württemberg) the funds raised are used to compensate farmers for the effects of reducing fertiliser use and the application of more expensive, but environmentally more acceptable, pesticides.

Table 6.1: Purpose of abstraction charge in selected countries

Country	Cost recovery	Revenue raising	Incentive	Replacement of taxation
France		Yes	Yes	
Germany	Yes	Yes(1)	Yes(1)	Yes
Netherlands		Yes(2)	(Yes)(3)	Yes(4)
United Kingdom (England and Wales)	Yes			

Notes:
(1) Depends on the charging scheme in the individual Land
(2) Provincial tax for water abstraction, groundwater only
(3) The charge is for groundwater only
(4) Introduced in 1995 for general tax raising purposes, i.e. green fiscal reform

The range of charges applied in selected EU Member States is given in Table 6.2.

In Germany higher charges are generally applied to groundwater abstractions, especially for uses other than potable supply. In two states (Hamburg and Hessen) charges are only applied to groundwater abstractions. The introduction of the charging scheme for groundwaters in Hamburg has resulted in a significant return of unused water rights - one of the main aims of the scheme. Whereas in Hessen, which levies the highest charges, a reduction in water consumption of 11% has been achieved although some of this reduction may be the result of the slowdown in economic activity.

Table 6.2: Range of abstraction charges applied in some EU Member States

Country	ecu/m³
France	0.01 – 0.02
Germany	0.02 – 0.53
Netherlands	
- National	0.15
- Provincial	0.08
United Kingdom	0.006 – 0.021

In the Netherlands, charges are only applied to groundwater abstractions since adequate surface water supplies are available. Two different charges are levied. The Provinces raise charges that are relatively low to finance research for the development of groundwater resources and for water planning. The second tax is collected centrally as part of general taxes. This is part of the general reform of the national tax system to shift the burden of taxation from income tax towards a tax on consumption including the consumption of natural resources.

The system in England and Wales is a cost recovery system to recover the cost of the regulator, the Environment Agency, incurred in performing its water resource functions. The charging scheme consists of two elements, an application charge to be paid when applying for a licence and an annual charge. The annual charge is based on the licensed volume taking into account:

- source (the highest charges are placed on those sources that are actively managed by financing infrastructures or by pumping to enhance water resources);
- season (higher charges are levied in the summer when resources are under greatest stress); and,
- loss factor (i.e. how much of the abstracted water is returned).

Different unit charges are applied in the different regions to take into account the scarcity of the water resources. However, the charges are relatively low.

In France, the six Water Agencies (Agences de l'Eau) implement the 'polluter-pays' and 'user-pays' principles, and collect, at their catchment level, financial charges paid by various categories of water users (local authorities, industries and farmers who irrigate) for water abstraction and consumption, pollution of water and modification of the hydrological regime. The funds collected are reallocated to provide financial assistance to reduce pollutant discharges and in a general sense to improve water management. Regarding the water abstraction and consumption scheme, charges are based on the volume abstracted and used, the scarcity of water resources and how much water is returned to the environment. Charges are generally higher for waters taken from upper reaches of rivers which tend to be less polluted. Furthermore, charges for groundwater tend to be higher than for surface waters.

In general, the abstraction charges in the four countries are relatively low compared to the price of drinking water and the incentive to use less water is therefore low. However, the generally higher charges for groundwater abstraction, especially for non-potable water uses, compared to surface water abstractions provide an incentive to use surface waters instead of groundwater. This incentive for substitution is likely to be more significant if charges are applied for groundwater only. The new National groundwater tax together with the existing provincial groundwater charge in the Netherlands will probably be sufficiently high to provide some incentive to use less water. Although the Dutch charges will still be lower than those applied in the German state of Hessen. In Hessen, which has a shortage of groundwater, a reduction in water abstracted has been observed. However, the charges have not been in operation long enough to establish whether other factors such as lower economic activity have contributed to the reduction. Only in France is the abstraction charge related to the vulnerability of the source. However, the availability of water resources is also taken into account in England and Wales in the setting of the regional unit charge. The charges applied in both countries are low and are unlikely to lead to a significant change in abstraction.

The current water abstraction charging schemes applied can generally be best described as financial instruments to raise revenue to cover costs or to fund specified activities rather than as economic instruments to change the behaviour of water users. Even though their main purpose is not to change the behaviour of water users they, nevertheless, have some influence on water abstractions. However, none of the charging schemes attempts to set the charges based on the site-specific true value of the water resource.

As water abstracted for irrigation is increasingly becoming a major issue it is interesting to note that charges for water used for irrigation tend to be very low, much lower than the charges for other users. The charges do not represent the true cost of water especially as irrigation tends to be practised in the summer when water resources are under greatest threat.

Effluent charges

The effluent charging schemes applied in different EU Member States also vary widely. Table 6.3 shows a summary of the schemes applied in selected EU Member States.

Table 6.3: Purpose of effluent charging schemes in selected countries

Country	Cost recovery	Revenue raising	Incentive
France	Yes	Yes	Yes
Germany	Yes		Yes
Netherlands	Yes	Yes	
United Kingdom (England & Wales)	Yes		

In France, the pollution tax collected by the Water Agencies is based on the quantity of pollution produced in a 'normal' day during the maximum discharge month within the whole year. The physico-chemical and biological/microbiological elements that are taken into account in the evaluation of the quantity of pollution are defined by orders and at the hydrographic levels by each Water Agency Basin Committee. The latter involves representatives of industries, farmers, municipalities, nature conservation associations and the government. The list of parameters may evolve according to the needs for protection of the environment but generally include suspended solids, oxidisable matter, toxics, phosphorus and nitrogen compounds. Each Agency Basin Committee, within the framework of a five-year action programme, also determines the monetary value of the parameters used for the calculation of the pollution fee.

In England and Wales the system is, as for the abstraction charging scheme, designed to recover the cost of the regulatory authority (Environment Agency) for its pollution control function. The annual charge covers the administration cost of the licence and the monitoring costs for compliance sampling. The monitoring costs are related to the contents of the discharge and the type of receiving water. As the monitoring costs are higher for the more difficult to analyse organic hazardous compounds, effluents containing these substances attract higher charges. Similarly, effluents discharged to vulnerable receiving waters require more frequent monitoring and therefore also higher charges, although the charges are low compared to those in the other countries. The French and Dutch systems are revenue raising schemes. Whereas the French system takes into account the vulnerability of the receiving water and the impact of the effluent the Dutch system applies a unit charge independent of the capacity of the receiving water. The Dutch charges are higher than the French charges and their impact in improving the environment has therefore been higher.

The German system can be described as an incentive system since charges are reduced by 75% once the limit values laid down in Federal Regulations for the specific industrial sector have been achieved. This reduction already applies during the construction phase (3 years) of the treatment plant. However, if the consent is breached the reduction in charges no longer applies. Unit pollution charges are applied nationally independently of the capacity of the receiving water. The money raised in the French, Dutch and German schemes is used to fund research and infrastructures for pollution abatement.

As for the abstraction charging schemes none of the effluent charging schemes are designed to be applied site specific to change the behaviour of the dischargers although in France and England/Wales the vulnerability of the receiving water is included in the assessment of the charges. The charges are lower than the Dutch and German charges and their impact has therefore been relatively low. The German authorities consider the pollution charge as a greater incentive to reduce point source pollution than the regulatory approach. The success of the scheme is probably due to the relatively high charges, which have been increased steadily over the years, and the incentive element built into the scheme.

A comparison of the level of charges applied in the different countries to a hypothetical effluent containing toxic metals is given in Table 6.4 together with the reduction in charges which can be achieved by applying Best Available Technology (BAT). The table shows that the charges in France and England/Wales are relatively low as well as the large incentive element in the German charging scheme if BAT is applied.

Table 6.4: Wastewater charges in some countries (ecu)

Country	Charge for Scenario 1(4)	Charge for Scenario 2(4)	Difference
France(1)	4241	1316	2925
Germany(2)	52132	4458	47674
Netherlands	48103	15500	32603
England and Wales(3)	4409	4409	0

Notes:

(1) Rhin-Meuse
(2) In Scenario 2 the application of BAT allows a reduction of 75% in the charge.
(3) Assumed that the discharge is categorised as Band 2 (potentially toxic metals).
Source: Schoot Uiterkamp et al. (1995).
(4) The improvement in concentration in COD 400 mg l^{-1} to 100 mg l^{-1}, BOD 100 mg l^{-1} to 20 mg l^{-1} suspended solids 40 mg l^{-1} to 20 mg l^{-1}, halogenated carbons 1 mg l^{-1} and 0.1 mg l^{-1}, total nitrogen 20 mg l^{-1} to 10 mg l^{-1}, reduced nitrogen 10 mg l^{-1} to 5 mg l^{-1}, total phosphorus 1 mg l^{-1} to 0.5 mg l^{-1}, zinc 2 mg l^{-1} to 1 mg l^{-1}, nickel, copper and lead each from 1 mg l^{-1} to 0.5 mg l^{-1}, chromium from 0.1 mg l^{-1} to 0.01 mg l^{-1}.

Overall appraisal of abstraction and effluent charges

The purpose of the charging schemes introduced in the different countries presented varies widely. Apart from the effluent charging scheme in Germany it would appear to be more accurate to describe the charging schemes applied as financial rather than strict economic instruments. The charging schemes have contributed towards improvements in water management. The degree of effectiveness does of course vary between the different countries as the charges applied vary widely.

The introduction of the new Dutch National groundwater abstraction charge is the first attempt for water management to use 'eco-taxes' to finance government revenue. The abstraction charges for the different user tend to vary widely with charges for irrigation usually being the lowest even though irrigation poses a significant threat to achieving sustainable water management especially as water for irrigation tends to be abstracted at times when the stress on water resources is greatest.

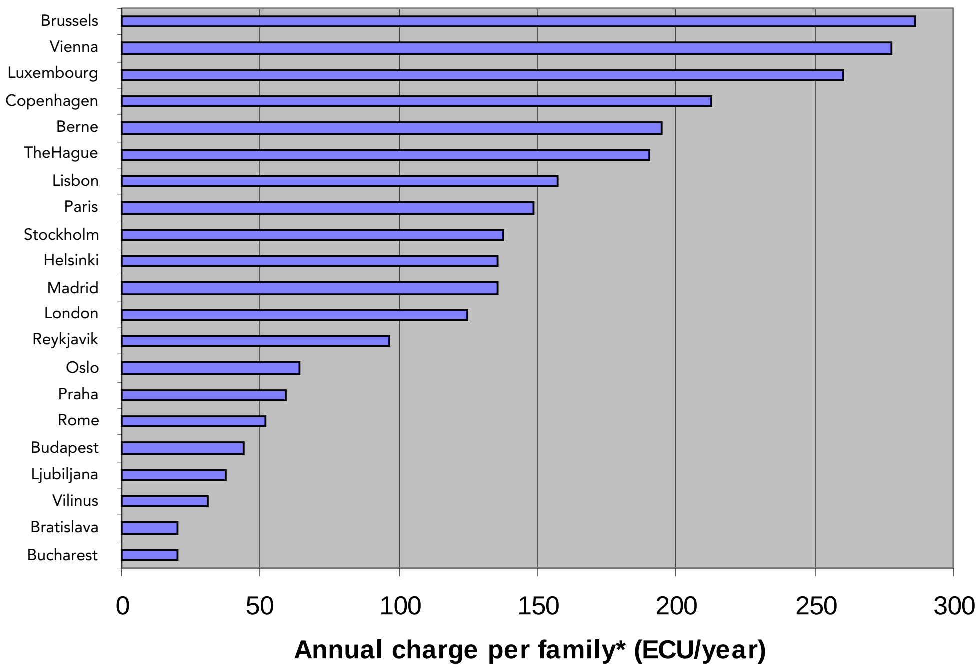
6.4.2. Water pricing

To meet the increasing requirements of EU Directives and public expectations for high water quality, water companies have to use complicated and high-technology treatment plants to supplement simple, natural processes for treating drinking water. For example, in Germany investments by water companies have roughly doubled since 1970 (Scherer 1993). Renewing maintenance-intensive distribution networks continues to account for about 2/3rd of the capital expenditure, while the remainder goes into catchment, treatment and quality control.

In France water prices can vary according to regions and according to the type of service (public/private, level of treatment). A survey performed in the Seine-Normandie Basin shows that the average price (including drinking water supply, waste water collection and treatment), paid by most (80%) inhabitants in the catchment, ranges from 1.5 to 2.7 ecu/ m^3 (10 to 18 Francs/ m^3). Charges in the Basin range from 0.15 to 6.8 ecu/ m^3 (AESN, 1997). All water charges are based on the water volume used and metered. They have regularly increased from the 1980s up to now. The cost of water in France include cost price (which includes the cost of water and the payment for drinking water supply), payment for water treatment services and various taxes.

Water charges in Western Europe vary from 52 ecu/year per family in Rome to 287 ecu/year per family in Brussels. Water charges in Central European cities are lower and vary from 20 ecu/year per family in Bucharest and Bratislava to 59 ecu/year per family in Prague (Figure 6.1).

Figure 6.1: Annual water charges in European cities in 1996



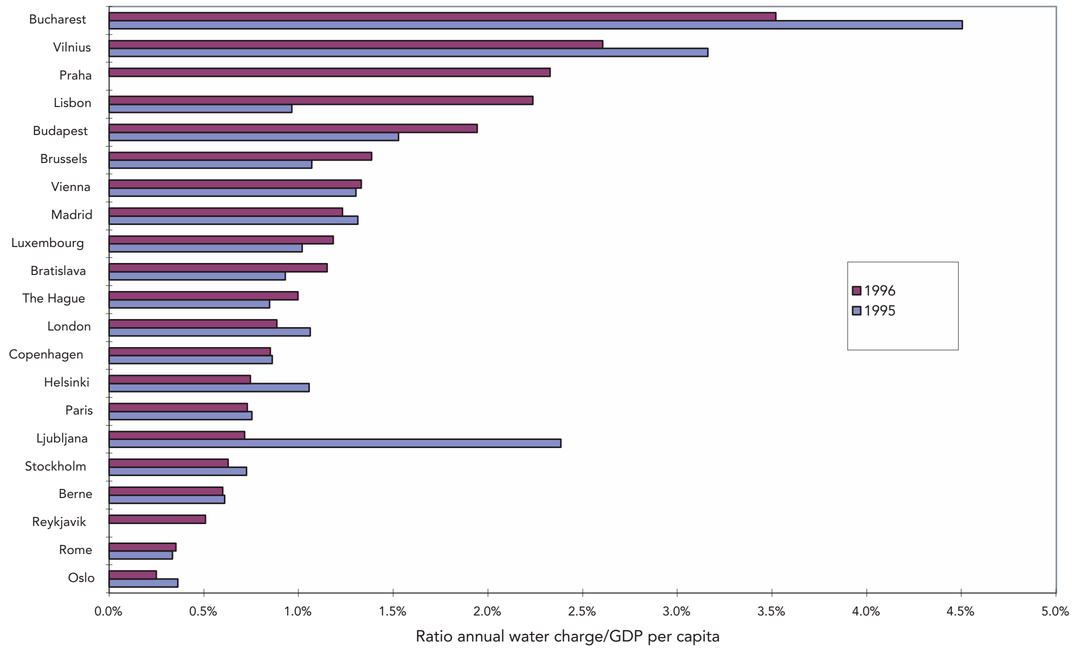
* family living in a house consuming 200 m³ /year (ECU as per June 1996)

(Source: IWSA, 1997)

Nevertheless, the annual water charge in relation to GDP per capita shows that the cost in Bucharest is the highest in Europe amounting to 3.5% followed by Vilnius 2.6% and Prague 2.3% and the lowest percentage of GDP per capita is 0.2% in Oslo. In Western Europe, the highest percentage is 2.2% in Portugal (Figure 6.2).

It is difficult to establish a general trend in Europe in relation to water charges; there are different factors to determine the final price of water (water availability, technical issues, political motives - see previous section). Cities such as Lisbon increased the annual water charge as percentage of GDP per capita from 1.0 in 1995 to 2.2% in 1996. The increase in Budapest for the same period was from 1.5 to 1.9%. Berne has kept the same percentage, 0.6%. The percentages in Madrid and Paris have decreased slightly from 1.3 to 1.2% and 0.8 to 0.7% respectively and in Ljubljana and Bucharest, the decrease is more significant: from 2.4 to 0.7% and 4.5 to 3.5%, respectively (Figur 6.2)

Figure 6.2: Annual water charge in European cities in relation to GDP per capita



(Source: IWSA Congress, 1997)

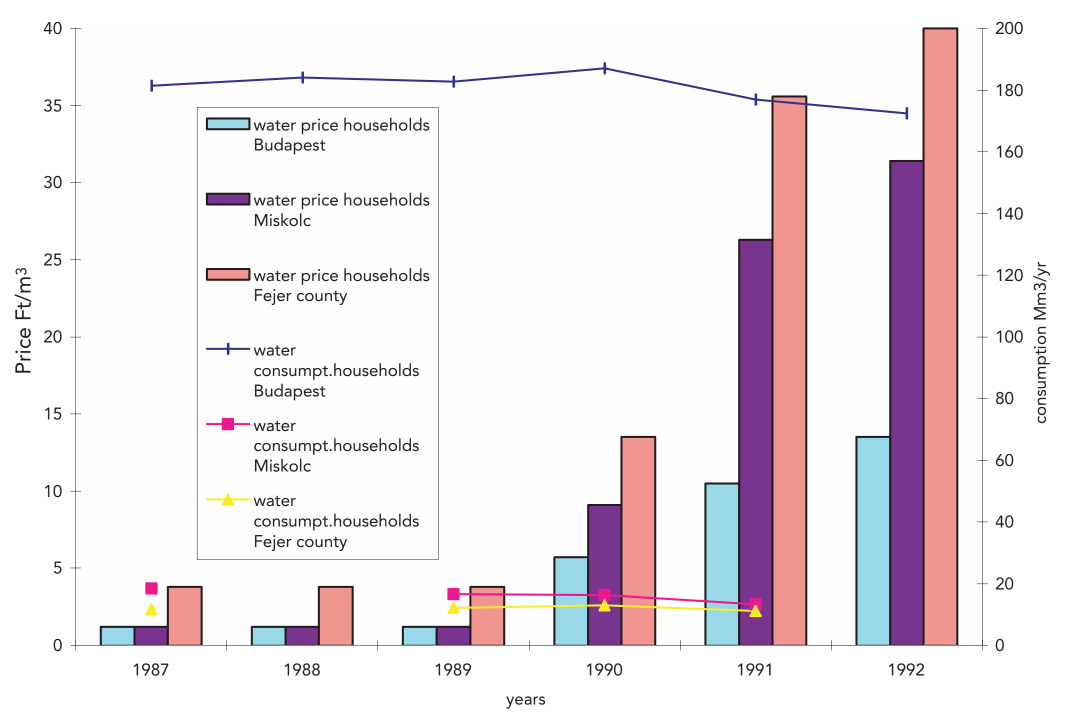
Several studies have demonstrated that rising water prices have a positive effect on both indoor and outdoor water conservation efforts (use of low-flow toilets, taps and shower-heads for example) (Agthe, 1996; ICWS, 1996). Another approach consists of action to regulate supply by introducing “block tariffs” to discourage a high use of water. In Barcelona the Water Supply Company introduced in 1983 a new tariff system based on a service quota and two blocks with increasing price. In 1991, after the 1989-1990 drought, a third block was introduced.

In Eastern Europe water prices have risen sharply at a much higher rate than inflation since 1989, following the need to replace vanishing state subsidies. For example in the eastern part of Germany and Hungary water impounding and distribution systems are now fully financed from charging revenues, with no subsidy from governments (with tariffs also including a portion for reconstruction and development of new schemes).

An analysis of the relation between water price and water consumption has been carried out for three different towns in Hungary: Budapest, a large city with a heavy concentration of industries and vast suburban areas with housing and gardens; Miskolc, the second largest town also with a heavy concentration of industries; and Fejer county with high living standards and few industries. From 1987 to 1992, water price went up by a factor of 10 in Budapest and by a factor of more than 20 in the other towns. In parallel, water consumption decreased by 5 to 28% for households and 20 to 30% for industries, depending on the price level before the increase (Figure 6.3). This shows that a price increase might have a much greater impact on consumption in countries and areas where the price of water had been low than in those where water had always been expensive.

In the eastern part of Germany where prices increased at a similar rate as in Hungary (the consumer price index increased about 14% from 1985 to 1992 for households and 9% for other than households), water consumption dropped 10% per annum between 1980 to 1991. Between 1990 and 1995 water consumption per person declined by 9% in the whole of Germany. Average daily water consumption currently amounts to 132 litres per person, the same level as twenty years ago. The drop in water consumption is not only because of the changes in water prices but also because of changes in consumer behaviour.

Figure 6.3: Relation between water tariffs and water consumption for households in Hungary



In the Czech Republic, water consumption was about 276 l/cap./year in 1980 and decreased to 195 l/cap./year in 1996 due not just to the decrease in industrial production but also to the increasing charges for water.

6.4.3. Water metering

Domestic metering is widespread in many countries (e.g. France, Germany and Portugal), but less common for example in the United Kingdom. (NRA, 1995). Water metering is assumed to increase population awareness of water use. For example, in the United Kingdom the use of water in metered versus non-metered households is estimated to be 10% lower. The installation of water meters frequently is in line with public concerns for better use of water resources and the request for a better management of the water environment. Reliable water metering is a stringent requirement for the implementation of effective water charges.

6.4.4. Improving efficiency of use

Urban water use

The concept of "Water Demand Management" refers to all those activities that aim to render the greatest possible amount of services using the least possible volume of water. "Water Conservation" corresponds to a more general definition and considers all those activities that aim to reduce water demand, improve efficiency of water use and avoid the deterioration of water resources. It deals with the origins of water demand from a technical and a socio-cultural point of view as well as with the protection of hydraulic ecosystems. The various activities which can be included in a water conservation programme can be distinguished by sectors of water use or by conceptual divisions, considering the following five categories:

- infrastructure programmes: improvements in the distribution (and recollection) system in order to reduce losses and enable the control of consumption by water users (e.g. improvement of network, repair of weak points, installation of measurement devices);
- programmes to improve efficiency: reduction of water consumption by means of technical modifications of installations (e.g. better hydraulic and sanitary equipment, design of public and private gardens in a way that allows to reduce water demand);

- substitution programmes: replacement of the use of drinking water from the public supply network through water of other origin, mainly re-utilisation;
- water saving programmes: reduction of water consumption through user education, tariff systems to encourage economic use, information campaigns, etc;
- management programmes: municipal regulations, tariff systems, commercial incentives and discounts for economic water use, hydraulic audits, loans and subsidies for improvement measures.

Case study example from Brittany, France

After facing several years of difficulties in providing drinking water (because of limited quantities and poor quality, especially caused by nitrate and pesticides), Brittany (in France) started a new scheme for water supply and management in 1990. Initial pilot action plans undertaken in several towns led to the reduction in public water consumption of 76% in 15 years (with a stable population size) obtained by the installation of low-flow toilets, watering equipment for public gardens, saving appliances in swimming pools, schools. The predicted development of peri-urban zones and the associated increase in water use led the regional and municipal authorities to launch new pilot action programmes to reduce domestic water use. In seven towns, the installation of water saving appliances (tap, shower, toilets) has reduced the water consumption by 31 m^3 /household while the use of new watering system has led to the reduction of 60% of water during summer time. In some towns the reduction in water consumption has attained 50% after 10 months. This pilot action has also increased the awareness of the population in an area where water quality is frequently one of the major problems. Co-financed by the Water Agency and Environment Ministry, the operation is going to extend beyond the region to make the population and tradesmen (plumbers) more sensitive to water use and saving equipment. This will including testing of existing appliances, installation of new water-saving equipment in households, identification/diagnosis of waterworks losses and improvement of the efficiency of water consumption. Such action programmes have also been conducted in several industries and in the field of agriculture (irrigation, drinking water for animals).

Agricultural water use

Regarding agricultural water use the measures of demand management have to be in line with the objectives of sustainable agriculture in terms of water conservation, protection of the environment, economic viability and social acceptance. In broad terms irrigation systems can be divided into the following two categories:

1. Irrigation systems in which the entire hydraulic system is managed by one (normally private) entity. Normally water in these systems is drained from a well and is brought to fields by methods of localised (pressure) irrigation.

2. Classical (frequently large scale) irrigation systems with major involvement of government or public entities, managing storage reservoirs and major canal distribution networks.

Following the flow of water in a classical irrigation systems from the reservoir to the fields and including the facilities for drainage, the elements of the hydraulic system can be distinguished as follows:

1. Network of principal canals with mains and branches.

2. Network of secondary canals, including the distribution to the field borders.

3. On-field distribution and drainage.

4. Secondary drainage network.

5. Main drainage collector.

Typically public water authorities manage the elements 1 and 5 of the hydraulic system and the storage reservoir. Elements 2 and 4 are normally administered by irrigation farmers associations and element 3 is dealt with by farmers.

The shared and alternate use of water over extensive periods of time and large distances, which is characteristic for this kind of exploitation, requires in the first place measures aimed at improving co-ordination between public water management authorities, irrigation farmers associations, and the final users. The ultimate consequences are dependent on the outcome of water supply management of the individual production units.

Bearing in mind the remarkable differences in the efficiency of water use which can exist between traditional irrigation systems with earth canals and gravity irrigation and modern systems with concrete lined canals, pipe distribution systems and localised irrigation systems an ample margin for improvement of water use can be identified.

Potential measures for improvement can be divided into those that aim to improve the performance of water distribution entities (public bodies and users associations) and those which aim to improve water use efficiency at farm level.

Measures can be further divided into those dealing with the improvement of existing infrastructure (e.g. concrete lining of canals, implementation of localised irrigation, levelling of fields and improved drainage), and those related to the non-structural aspects of irrigation (e.g. improvement of organisation and management, improve knowledge about water losses, establish information systems, improve determination of crop demand and adjustment of water allocations, optimisation of timing, promote users initiatives for improvements, and tariff systems).

Similarly to urban water use the potential of using secondary water effluents after adequate treatment opens considerable possibilities for water savings.

Industrial water use

In industrial water use the environmental benefits of reducing water demand go in parallel with the advantage of reducing the volume of effluents and thus diminishing, at least in volume, the burden to provide adequate wastewater treatment.

Improvement programmes to be applied are principally similar to the ones applicable in urban water supply. In the case of industries the measures which promise most success in terms of demand reduction are those determining the legal and regulatory framework and all measures related to the economic cost of water use. Generally the principle of internalisation of all direct and indirect costs associated with water use and emissions applies.

Programmes aiming at the promotion of water substitution, re-utilisation and especially recycling promise major saving rates. Also the process of rationalisation of production in larger units tends to reduce the consumption of water per product unit.

6.5. Infrastructure responses

6.5.1. Network efficiency – leakages

Network efficiency has direct consequences on total water abstractions. In most countries leakage in water distribution networks is still a major problem. Comparison of leakage in three European countries (United Kingdom (England and Wales), France and Germany), undertaken by the United Kingdom water industry regulators (OFWAT, 1997) shows that leakage in main and customer supply pipes varies from 8.4 (in England and Wales) to 3.7 m^3 per km of main pipe per day (West Germany), which correspond to 243 and 112 l/property/day, respectively.

Analyses in France have shown that the network efficiency (supplied volumes divided by abstracted volumes) can vary from 68% across a highly rural area to 85% for the Paris region. The national average was estimated to be around 70% in 1990. Assumptions of possible future network efficiencies range from 78% in urban areas and 72% in rural areas for the less optimistic scenario to 80% in the most optimistic scenario for both situations.

Studies in Spain indicate that network efficiencies in urban areas range from 77% (Madrid) to 60% (Bilbao). The national average in settlements with more than 20,000 inhabitants is estimated to be around 80% (AEAS, 1997). Recent studies appear to indicate an upward trend in distribution efficiency, showing an increase from 68% in 1990 to 72% in 1994.

In Italy, the IRSA study indicates that the average value of losses is 15% of the total water delivered, but 31% of the total water delivered in Rome and 30% in Bari does not reach the final user. In Austria water suppliers' losses were estimated at 10% in the 1990s. The objective of the Austrian authorities is to reduce these to 7%. Over the last 17 years, the volume of water losses has decreased from 47 to 15 million m^3 (Ambassade de France en Autriche, 1993).

Average leakage of drinking water from pipe lines in Central and Eastern European countries are estimated to range from 27% in the Slovak Republic to 50% in Moldova and Ukraine (Society of Development and International Co-operation, 1995). In the Czech Republic the amount of water losses from the network is about 33%.

Different options can be used to reduce leakage:

- repair of visible leaks;
- establishment of leakage control zones;
- awareness, location and repair of leaks not visible from the surface;
- telemetry of zone flows;
- pressure reduction;
- mains replacement;
- subsidised/free detection and repair of domestic customer/business supply pipe leakage;
- repair of leakage through the structure of service reservoirs;
- minimisation of service reservoir overflow losses;
- trunk main leakage detection and repair.

Water supply companies in the United Kingdom have used most of these options to control the leakage. Table 6.5 shows the estimate of leakage reduction in the recent years for one United Kingdom Water Company.

Table 6.5: Leakage reduction in Yorkshire region (United Kingdom)

Leakage (Ml/d)	1994-95	1996-97
Total leakage	536	420
Supply pipe losses	101	98
Distribution losses	435	322

(Source: Yorkshire Water Services, 1997)

The company considers that there is a little scope for further reductions through repairing visible leaks and establishing leakage control zones. However, other options, such as telemetry of zone flows, pressure reduction, subsidised/free detection and repair of domestic customer/ business supply pipe leakage, repair of leakage through the structure of service reservoirs and mains replacement, are considered as options for further leakage reduction.

In a study to identify the most cost-effective measures to control leakage in combination with other measures to ensure a supply/demand balance, the company compared and assessed the costs and yields achievable using some of these last methods (Table 6.6).

Table 6.6: Estimates of division of savings

Option	Yields (cumulative) M l/d		
	97/98	98/99	99/00
Service reservoir losses. Total leakage reduction	0	7	14
25% extra find & fix. Total leakage reduction	12	24	24
Pressure reduction. Total leakage reduction	6	14	20
Mains replacement. Total leakage reduction	4	9	13
Telemetry of zones. Total leakage reduction	0	2	4
Total reduction	22	56	75

(Source: Yorkshire Water Services, 1997)

In general terms it can be stated that the increase in water consumption occurred under the perception that water was abundant and cheap, two concepts which tend to vanish in the light of growing water pollution, droughts and increasing water prices. The reinforcement of European and national legislation (emission limits, standards for discharges, etc.) and the rise in the cost of water are leading municipalities and industries to reduce their water use and encourage investments in new water saving processes and equipment.

6.5.2. Increase in reservoir capacity

The use of storage reservoirs helps overcome the uneven distribution of natural water resources over time. Run-off in the humid season can be held back and used in the dry season (seasonal regulation), while water available in humid years can be stored and used in dry years (inter-annual regulation).

At present about 3500 major reservoirs (formed by dams according to the ICOLD definition) with a total gross capacity (total water volume at normal maximum water levels) of approximately 150,000 million m^3 are in operation in Europe (EU15 plus Norway and Iceland) (ETC-IW, 1997). The greatest storage capacities are available in Spain (52,000 Mio. m^3), Norway (38,000 Mio. m^3) Sweden (21,000 Mio. m^3) and Finland (15,000 Mio. m^3). The greatest number of major reservoirs are found in Spain, France and the United Kingdom with 849, 521 and 517, respectively.

The primary functions of reservoirs in Europe are hydroelectric power production, storage for public water supply and irrigation. Further functions include flood defence, recreation, navigation, fish farming and industrial supply. Frequently reservoirs fulfil several functions at the same time. The purposes of reservoirs are directly related to the specific features of water use in the various countries. Storage for irrigation is required mainly in Spain, Italy, France and Portugal. In contrast, public water supply is the main function in the United Kingdom and Germany.

The greatest increases in total reservoir capacity in Europe occurred between 1955 and 1985, rising from a capacity of 25,000 million m^3 in 1950 to around 120,000 million m^3 in 1980.

Regarding the potential for future storage reservoirs in Europe, it needs to be taken into account that the most economic dam sites have already been selected and the respective schemes implemented. Consequently, future dams will face higher economic and, if care is not taken, environmental costs. Also, political and societal attitudes towards big hydraulic infrastructure projects are today much more critical than in the past. The prospect of a major increase in reservoir capacity in Europe consequently needs to be considered with extreme caution.

6.5.3. Increase in groundwater use

In semi-arid regions or regions of water scarcity aquifers play a vital role in meeting water demand, not only as regards water quality and quantity but also in relation to space and time. Aquifers can be an efficient natural solution to water scarcity, being able to overcome a wide range of situations: supplying water under a variety of conditions, controlling abundant reserves and covering extensive areas, as well as transporting and distributing water. Aquifers are also important elements in the protection of water quality, providing quality reserves in areas where surface run-off in summer proves insufficient to maintain acceptable standards of water quality, and even when run-off is too low to maintain minimum ecological discharges.

However, the use of aquifers (in semi-arid areas) is dependent on annual recharge and requires effective management if sustainability is to be achieved. In some southern regions of the EEA area aquifers have very limited annual recharge. Tourism and peak water demand in summer exert additional pressure on groundwater reserves. On the other hand the climate in these areas frequently allows the growing of high-yield crops, which may require substantial amounts of water for irrigation during the whole year.

The management of water resources, understood as a set of operational rules which determine the handling of water resource systems in general and the management of aquifers in particular, has proven to be complicated and costly to establish and maintain.

Intensive use of aquifers can give rise to over-exploitation, depending on the balance between abstraction and renewable resources. In the semi-arid regions of Mediterranean Europe the absence of abundant rainfall and run-off increasingly encourages the use of groundwater resources, frequently leading to excessive abstraction for irrigation and over-exploitation. The resulting increase in productivity and changes of land use can initiate a cycle of non-sustainable socio-economic development within an area. More and more resources are exploited to satisfy the increasing demand of population and agriculture, exacerbating the already threatened environment by reducing groundwater levels and, on some occasions, accelerating desertification. The lowering of water tables also damages natural wetlands and wet ecosystems.

This scenario is in contrast to Central and Northern Europe where over-exploitation is mainly a consequence of the fact that groundwater resources historically have provided a low-cost, high-quality source of public water supply.

The increase in groundwater abstraction therefore faces certain limitations from an environmental point of view, given the problems of aquifer over-exploitation and lowering of groundwater tables already observed especially in southern areas of Europe. Also, in some aquifers, restrictions as regards water quality exist, limiting in particular the use of drinking water and increasing the costs of water treatment.

Nonetheless, it should be taken into consideration that especially in semi-arid areas groundwater resources frequently constitute a vital element of water supply systems, due to their capacity for forming natural reservoirs and the fact that often they are the only possible source of supply. The joint use of surface waters and groundwater presents opportunities to make use of the natural buffer capacity of aquifers in dry periods, and to ensure recharge when water is abundantly available.

The potential to increase the use of groundwater resources depends, of course, on the characteristics of the specific aquifer considered.

6.5.4. Increase of re-use and recycling

The practise of waste water re-use is increasing greatly within the EU, mostly to alleviate the lack of water resources in certain regions, such as in Southern European countries but also to protect the environment especially in coastal waters by removing all discharges into fragile receiving waters (IPTS 1997). Article 12 of the Urban Waste Water Treatment Directive (91/271/EEC) mentions that treated water shall be re-used whenever appropriate. The largest application of this re-use is the irrigation of crops, golf courses and sports fields where pathogens from the wastewater may be in contact with the public. In a parallel development Europe and mostly the Northern European countries import produce and flowers irrigated with reclaimed wastewater from Southern Mediterranean countries. There are however at present no regulations on wastewater re-use in Europe.

The potential for water re-use and recycling has not yet been exploited in many areas. A decisive factor to achieve a higher percentage of water re-use is the establishment of effective incentives, which in many instances will be of either an economic or a regulatory nature. One of the fundamental advantages of water re-use is the fact that in many cases the resource employed is available in the vicinity of its prospective new use, i.e. urban agglomerations and industrial sites.

The limiting factor for water re-use can in many circumstances be the quality of the water available and potential hazards for secondary users. To examine the economic viability of water re-use a careful benefit-cost analysis for the various parties involved needs to be carried out.

6.5.5. Desalination

At present seawater desalination is being applied mainly in areas where no other sources of supply are available at competitive costs. The total volume of desalination in Europe is limited compared to other sources of supply. The essential factor which conditions the implementation of seawater desalination is the cost of water from desalination plants (presently of the order of magnitude of 0.7 ecu per m^3 , including energy cost and the depreciation). The potential of seawater desalination as a viable option for the future depends primarily on advances in desalination technology, evolution of the costs of energy and the cost of water from alternative sources. From an environmental viewpoint a careful examination is required to clarify up to which point the use of primary energy for the production of water is environmentally sensible and economically viable.

On the Balearic archipelago, desalination of seawater and brackish water already provides a substantial part of total urban water supply. Characterised by a comparatively dry climate and relatively limited surface water resources, the Balearic Islands have a tourist population more than ten times the number of their permanent residents (8.5 Mio. visitors per year compared to 790,000 permanent inhabitants). At the same time the level of income is relatively high, thanks to the strong tourism sector and massive capital inflow from outside. The combination of these circumstances have led to a situation in which the desalination capacity (91,500 m^3 /day) accounts for about a third of total urban water demand (106 Mio. m^3 /year) (Fayas *et al.*, 1997).

Table 6.7 shows the use of conventional supply sources compared to non-conventional sources (re-use and desalination) in southern European countries (Plan Bleu 1997). In all countries except Malta non-conventional sources are only very minor; in Malta they amount to 46% of the total.

Table 6.7: Diversity of water supply sources at the national level

Country	Year	1	2	3	4	5	6	7
Cyprus	1990	0.38	0.372	0.02	0.011	0.008	97.90	5.00
France	1994	40.67	40.67	*	*	*	100.00	*
Greece	1990	7.03	7.03		**		100.00	0.00
Italy	1990	45.00	45.00		**		100.00	0.00
Malta	1990	0.0391	0.0211	0.02	**	0.018	54.00	46.04
Monaco	1991	11.80	11.80	0.05	0.05	0.0034	99.50	0.45
Spain	1992	34.49	34.379	0.12	0.096	0.019	99.70	0.33

* not available**nil or negligible
(1) Total demand km³/year
(2) Withdrawals from conventional sources km³ /year
(3) Total non-conventional production km³ /year
(4) Wastewater re-use km³ /year
(5) Desalination km³ /year
(6) Conventional sources % (column 2 ÷ column 1)
(7) Non conventional water production % (column 3 ÷ column 1)

(Source: Plan Bleu, 1997)

6.5.6. Inter-basin transfers

Since ancient times mankind has made use of artificial structures for water transfer from one river basin to another. Frequently the scale of inter-basin transfers is considerable, with capacities of several hundred cubic meters per second. Table 6.8 presents a summary of major inter-basin transfer schemes in the world. The major examples of inter-basin transfers in Europe are the Rhône-Languedoc transfer and the Canal de Provence in France, with capacities of 75 and 40 m^3 /s, respectively. A variety of other transfers exists, for example in Belgium, Greece, Spain and the United Kingdom.

The construction of inter-basin transfers can certainly be an efficient and cost-effective means of satisfying water demand in hydraulically deficient regions. What needs to be assured in all cases is environmental sustainability on the one hand and economic viability on the other. Especially in regions where either the evidence or the public perception of water shortage exists, attempts to carry water from one catchment to another can encounter fierce resistance from potential donors.

Table 6.8: Examples of major inter-basin transfers

Name	Country	Capacity (m^3 /s)	Use
Transfer of river Churchill	Canada	807 (1)	Hydroelectricity
"La Grande" complex	Canada	1600	Hydroelectricity
Chung-Jiang transfer	China	400	Public water supply, drainage, navigation, irrigation
Eastern Way	China	600	Public water supply, navigation, irrigation
Central Way	China	320 (1)	Public water supply, irrigation
Western Way	China	630 (1)	Public water supply, hydroelectricity, irrigation
Qatarra	Egypt	656	Hydroelectricity
Karacum transfer	Former USSR	247	Irrigation
Northern Krim transfer	Former USSR	260 (1)	Irrigation
Great Fergana transfer	Former USSR	190	Irrigation
Jongley project	Sudan	220 (1)	Irrigation
Central Valley Project	USA	130 - 168 (1)	Public water supply, flood control, hydroelectricity, irrigation, recreation
All American Canal	USA	156	Hydroelectricity, irrigation
Rhone-Languedoc transfer	France	75	Public water supply, irrigation

Canal de Provence	France	40	Public water supply, irrigation
Tajo Segura transfer	Spain	33	Public water supply, irrigation

(1) Capacity calculated from annual transfer volume, assuming constant flow.

(Source: CEDEX, 1994)

6.6. Social policy and environmental ethics

The World Bank considers a cost of up to 5% of household income as affordable for water services. This compares with a cost of about 1% of household income in the EU Member States. For instance in 1996 the average household income in the United Kingdom was £22,780 and the average bill for water services was £228. However, these figures disguise the fact that the impact of water services charges tends to be much more significant for the poorer sections of society than for the more affluent sections. This is only partly ameliorated by the often lower water usage by the poorer population because of the lack of large gardens and water-using appliances although the per household usage of large poor families can of course also be quite high. Different approaches have been adopted in various countries to ensure that water prices are affordable for the population.

Two distinct issues need to be considered: how can the impact of charges on the general population be made affordable and how can the charges be made affordable by the poorer sections of society.

During the development stage of a water supply and sewerage system the impact of the investment on charges is often reduced by subsidies paid for out of general taxes. This is one way of shifting the burden from the poorer to the richer sections of society. To assist national governments to provide the necessary funding financial assistance is frequently provided to countries. For instance large sums of EU money are currently spent to build up and improve the infrastructure for water services in the Cohesion Countries Portugal, Spain Ireland and Greece. However, even countries with 'mature' systems often consider it necessary to provide some assistance to individual municipalities to ensure that the charges to meet new legislative requirements are affordable by the population. Table 6.9 shows the sources of funding in terms of own and external funds for water services for selected EU Member States (Zabel and Buckland 1995).

Table 6.9: Funding for investments in water services

Country	Own resources %	External funds(1)
France	60-80	20-40
Germany	50-60	40-50
Netherlands	70-100	0-30(2)
Portugal	20	80(3)
United Kingdom (England and Wales)	100	0

(1) Includes funds from abstraction and effluent charges
(2) Sewage services only
(3) Approximately 80% from EU funds

Some of these subsidies are provided as soft loans and others are derived from the abstraction and effluent charges or general taxes. The money raised from the charges can be considered as recycling of funds often from the larger systems that have the benefit of scale to the smaller units. In England and Wales full cost recovery has been practised since privatisation. However, as part of privatisation a large subsidy was provided to the companies by writing off a significant portion of the debt and by providing extra funds for environmental improvements. This system also has the advantage, since companies are regionally based, that there is a degree of charge equalisation between the generally more expensive rural and the less expensive urban systems because of the benefits of scale. In a regionally based system it would also not be sensible to create subsidies by collecting abstraction and effluent charges and then recycling the money raised to different parts of the same company. Regionalisation has of course also been applied in other countries (e.g. the Ruhrverband in Germany) to obtain the benefits of scale. Some benefits of scale can also be derived by the French system where the large private companies bring the expertise for the design and operation of the system that would not be available to the same degree to small systems. By combining different utility services (e.g. gas and electricity) with water services can also result in benefits in terms of expertise and can also lead to lower operating costs (lower metering cost if all meters can be read at the same time). This system is widely applied in Germany. The tax system can also be used to minimise water services charges. Many countries, for instance, do not charge value added tax (VAT) on water services or sewerage services or both. Allowing water services companies to write off debts against profits can also reduce water services charges.

Whereas the measures discussed above may lead to generally lower charges for the services for all consumers particularly when developing the system, the problem still remains on how best to make the charges affordable to all sections of society. Different countries have developed different approaches to this problem. In the United Kingdom most consumers pay their water charges depending on the value (rateable value) of the property they live in, with only 8% of households having a water meter. As the poorer population tends to live in lower valued housing their water bills tend to be lower (i.e. more affordable) and is also independent of the number of people living in the house. Customers in the United Kingdom now have a water meter installed which may be attractive for single people not using a large amount of water. A similar system without universal metering operates in France where the flats in large apartment blocks, in which the poorer section of society tends to live, are rarely individually metered.

For metered customers the charge for water can be influenced by the ratio between standing charge and volume charge. Based on the actual cost to the water supplier the standing charge should be more than 80% of the total charge with the remainder as variable charge since the fixed assets tend to be very large whereas the variable costs of providing the water are relatively small. However, in practice, the percentage of the charge related to the standing charge tend to be generally low (< 25%) and the volume related charge high (>75%). Thus there is some incentive to use less water to obtain an economic benefit. This system would also be attractive for low water users (e.g. single pensioners). An alternative approach to make water charges affordable for the poorer section of society is to use a banding system of charges with a low charge for a certain minimum amount per consumer or household per year and higher charges for usage above the minimum amount (the higher charges could of course be further banded). In extreme cases charges may have to be paid directly by the social services.

It is difficult to assess the effect of water prices on consumption, since insufficient information is available on prices charged locally in different countries and their effect on consumption. In addition, the definition of “small industry”, which is included in the public water consumption data, varies between countries. However, indications are that the high prices charged in Germany for water services had some effect on water consumption (Table 6.10).

Table 6.10: Comparison of water prices and consumption

Country	Water consumption l/inhabitant/day	Household bill for water services (200 m³ /y) (1993) (ECU) [(1)]
France	161	410
Germany	144	600
Netherlands	173	300
United Kingdom (England and Wales)	161	330

[(1)] based on charges in selected towns

(Source: WSA 1994)

When using the pricing mechanism to reduce demand, the socio-economic impact needs to be assessed to ensure the pricing structure is equitable. In addition in order to maintain the income of the water supplier to carry out its duty the charges will normally have to be raised as consumption goes down because of the high fixed costs. The overall benefit to consumers of saving money by saving water may therefore be small unless of course major infrastructure expenditure can be saved (e.g. the building of a new reservoir) which would otherwise have increased charges substantially.

Economic instruments, such as abstraction charges, are widely seen as valuable tools to achieve sustainable water management. However, when applying these tools it is important to consider the implications of these economic instruments. They are only effective in terms of their environmental goal to reduce water abstractions when the person who has to pay the charge or tax can actually benefit by responding to the increased charge by reducing consumption. The user will therefore have to be equipped with a water meter. However, when applying these economic instruments to public water supply the impact not only on health and hygiene but also on affordability by the poorer section of society needs to be taken into account, since such charges will hit the poorer population generally proportionately harder than other consumers. The impact on the water distribution system (e.g. longer residence time of the water in the system, which may affect taste and odour and bacterial quality) and on the sewerage system (e.g. more concentrated sewage, lower flow, blockages) will also need to be taken into account.

The currently applied abstraction charges can best be described as financial instruments raising revenue either to fund the cost of the regulator for its water resource function or to fund infrastructure projects to improve water resources and water supply. If funds are used for infrastructure projects it is important to ensure that, if they are provided to companies, these companies do not obtain a competitive advantage.

Charges are generally not related to the true cost of water and are not the same for all users. In particular agricultural users usually pay very low charges that are not related to the real environmental impact of agricultural use. Some success has been achieved in those countries where charges have been placed only on groundwater abstractions or where higher charges have been introduced for groundwater abstractions compared to surface water abstractions. This is particularly so for non-public water supply used to change the behaviour of abstractors and reserve the usually higher quality groundwater supplies for potable water abstractions.

To be effective in protecting the environment, charges need to reflect the true value of the water for the particular aquatic environment taking into account all the uses. The charges therefore need to be site specific. However, at present, no standard method has been devised to assess the true value of water at different sites.

The national groundwater tax in the Netherlands is part of the general reform of the national tax system to shift the burden from income tax towards a tax on consumption including the consumption of natural resources. If this tax were passed on to the consumer it would, like VAT, have a proportionally higher socio-economic impact on the poorer section of society who might not benefit correspondingly from a reduction in other taxes (e.g. income tax). It also has to be taken into account that the tax is applied directly to an essential good. If the tax is successful in reducing consumption, charges will need to be increased to compensate for the reduction in use to maintain the tax income stream.

When introducing economic instruments for water management the impact on the wider economy also needs to be taken into account. For instance very large water users may become uncompetitive if the charges are only introduced in one country. For instance in introducing the energy tax in Scandinavia special tax rates are being applied to the high energy users to ensure they can remain competitive.

7. Data and information gaps - the way forward

7.1. Data and information gaps

This report is based on information derived from a variety of national and international publications, studies, yearbooks and databases. As is common, however, in this type of international study the data is variable depending on the sources considered. In the field of water studies this is especially true for data related to water abstraction and sectoral use. As described in detail in chapter 3 of this report, in the various countries considered different definitions of the concepts analysed and different ways of establishing and structuring records obviously exist.

This report tries to overcome these obstacles by quoting several sources wherever possible. Nonetheless, there is a need to harmonise records if satisfactory comparability between countries is to be achieved.

With regard to information about water quality there seems to be a certain lack of data, especially concerning the quality of groundwater, where very few data are available on an international scale. Substantial improvements are required in this field if the implementations of the respective EC Directives are to be monitored effectively.

7.2. Future lines of study and investigation

The first priority for future work should be the improvement of the present state of information. Analyses need reliable data for evaluation, comparison, forecast and monitoring.

During the course of this study it has become obvious that in many areas few meaningful data are available for all countries considered. In other areas data on a European scale, though available, needs to be considered with reservations, due to the fact that no common procedure to elaborate records exists. Future studies consequently have to concentrate on improving the availability and quality of information and to establish a consistent methodology for presenting records.

It is also necessary to ensure, on the national level, that the data on water resources are validated by an official body and, on the international level, that data collection on water resources, demand and quality is co-ordinated with the aim to provide users and policy makers with reliable and homogeneous data based on the same definitions and concepts.

An essential element of policies aiming to reduce water demand should be the regular monitoring of water abstraction and water use and the establishment of water efficiency indicators to be published on a regular basis. Trends in water abstraction and progress in water conservation programmes need to be detected quickly and information be put at the disposition of the public and relevant authorities. Managers and users need to be provided regularly with information about the latest achievements of water conservation programmes.

In future, analysis should be oriented to providing assistance in the implementation and monitoring of EC Directives related to water quality and the protection of the hydraulic environment. Consistent and reliable information is required to ensure that the legislative guidelines are followed.

8. Conclusions

Sources and uses of water

1. The principal source of abstracted freshwater in the EU Member States is surface water (about 75% of the total water abstracted for all uses) with a large part of the remainder from groundwater (about 25%) and only minor contributions from desalination of seawater and from re-use of treated effluents.

2. In countries such as Austria, Denmark, Portugal, Iceland and Switzerland, over 75% of the water for urban water demand is abstracted from groundwater, between 50-75% in Belgium (Flanders), Finland, France, Germany, Luxembourg and the Netherlands, and less than 50% in Iceland, Norway, Spain, Sweden, the United Kingdom and Czech Republic.

3. Groundwater is generally of superior quality to surface water and requires less treatment. Thus, groundwater reserves are increasingly being exploited in preference to surface water sources and in many parts of Europe this has led to over-abstraction and a lowering of the groundwater table. This in turn has resulted in the degradation of spring fed rivers, destruction of wetlands and, in coastal areas intrusion of saline water into aquifers.

4. The uses of abstracted freshwater in Europe are for urban water demand (14%), agriculture (30%), industry (10%), cooling water excluded, cooling water for power generation and hydropower (32%), and other and undefined uses (14%).

5. The analysis of trends in the total abstraction of freshwater in Europe should take into account the fact that important deviations may exist between data derived from different sources. Given the variety of phenomena observed it does not appear recommendable to identify a general trend in freshwater abstraction on a European scale.

Agriculture

6. One of the biggest driving forces and pressures on water resources is agriculture and the changes in its practices. In many EU Member States there has been a relative decrease in importance of agriculture in comparison with other economic sectors. In terms of water use agriculture accounts for approximately 30% of total water abstractions and more than 50% of consumptive water uses. However, in Southern European countries (Greece, Italy, Portugal and Spain) these percentages rise to 62% of total uses and 73% of consumptive uses, respectively. Agriculture is still a very important economic sector in the EU Accession Countries.

7. The most important agricultural water use is for irrigation. This is particularly so in the Mediterranean countries where agriculture accounts for about 83% of total demand in Greece, 57% in Italy, 68% in Spain and 52% in Portugal. This is in marked contrast to Northern and Eastern European countries where, on average, less than 10% of the resources are used for irrigation.

8. Over the past decades the trend in agricultural water use has, in general, been upward, due to increasing irrigation. However, more recently the rate of increase of the irrigated areas has been diminishing in several countries. In general a major influence on the increase in irrigated land in the EU has been the Common Agricultural Policy, which controls the type and quantity of crops grown.

9. In Southern Europe agriculture requires a much higher share of water resources than would be expected from its relative contribution to national production and employment. It is also clear that the gains in agriculture productivity observed in Western Europe have not yet been achieved in the south and the east. Pressures on agricultural water use may therefore increase in these parts of Europe. In Eastern Europe agricultural water demand has been falling as a result of economic problems and changes in land ownership.

Population and urbanisation

10. Changes in population, population distribution and density are key factors influencing the demand for water resources. The population of the EU has increased by more than 72 million since 1960 with growth rates being positive in nearly all countries. Some forecasts indicate that the population growth rates are expected to decrease over the next 30 years. More than two thirds of the population in the EU live in urban areas with, for most countries, the proportion of the population living in settlements below 2,000 inhabitants clearly decreasing.

11. Water use by households and small businesses shows large differences between countries. Denmark, Germany, Luxembourg and Sweden have decreased their consumption whereas in countries like Austria, Belgium, France, Italy, the Netherlands, Switzerland and especially Norway, there have been increases. Consumption measured as volume and percentage of total water use also increased in all countries between 1980 and 1993, except for Denmark, Luxembourg and Germany where volumes were stable.

Industry

12. In many European countries (e.g. the Netherlands, France and the United Kingdom), industrial water demand has been decreasing through the 1980s and 1990s. This is due primarily to economic recession with plant closures in heavy water using industries such as textiles, iron and steel and a move towards less water intensive service industries. Technological improvements in water using equipment and increased recycling are also contributing to the decline. In Eastern Europe, abstractions have declined due to falling industrial production.

Tourism

13. Over the last 40 years mass tourism has become very important in some national economies. Tourism has a tendency to have distinct seasonal variations and to be in "good weather areas", which are often associated with limited availability of water resources particularly in peak holiday periods. For example in Spain the major part of tourism is directed to the eastern and southern coasts, regions which already are suffering from stress on water resources. Also in the Alps, tourism puts considerable pressure on water resources. Consumption of water by tourists is higher than for normal consumers, domestic water needs are nearly two times higher. Also, tourists often require large volumes of water for recreation such as for swimming pools, water parks and golf courses (the water needed for maintaining a golf course is around 10 million m^3 /year, the same as for well irrigated schemes).

Climate change

14. Predictions on climate change indicate a temperature increase of 1º to 3.5º C by 2030, which together with a 10% reduction in precipitation could lead to a 40% to 70% reduction in renewable water resources in semi-arid regions. Furthermore, a temperature increase could cause snow to melt earlier, increasing winter run-off and reducing the thawing processes in spring and summer. Even in areas where precipitation increases, greater evaporation could lead to lower run-off. A variation in the risk and intensity of droughts is the most serious negative impact of climate change on water resources in arid and semi-arid regions. A reduction in water availability could lead to desertification in zones where the balance is particularly fragile. Climate change can have considerable repercussions on the flood regime. The predicted variation in storm magnitude and frequency could give rise to a spectacular increase in run-off in short periods of time, which would aggravate the already catastrophic effects of floods, thus making it necessary to review present techniques for water resources estimating, prevention prediction and management.

Water availability

15. Freshwater resources across Europe varies greatly with annual run-off ranging from over 3000 mm in parts of Norway to less than 25 mm per year in the Spanish South East and parts of Eastern Europe. Transboundary flows make a significant contribution to the

resources of many countries. In Hungary, for instance, freshwater originating from neighbouring countries accounts for as much as 95% of the total resource. In the Netherlands and Slovak Republic this figure is over 80%, while Germany, Greece, Luxembourg and Portugal all rely on imported water for over 40% of their resources.

16. Potentially, all countries have sufficient resources to meet national demand. However there may be problems on regional or local scale. The greatest demand for water is normally concentrated in the densely populated urban conurbations. The demand for European water resources has increased from 100 km^3 per year in 1950 to 551 km^3 per year in 1990.

Impacts and stress on water resources

17. Water stress is generally related to over-abstraction of water in relation to the resources available in a particular area. Demand for freshwater can exceed the local long-term availability of the resource, especially in Southern Europe and the industrial centres of the north. In these areas such demand can not be sustained unless action is taken to artificially boost local supply (e.g. reservoir construction). Seasonal or inter-annual variation in the availability of freshwater resources will, at times, induce problems of water stress.

18. Over-abstraction of both surface and groundwaters is having serious impacts on associated terrestrial and aquatic ecosystems. Such impacts can be exacerbated during periods of low rainfall and river flow when there may also be increased pressures on supplies to meet urban needs, such as from watering gardens, and from irrigation of water dependent crops. The exceedance of demand over supply leads to restrictions of uses (e.g. hose-pipe bans) during extended periods of time in countries such as the United Kingdom.

Responses - European policy

19. The EC's proposal for an Action Programme for Integrated Groundwater Protection and Management (COM(96) 315 final) requires a programme of actions for the sustainable management and protection of freshwater resources to be implemented by the year 2000 on national and Community level. Many of the recommendations in the GAP are now found in the proposed Framework Water Directive (COM(97) 49 final) which, once implemented, will establish a legally binding framework to promote sustainable water consumption based on long-term protection of available water resources.

Responses - demand side management

20. Economic instruments, such as abstraction charges and pricing mechanisms, are widely seen as valuable tools to achieve sustainable water management. However, they are only effective in terms of their environmental goal to reduce water abstractions when the person who has to pay the charge or tax can actually benefit by responding to the increased charge, by reducing consumption.

21. When applying economic instruments to public water supply the impact on health and hygiene and also on the affordability by the poorer section of society needs to be taken into account as such charges will generally hit the poorer population proportionately harder than the other consumers. In addition in order to maintain the income of the water supplier to carry out its duty the charges will normally have to be raised as consumption goes down because of the high fixed costs. The overall benefit to consumers of saving money by saving water may therefore be small unless of course major infrastructure expenditure can be saved (e.g. the building of a new reservoir) which would otherwise have increased charges substantially.

22. When introducing economic instruments for water management the impact on the wider economy needs to be taken into account. For instance very large water users may become uncompetitive if the charges are only introduced in one particular country.

23. Charges are generally not related to the true cost of water and are not the same for all users. To be effective in protecting the environment charges need to reflect the true value of the

water for the particular aquatic environment taking into account all the uses. The charges therefore need to be site specific. However, at present no standard method has been devised to assess the true value of water at different sites.

24. Water prices for domestic consumers in Western Europe varies from 52 ecu/family per year in Rome to 287 ecu/year in Brussels. Water charges in Central European cities are lower and vary from 20 ecu/year in Bucharest and Bratislava to 59 ecu/year in Prague. Nevertheless, the annual water charge in relation to GDP per capita shows that the cost in Bucharest is the highest in Europe amounting to 3.5% of GDP per capita followed by Vilnius 2.6% and Prague 2.3%, and the lowest is 0.2% in Oslo. In Western Europe, the highest percentage is 2.2% of GDP per capita in Portugal. Several studies have demonstrated that rising water prices for domestic consumers have a positive affect on both indoor and outdoor water conservation efforts (use of low-flow toilets, taps and shower heads for example)

25. Domestic metering is widespread in many countries (e.g. Denmark, France, Germany, the Netherlands, Portugal and Spain), but less common for example in the United Kingdom. Water metering is assumed to increase population awareness of water use. For example, in the United Kingdom the use of water in metered is estimated to be 10% lower than in non-metered households. The installation of water meters is frequently in line with public concerns for better use of water resources and the request for a better management of the water environment. Reliable water metering is an essential requirement for the implementation of effective water charges.

Responses - infrastructure responses

26. Network efficiency has direct consequences on total water abstractions. In most countries leakage in water distribution networks is still substantial. Comparison of leakage in three European countries (United Kingdom, France and Germany), shows that leakage in main and customer supply pipes varies from 8.4 (in parts of the United Kingdom) to 3.7 m^3 per km of main pipe per day (West Germany), which corresponds to 243 and 112 l/property/day, respectively. In the United Kingdom it has been estimated that stopping leakage of supply pipes would save over 1000 million litres of water per day.

27. The use of storage reservoirs overcomes the uneven distribution of natural water resources over time. Run-off in the wet season can be held back and used in dry seasons and years. At present about 3,500 major reservoirs, with a total gross capacity of approximately 150,000 million m^3 are in operation in Europe (EU15 plus Norway and Iceland). The greatest storage capacities are available in Spain (52,000 million m^3), Norway (38,000 million m^3), Sweden (21,000 million m^3) and Finland (15,000 million m^3). The greatest number of major reservoirs is found in Spain, France and the United Kingdom with 849, 521 and 517, respectively.

28. Waste water re-use is increasing within the EU, mostly to alleviate the lack of water resources in certain regions, such as in Southern European countries but also to protect the environment especially in coastal waters by removing all discharges into sensitive receiving waters. Article 12 of the Urban Waste Water Treatment Directive (91/271/EEC) states that treated water shall be re-used whenever appropriate. The largest application of this re-use is the irrigation of crops, golf courses and sports fields where pathogens from the wastewater may come in contact with the public. There are however at present no regulations on wastewater re-use in Europe.

29. At present seawater desalination is being applied mainly in areas where no other sources of supply are available at competitive costs. The total volume of desalination in Europe is limited compared to other sources of supply. There are also examples of inter-basin water transfer schemes being used to alleviate short and long terms water shortages in particular basins or regions.

Conclusions

30. It is recommended that national monitoring and data gathering concentrate on the improvement of the present state of information, trying to establish reliable records on a European scale and provide meaningful information to decision makers. It is further proposed that data collection on water resources and demand is co-ordinated at international level, with the aim to provide users and policy-makers with reliable and homogeneous data based on the same definitions and concepts. The complexity of the problems to be tackled has to be fully recognised and understood if programmes and regulations are to be effective. Furthermore, the essential element of any policy to protect the aquatic environment has to be the regular monitoring of the implementation of the measures taken.

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